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```
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```
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```

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```
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```

```
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Ty Coon, President of Vice
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 */
```

## 1.3 bzip2 1.0.6

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Julian Seward, Cambridge, UK.

[jseward@acm.org](mailto:jseward@acm.org)

bzip2/libbzip2 version 1.0.2 of 30 December 2001

```
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```

```
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/*
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libbz2.dll test program.
by Yoshioka Tsuneo (tsuneo@rr.iij4u.or.jp)
This file is Public Domain. Welcome any email to me.

usage: minibz2 [-d] [-{1,2,..9}] [[srcfilename] destfilename]
*/
```

## 1.4 ncurses 5.9

### 1.4.1 Available under license :

Upstream source <http://invisible-island.net/ncurses/ncurses-examples.html>

Current ncurses maintainer: Thomas Dickey <[dickey@invisible-island.net](mailto:dickey@invisible-island.net)>

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Files: install-sh

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## 1.5 glib 2.42.1

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"Source code" for a work means the preferred form of the work for making modifications to it. For a library, complete source code means all the source code for all modules it contains, plus any associated interface definition files, plus the scripts used to control compilation and installation of the library.

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(For example, a function in a library to compute square roots has a purpose that is entirely well-defined independent of the application. Therefore, Subsection 2d requires that any application-supplied function or table used by this function must be optional: if the application does not supply it, the square root function must still compute square roots.)

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This option is useful when you wish to copy part of the code of the Library into a program that is not a library.

4. You may copy and distribute the Library (or a portion or derivative of it, under Section 2) in object code or executable form under the terms of Sections 1 and 2 above provided that you accompany it with the complete corresponding machine-readable source code, which must be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange.

If distribution of object code is made by offering access to copy from a designated place, then offering equivalent access to copy the source code from the same place satisfies the requirement to distribute the source code, even though third parties are not compelled to copy the source along with the object code.

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Section 6 states terms for distribution of such executables.

When a "work that uses the Library" uses material from a header file that is part of the Library, the object code for the work may be a derivative work of the Library even though the source code is not. Whether this is true is especially significant if the work can be linked without the Library, or if the work is itself a library. The threshold for this to be true is not precisely defined by law.

If such an object file uses only numerical parameters, data structure layouts and accessors, and small macros and small inline

functions (ten lines or less in length), then the use of the object file is unrestricted, regardless of whether it is legally a derivative work. (Executables containing this object code plus portions of the Library will still fall under Section 6.)

Otherwise, if the work is a derivative of the Library, you may distribute the object code for the work under the terms of Section 6.

Any

executables containing that work also fall under Section 6, whether or not they are linked directly with the Library itself.

6. As an exception to the Sections above, you may also combine or link a "work that uses the Library" with the Library to produce a work containing portions of the Library, and distribute that work under terms of your choice, provided that the terms permit modification of the work for the customer's own use and reverse engineering for debugging such modifications.

You must give prominent notice with each copy of the work that the Library is used in it and that the Library and its use are covered by this License. You must supply a copy of this License. If the work during execution displays copyright notices, you must include the copyright notice for the Library among them, as well as a reference directing the user to the copy of this License. Also, you must do one of these things:

a) Accompany the work with the complete corresponding machine-readable source code for the Library including whatever changes were used in the work (which must be distributed under Sections 1 and 2 above); and, if the work is an executable linked with the Library, with the complete machine-readable "work that uses the Library", as object code and/or source code, so that the user can modify the Library and then relink to produce a modified executable containing the modified Library. (It is understood that the user who changes the contents of definitions files in the Library will not necessarily be able to recompile the application to use the modified definitions.)

b) Use a suitable shared library mechanism for linking with the Library. A suitable mechanism is one that (1) uses at run time a copy of the library already present on the user's computer system, rather than copying library functions into the executable, and (2) will operate properly with a modified version of the library, if the user installs one, as long as the modified version is interface-compatible with the version that the work was made with.

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d) If distribution of the work is made by offering access to copy from a designated place, offer equivalent access to copy the above specified materials from the same place.

e) Verify that the user has already received a copy of these materials or that you have already sent this user a copy.

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It may happen that this requirement contradicts the license restrictions of other proprietary libraries that do not normally accompany the operating system. Such a contradiction means you cannot use both them and the Library together in an executable that you distribute.

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## TERMS AND CONDITIONS

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The

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Version 3, 29 June 2007

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@appendixsec GNU LESSER GENERAL PUBLIC LICENSE

@cindex LGPL, Lesser General Public License

@center Version 2.1, February 1999

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@ifinfo

@center GNU LESSER GENERAL PUBLIC LICENSE

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Verify that the user has already received a copy of these materials or that you have already sent this user a copy.

@end enumerate

For an executable, the required form of the ``work that uses the Library" must include any data and utility programs needed for reproducing the executable from it. However, as a special exception, the materials to be distributed need not include anything that is normally distributed (in either source or binary form) with the major components (compiler, kernel, and so on) of the operating system on which the executable runs, unless that component itself accompanies the executable.

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@item

Accompany the combined library with a copy of the same work based on the Library, uncombined with any other library facilities. This must be distributed under the terms of the Sections above.

@item

Give prominent notice with the combined library of the fact

that part of it is a work based on the Library, and explaining where to find the accompanying uncombined form of the same work.

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@iftex

@heading END OF TERMS AND CONDITIONS

@end iftex

@ifinfo

@center END OF TERMS AND CONDITIONS

@end ifinfo

@page

@appendixsubsec How to Apply These Terms to Your New Libraries

If you develop a new library, and you want it to be of the greatest  
possible use to the public, we recommend making it free software that  
everyone can redistribute and change. You can do so by permitting  
redistribution under these terms (or, alternatively,

under the terms of the  
ordinary General Public License).

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safest to attach them to the start of each source file to most effectively  
convey the exclusion of warranty; and each file should have at least the  
``copyright" line and a pointer to where the full notice is found.

```
@smallexample
@var{one line to give the library's name and an idea of what it does.}
Copyright (C) @var{year} @var{name of author}
```

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```
You should
have received a copy of the GNU Lesser General Public
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Foundation, Inc., 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301,
USA.
@end smallexample
```

Also add information on how to contact you by electronic and paper mail.

You should also get your employer (if you work as a programmer) or your  
school, if any, to sign a ``copyright disclaimer" for the library, if  
necessary. Here is a sample; alter the names:

```
@smallexample
Yoyodyne, Inc., hereby disclaims all copyright interest in the library
`Frob' (a library for tweaking knobs) written by James Random Hacker.
```

```
@var{signature of Ty Coon}, 1 April 1990
Ty Coon, President of Vice
@end smallexample
```

```
That's all there is to it!
@ignore
@c Set file name and title for man page.
@setfilename gpl
@settitle GNU General Public License
```

@c man begin SEEALSO

gfdl(7), fsf-funding(7).

@c man end

@c man begin COPYRIGHT

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@c man end

@end ignore

@node Copying

@c man begin DESCRIPTION

@appendix GNU GENERAL PUBLIC LICENSE

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@center Version 3, 29 June 2007

@c This file is intended to be included within another document,

@c hence no sectioning command or @node.

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To prevent this, the GPL assures that patents cannot be used to render the program non-free.

The precise terms and conditions for copying, distribution and modification follow.

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@enumerate 0  
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The ``source code" for a work means the preferred form of the work for making modifications to it. ``Object code" means any non-source form

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The "Corresponding Source" for a work in object code form means all the source code needed to generate, install, and (for an executable work) run the object code and to modify the work, including scripts to control those activities. However, it does not include the work's System Libraries, or general-purpose tools or generally available free programs which are used unmodified in performing those activities but which are not part of the work. For example, Corresponding Source includes interface definition files associated with source files for the work, and the source code for shared libraries and dynamically linked subprograms that the work is specifically designed to require, such as by intimate data communication or control flow between those subprograms and other parts of the work.

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The work must carry prominent notices stating that you modified it, and giving a relevant date.

@item

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You may convey a covered work in object code form under the terms of



sections 4 and 5, provided that you also convey the machine-readable Corresponding Source under the terms of this License, in one of these ways:

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Convey the object code in, or embodied in, a physical product (including a physical distribution medium), accompanied by the Corresponding Source fixed on a durable physical medium customarily used for software interchange.

@item

Convey the object code in, or embodied in, a physical product (including a physical distribution medium), accompanied by a written offer, valid for at least three years and valid for as long as you offer spare parts or customer support for that product model, to give anyone who possesses the object code either (1) a copy of the Corresponding Source for all the software in the product that is covered by this License, on a durable physical medium customarily used for software interchange, for a price no more than your reasonable cost of physically performing this conveying of source, or (2) access to copy the Corresponding Source from a network server at no charge.

@item

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@item

Convey the object code using peer-to-peer transmission, provided you inform other peers where the object code and Corresponding Source of the work are being offered to the general public at no charge under subsection 6d.

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```
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```

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## 1.7 glibc 2.21

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## 1.14 ethtool 3.14

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```

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```

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```
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Gnomovision comes with ABSOLUTELY NO WARRANTY; for details type `show w'.
This is free software, and you are welcome to redistribute it
under certain conditions; type `show c' for details.
```

The hypothetical commands

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```
Yoyodyne, Inc., hereby disclaims all copyright interest in the program
`Gnomovision' (which makes passes at compilers) written by James Hacker.
```

```
<signature of Ty Coon>, 1 April 1989
Ty Coon, President of Vice
```

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(This file is under construction.) -\*- text -\*-

If you've contributed to gas and your name isn't listed here, it is not meant as a slight. I just don't know about it. Email me, nickc@redhat.com and I'll correct the situation.

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+++++

Dean Elsner wrote the original gas for vax. [more details?]

Jay Fenlason maintained gas for a while, adding support for

gdb-specific debug information and the 68k series machines, most of the preprocessing pass, and extensive changes in messages.c, input-file.c, write.c.

K. Richard Pixley maintained gas for a while, adding various enhancements and many bug fixes, including merging support for several processors, breaking gas up to handle multiple object file format backends (including heavy rewrite, testing, an integration of the coff and b.out backends), adding configuration including heavy testing and verification of cross assemblers and file splits and renaming, converted gas to strictly ansi C including full prototypes, added support for m680[34]0 & cpu32, considerable work on i960 including a coff port (including considerable amounts of reverse engineering), a sparc opcode file rewrite, decstation, rs6000, and hp300hpux host ports, updated "know" assertions and made them work, much other reorganization, cleanup, and lint.

Ken Raeburn wrote the high-level BFD interface code to replace most of the code in format-specific I/O modules.

The original Vax-VMS support was contributed by David L. Kashtan. Eric Youngdale and Pat Rankin have done much work with it since.

The Intel 80386 machine description was written by Eliot Dresselhaus.

Minh Tran-Le at IntelliCorp contributed some AIX 386 support.

The Motorola 88k machine description was contributed by Devon Bowen of Buffalo University and Torbjorn Granlund of the Swedish Institute of Computer Science.

Keith

Knowles at the Open Software Foundation wrote the original MIPS back end (tc-mips.c, tc-mips.h), and contributed Rose format support that hasn't been merged in yet. Ralph Campbell worked with the MIPS code to support a.out format.

Support for the Zilog Z8k and Hitachi H8/300, H8/500 and SH processors (tc-z8k, tc-h8300, tc-h8500, tc-sh), and IEEE 695 object file format (obj-ieee), was written by Steve Chamberlain of Cygnus Solutions. Steve also modified the COFF back end (obj-coffbfd) to use BFD for some low-level operations, for use with the Hitachi, 29k and Zilog targets.

John Gilmore built the AMD 29000 support, added .include support, and simplified the configuration of which versions accept which pseudo-ops. He updated the 68k machine description so that Motorola's

opcodes always produced fixed-size instructions (e.g. jsr), while synthetic instructions remained shrinkable (jbsr). John fixed many bugs, including true tested cross-compilation support, and one bug in relaxation that took a week and required the proverbial one-bit fix.

Ian Lance Taylor of Cygnus Solutions merged the Motorola and MIT syntaxes for the 68k, completed support for some COFF targets (68k, i386 SVR3, and SCO Unix), wrote the ECOFF support based on Michael Meissner's mips-tfile program, wrote the PowerPC and RS/6000 support, and made a few other minor patches. He handled the binutils releases for versions 2.7 through 2.9.

David Edelsohn contributed fixes for the PowerPC and AIX support.

Steve Chamberlain made gas able to generate listings.

Support for the HP9000/300 was contributed by Glenn Engel of HP.

Support for ELF format files has been worked on by Mark Eichin of Cygnus Solutions (original, incomplete implementation), Pete Hoogenboom at the University of Utah (HPPA mainly), Michael Meissner of the Open Software Foundation (i386 mainly), and Ken Raeburn of Cygnus Solutions (sparc, initial 64-bit support).

Several engineers at Cygnus Solutions have also provided many small bug fixes and configuration enhancements.

The initial Alpha support was contributed by Carnegie-Mellon University. Additional work was done by Ken Raeburn of Cygnus Solutions. Richard Henderson then rewrote much of the Alpha support.

Ian Dall updated the support code for the National Semiconductor 32000 series, and added support for Mach 3 and NetBSD running on the PC532.

Klaus Kaempf ported the assembler and the binutils to openVMS/Alpha.

Steve Haworth contributed the support for the Texas Instruction c30 (tms320c30).

H.J. Lu has contributed many patches and much testing.

Alan Modra reworked much of the i386 backend, improving the error checking, updating the code, and improving the 16 bit support, using patches from the work of Martynas Kunigelis and H.J. Lu.

Many others have contributed large or small bugfixes and enhancements. If

you've contributed significant work and are not mentioned on this list, and want to be, let us know. Some of the history has been lost; we aren't intentionally leaving anyone out.

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Most GNU software, including some libraries, is covered by the ordinary GNU General Public License. This license, the GNU Lesser General Public License, applies to certain designated libraries, and is quite different from the ordinary General Public License. We use this license for certain libraries in order to permit linking those libraries into non-free programs.

When a program is linked with a library, whether statically or using a shared library, the combination of the two is legally speaking a combined work, a derivative of the original library. The ordinary General Public License therefore permits such linking only if the entire combination fits its criteria of freedom. The Lesser General Public License permits more lax criteria for linking other code with the library.

We call this license the "Lesser" General Public License because it does Less to protect the user's freedom than the ordinary General

Public License. It also provides other free software developers Less of an advantage over competing non-free programs. These disadvantages are the reason we use the ordinary General Public License for many libraries. However, the Lesser license provides advantages in certain special circumstances.

For example, on rare occasions, there may be a special need to encourage the widest possible use of a certain library, so that it becomes a de-facto standard. To achieve this, non-free programs must be allowed to use the library. A more frequent case is that a free library does the same job as widely used non-free libraries. In this case, there is little to gain by limiting the free library to free software only, so we use the Lesser General Public License.

In other cases, permission to use a particular library in non-free programs enables a greater number of people to use a large body of free software. For example, permission to use the GNU C Library in non-free programs enables many more people to use the whole GNU operating system, as well as its variant, the GNU/Linux operating system.

Although the Lesser General Public License is Less protective of the users' freedom, it does ensure that the user of a program that is linked with the Library has the freedom and the wherewithal to run that program using a modified version of the Library.

The precise terms and conditions for copying, distribution and modification follow. Pay close attention to the difference between a "work based on the library" and a "work that uses the library". The former contains code derived from the library, whereas the latter must be combined with the library in order to run.

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0. This License Agreement applies to any software library or other program which contains a notice placed by the copyright holder or other authorized party saying it may be distributed under the terms of this Lesser General Public License (also called "this License"). Each licensee is addressed as "you".

A "library" means a collection of software functions and/or data prepared so as to be conveniently linked with application programs (which use some of those functions and data) to form executables.

The "Library", below, refers to any such software library or work which has been distributed under these terms. A "work based on the

Library" means either the Library or any derivative work under copyright law: that is to say, a work containing the Library or a portion of it, either verbatim or with modifications and/or translated straightforwardly into another language. (Hereinafter, translation is included without limitation in the term "modification".)

"Source code" for a work means the preferred form of the work for making modifications to it. For a library, complete source code means all the source code for all modules it contains, plus any associated interface definition files, plus the scripts used to control compilation and installation of the library.

Activities other than copying, distribution and modification are not covered by this License; they are outside its scope. The act of running a program using the Library is not restricted, and output from such a program is covered only if its contents constitute a work based on the Library (independent of the use of the Library in a tool for writing it). Whether that is true depends on what the Library does and what the program that uses the Library does.

1. You may copy and distribute verbatim copies of the Library's complete source code as you receive it, in any medium, provided that you conspicuously and appropriately publish on each copy an appropriate copyright notice and disclaimer of warranty; keep intact all the notices that refer to this License and to the absence of any warranty; and distribute a copy of this License along with the Library.

You may charge a fee for the physical act of transferring a copy, and you may at your option offer warranty protection in exchange for a fee.

2. You may modify your copy or copies of the Library or any portion of it, thus forming a work based on the Library, and copy and distribute such modifications or work under the terms of Section 1 above, provided that you also meet all of these conditions:

- a) The modified work must itself be a software library.
- b) You must cause the files modified to carry prominent notices stating that you changed the files and the date of any change.
- c) You must cause the whole of the work to be licensed at no charge to all third parties under the terms of this License.
- d) If a facility in the modified

Library refers to a function or a table of data to be supplied by an application program that uses the facility, other than as an argument passed when the facility is invoked, then you must make a good faith effort to ensure that, in the event an application does not supply such function or table, the facility still operates, and performs whatever part of its purpose remains meaningful.

(For example, a function in a library to compute square roots has a purpose that is entirely well-defined independent of the application. Therefore, Subsection 2d requires that any application-supplied function or table used by this function must be optional: if the application does not supply it, the square root function must still compute square roots.)

These requirements apply to the modified work as a whole. If identifiable sections of that work are not derived from the Library, and can be reasonably considered independent and separate works in themselves,

then this License, and its terms, do not apply to those sections when you distribute them as separate works. But when you distribute the same sections as part of a whole which is a work based on the Library, the distribution of the whole must be on the terms of this License, whose permissions for other licensees extend to the entire whole, and thus to each and every part regardless of who wrote it.

Thus, it is not the intent of this section to claim rights or contest your rights to work written entirely by you; rather, the intent is to exercise the right to control the distribution of derivative or collective works based on the Library.

In addition, mere aggregation of another work not based on the Library with the Library (or with a work based on the Library) on a volume of a storage or distribution medium does not bring the other work under the scope of this License.

3. You may opt to apply the terms of the ordinary GNU General Public License instead of this License to a given copy of the Library. To do this, you must alter all the notices that refer to this License, so that they refer to the ordinary GNU General Public License, version 2, instead of to this License. (If a newer version than version 2 of the ordinary GNU General Public License has appeared, then you can specify that version instead if you wish.) Do not make any other change in these notices.

Once this change is made in a given copy, it is irreversible for

that copy, so the ordinary GNU General Public License applies to all subsequent copies and derivative works made from that copy.

This option is useful when you wish to copy part of the code of the Library into a program that is not a library.

4. You may copy and distribute the Library (or a portion or derivative of it, under Section 2) in object code or executable form under the terms of Sections 1 and 2 above provided that you accompany it with the complete corresponding machine-readable source code, which must be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange.

If distribution of object code is made by offering access to copy from a designated place, then offering equivalent access to copy the source code from the same place satisfies the requirement to distribute the source code, even though third parties are not compelled to copy the source along with the object code.

5. A program that contains no derivative of any portion of the Library, but is designed to work with the Library by being compiled or linked with it, is called a "work that uses the Library". Such a work, in isolation, is not a derivative work of the Library, and therefore falls outside the scope of this License.

However, linking a "work that uses the Library" with the Library creates an executable that is a derivative of the Library (because it contains portions of the Library), rather than a "work that uses the library". The executable is therefore covered by this License.

Section 6 states terms for distribution of such executables.

When a "work that uses the Library" uses material from a header file that is part of the Library, the object code for the work may be a derivative work of the Library even though the source code is not. Whether this is true is especially significant if the work can be linked without the Library, or if the work is itself a library. The threshold for this to be true is not precisely defined by law.

If such an object file uses only numerical parameters, data structure layouts and accessors, and small macros and small inline functions (ten lines or less in length), then the use of the object file is unrestricted, regardless of whether it is legally a derivative work. (Executables containing this object code plus portions of the Library will still fall under Section 6.)

Otherwise, if the work is a derivative of the Library, you may



distribute the object code for the work under the terms of Section 6.

Any

executables containing that work also fall under Section 6, whether or not they are linked directly with the Library itself.

6. As an exception to the Sections above, you may also combine or link a "work that uses the Library" with the Library to produce a work containing portions of the Library, and distribute that work under terms of your choice, provided that the terms permit modification of the work for the customer's own use and reverse engineering for debugging such modifications.

You must give prominent notice with each copy of the work that the Library is used in it and that the Library and its use are covered by this License. You must supply a copy of this License. If the work during execution displays copyright notices, you must include the copyright notice for the Library among them, as well as a reference directing the user to the copy of this License. Also, you must do one of these things:

a) Accompany the work with the complete corresponding machine-readable source code for the Library including whatever changes were used in the work (which must be distributed under Sections 1 and 2 above); and, if the work is an executable linked with the Library, with the complete machine-readable "work that uses the Library", as object code and/or source code, so that the user can modify the Library and then relink to produce a modified executable containing the modified Library. (It is understood that the user who changes the contents of definitions files in the Library will not necessarily be able to recompile the application to use the modified definitions.)

b) Use a suitable shared library mechanism for linking with the Library. A suitable mechanism is one that (1) uses at run time a copy of the library already present on the user's computer system, rather than copying library functions into the executable, and (2) will operate properly with a modified version of the library, if the user installs one, as long as the modified version is interface-compatible with the version that the work was made with.

c) Accompany the work with a written offer, valid for at least three years, to give the same user the materials specified in Subsection 6a, above, for a charge no more than the cost of performing this distribution.

d) If distribution of the work is made by offering access to copy

from a designated place, offer equivalent access to copy the above specified materials from the same place.

e) Verify that the user has already received a copy of these materials or that you have already sent this user a copy.

For an executable, the required form of the "work that uses the Library" must include any data and utility programs needed for reproducing the executable from it. However, as a special exception, the materials to be distributed need not include anything that is normally distributed (in either source or binary form) with the major components (compiler, kernel, and so on) of the operating system on which the executable runs, unless that component itself accompanies the executable.

It may happen that this requirement contradicts the license restrictions of other proprietary libraries that do not normally accompany the operating system. Such a contradiction means you cannot use both them and the Library together in an executable that you distribute.

7. You may place library facilities that are a work based on the Library side-by-side in a single library together with other library facilities not covered by this License, and distribute such a combined library, provided that the separate distribution of the work based on the Library and of the other library facilities is otherwise permitted, and provided that you do these two things:

a) Accompany the combined library with a copy of the same work based on the Library, uncombined with any other library facilities. This must be distributed under the terms of the Sections above.

b) Give prominent notice with the combined library of the fact that part of it is a work based on the Library, and explaining where to find the accompanying uncombined form of the same work.

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Version 2, June 1991

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[This is the first released version of the library GPL. It is numbered 2 because it goes with version 2 of the ordinary GPL.]

#### Preamble

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When we speak of free software, we are referring to freedom, not price. Our General Public Licenses are designed to make sure that you have the freedom to distribute copies of free software (and charge for this service if you wish), that you receive source code or can get it if you want it, that you can change the software or use pieces of it in new free programs; and that you know you can do these things.

To protect your rights, we need to make restrictions that forbid anyone to deny you these rights or to ask you to surrender the rights. These restrictions translate to certain responsibilities for you if you distribute copies of the library, or if you modify it.

For example, if you distribute copies of the library, whether gratis or for a fee, you must give the recipients all the rights that we gave you. You must make sure that they, too, receive or can get the source

code. If you link a program with the library, you must provide complete object files to the recipients so that they can relink them with the library, after making changes to the library and recompiling it. And you must show them these terms so they know their rights.

Our method of protecting your rights has two steps: (1) copyright the library, and (2) offer you this license which gives you legal permission to copy, distribute and/or modify the library.

Also, for each distributor's protection, we want to make certain that everyone understands that there is no warranty for this free library. If the library is modified by someone else and passed on, we want its recipients to know that what they have is not the original version, so that any problems introduced by others will not reflect on the original authors' reputations.

Finally, any free program is threatened constantly by software patents. We wish to avoid the danger that companies distributing free software will individually obtain patent licenses, thus in effect transforming the program into proprietary software. To prevent this, we have made it clear that any patent must be licensed for everyone's free use or not licensed at all.

Most GNU software, including some libraries, is covered by the ordinary GNU General Public License, which was designed for utility programs. This license, the GNU Library General Public License, applies to certain designated libraries. This license is quite different from the ordinary one; be sure to read it in full, and don't assume that anything in it is the same as in the ordinary license.

The reason we have a separate public license for some libraries is that they blur the distinction we usually make between modifying or adding to a program and simply using it. Linking a program with a library, without changing the library, is in some sense simply using the library, and is analogous to running a utility program or application program. However, in a textual and legal sense, the linked executable is a combined work, a derivative of the original library, and the ordinary General Public License treats it as such.

Because of this blurred distinction, using the ordinary General Public License for libraries did not effectively promote software sharing, because most developers did not use the libraries. We concluded that weaker conditions might promote sharing better.

However, unrestricted linking of non-free programs would deprive the

users of those programs of all benefit from the free status of the libraries themselves. This Library General Public License is intended to permit developers of non-free programs to use free libraries, while preserving your freedom as a user of such programs to change the free libraries that are incorporated in them. (We have not seen how to achieve this as regards changes in header files, but we have achieved it as regards changes in the actual functions of the Library.) The hope is that this will lead to faster development of free libraries.

The precise terms and conditions for copying, distribution and modification follow. Pay close attention to the difference between a "work based on the library" and a "work that uses the library". The former contains code derived from the library, while the latter only works together with the library.

Note that it is possible for a library to be covered by the ordinary General Public License rather than by this special one.

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You may charge a fee for the physical act of transferring a copy, and you may at your option offer warranty protection in exchange for a fee.

2. You may modify your copy or copies of the Library or any portion of it, thus forming a work based on the Library, and copy and distribute such modifications or work under the terms of Section 1 above, provided that you also meet all of these conditions:

a) The modified work must itself be a software library.

b) You must cause the files modified to carry prominent notices stating that you changed the files and the date of any change.

c) You must cause the whole of the work to be licensed at no charge to all third parties under the terms of this License.

d) If a facility in the modified Library refers to a function or a table of data to be supplied by an application program that uses the facility, other than as an argument passed when the facility is invoked, then you must make a good faith effort to ensure that, in the event an application does not supply such function or table, the facility still operates, and performs whatever part of its purpose remains meaningful.

(For example, a function in a library to compute square roots has a purpose that is entirely well-defined independent of the application. Therefore, Subsection 2d requires that any application-supplied function or table used by this function must

be optional: if the application does not supply it, the square

root function must still compute square roots.)

These requirements apply to the modified work as a whole. If identifiable sections of that work are not derived from the Library, and can be reasonably considered independent and separate works in themselves, then this License, and its terms, do not apply to those sections when you distribute them as separate works. But when you distribute the same sections as part of a whole which is a work based on the Library, the distribution of the whole must be on the terms of this License, whose permissions for other licensees extend to the entire whole, and thus to each and every part regardless of who wrote it.

Thus, it is not the intent of this section to claim rights or contest your rights to work written entirely by you; rather, the intent is to exercise the right to control the distribution of derivative or collective works based on the Library.

In addition,

mere aggregation of another work not based on the Library with the Library (or with a work based on the Library) on a volume of a storage or distribution medium does not bring the other work under the scope of this License.

3. You may opt to apply the terms of the ordinary GNU General Public License instead of this License to a given copy of the Library. To do this, you must alter all the notices that refer to this License, so that they refer to the ordinary GNU General Public License, version 2, instead of to this License. (If a newer version than version 2 of the ordinary GNU General Public License has appeared, then you can specify that version instead if you wish.) Do not make any other change in these notices.

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This option is useful when you wish to copy part of the code of the

Library into a program that is not a library.

4. You may copy and distribute the Library (or a portion or derivative of it, under Section 2) in object code or executable form under the terms of Sections 1 and 2 above provided that you accompany it with the complete corresponding machine-readable source code, which must be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange.

If distribution of object code is made by offering access to copy from a designated place, then offering equivalent access to copy the source code from the same place satisfies the requirement to distribute the source code, even though third parties are not compelled to copy the source along with the object code.

5. A program that contains no derivative of any portion of the Library, but is designed to work with the Library by being compiled or linked with it, is called a "work that uses the Library". Such a work, in isolation, is not a derivative work of the Library, and therefore falls outside the scope of this License.

However, linking a "work that uses the Library" with the Library creates an executable that is a derivative of the Library (because it contains portions of the Library), rather than a "work that uses the library". The executable is therefore covered by this License. Section 6 states terms for distribution of such executables.

When a "work that uses the Library" uses material from a header file that is part of the Library, the object code for the work may be a derivative work of the Library even though the source code is not. Whether this is true is especially significant if the work can be linked without the Library, or if the work is itself a library. The threshold for this to be true is not precisely defined by law.

If such an object file uses only numerical parameters, data structure layouts and accessors, and small macros and small inline functions (ten lines or less in length), then the use of the object file is unrestricted, regardless of whether it is legally a derivative work. (Executables containing this object code plus portions of the Library will still fall under Section 6.)

Otherwise, if the work is a derivative of the Library, you may distribute the object code for the work under the terms of Section 6. Any executables containing that work also fall under Section 6, whether or not they are linked directly with the Library itself.

6. As an exception to the Sections above, you may also compile or link a "work that uses the Library" with the Library to produce a work containing portions of the Library, and distribute that work under terms of your choice, provided that the terms permit modification of the work for the customer's own use and reverse engineering for debugging such modifications.

You must give prominent notice with each copy of the work that the Library is used in it and that the Library and its use are covered by

this License. You must supply a copy of this License. If the work during execution displays copyright notices, you must include the copyright notice for the Library among them, as well as a reference directing the user to the copy of this License. Also, you must do one of these things:

a) Accompany the work with the complete corresponding machine-readable source code for the Library including whatever changes were used in the work (which must be distributed under Sections 1 and 2 above); and, if the work is an executable linked with the Library, with the complete machine-readable "work that uses the Library", as object code and/or source code, so that the user can modify the Library and then relink to produce a modified executable containing the modified Library. (It is understood that the user who changes the contents of definitions files in the Library will not necessarily be able to recompile the application to use the modified definitions.)

b) Accompany the work with a written offer, valid for at least three years, to give the same user the materials specified in Subsection 6a, above, for a charge no more than the cost of performing this distribution.

c) If distribution of the work is made by offering access to copy from a designated place, offer equivalent access to copy the above specified materials from the same place.

d) Verify that the user has already received a copy of these materials or that you have already sent this user a copy.

For an executable, the required form of the "work that uses the Library" must include any data and utility programs needed for reproducing the executable from it. However, as a special exception, the source code distributed need not include anything that is normally distributed (in either source or binary form) with the major components (compiler, kernel, and so on) of the operating system on which the executable runs, unless that component itself accompanies the executable.

It may happen that this requirement contradicts the license restrictions of other proprietary libraries that do not normally accompany the operating system. Such a contradiction means you cannot use both them and the Library together in an executable that you distribute.

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```
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## 1.22 libdaemon 0.14

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That's all there is to it!

## 1.23 libnss-mdns 0.10

## 1.23.1 Available under license :

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Version 2.1, February 1999

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The End

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abstract: 'Build and install Perl modules'

author:

- 'Ken Williams <kwilliams@cpan.org>'

- "Development questions, bug reports, and patches should be sent to the\nModule-Build mailing list at <module-build@perl.org>."

build\_requires:

File::Temp: 0.15

Test::Harness: 3.16

Test::More: 0.49

generated\_by: 'Module::Build version 0.3608'

license: gpl

meta-spec:

url: <http://module-build.sourceforge.net/META-spec-v1.4.html>

version: 1.4

name: Module-Build

resources:

MailingList: <mailto:module-build@perl.org>

license: <http://dev.perl.org/licenses/>

repository: <http://github.com/dagolden/module-build/>

version: 3

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Julian Seward, jseward@bzip.org  
bzip2/libbzip2 version 1.0.6 of 6 September 2010

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```
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```

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Also add information on how to contact you by electronic and paper mail.

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```
Gnomovision version 69, Copyright (C) 19xx name of author
Gnomovision comes with ABSOLUTELY NO WARRANTY; for details type `show w'.
This is free software, and you are welcome to redistribute it
under certain conditions; type `show c' for details.
```

The hypothetical commands `show w' and `show c' should show the  
appropriate parts of the General Public License.

Of course, the  
commands you use may be called something other than `show w' and `show  
c'; they could even be mouse-clicks or menu items--whatever suits your  
program.

You should also get your employer (if you work as a programmer) or your  
school, if any, to sign a "copyright disclaimer" for the program, if  
necessary. Here a sample; alter the names:

```
Yoyodyne, Inc., hereby disclaims all copyright interest in the
program `Gnomovision' (a program to direct compilers to make passes
at assemblers) written by James Hacker.
```

```
<signature of Ty Coon>, 1 April 1989
Ty Coon, President of Vice
```

That's all there is to it!  
#!perl

=head1 NAME

copyright.t

=head1 DESCRIPTION

Tests that the latest copyright years in the top-level README file and the C<perl -v> output match each other.

If the test fails, update at least one of README and perl.c so that they match reality.

Optionally you can pass the C<--now> option to check they are at the current year. This isn't checked by default, so that it doesn't fail for people working on older releases. It should be run before making a new release.

=cut

```
use strict;
use Config;
BEGIN { require './test.pl' }

if ( $Config{usecrosscompile} ) {
    skip_all( "Not all files are available during cross-compilation" );
}

my ($opt) = @ARGV;

my $readme_year = readme_year();
my $v_year = v_year();

# Check that both copyright dates are up-to-date, but only if requested, so
# that tests still pass for people intentionally working on older versions:
if ($opt eq '--now')
{
    my $current_year = (gmtime)[5] + 1900;
    is $v_year, $current_year, 'perl -v copyright includes current
year';
    is $readme_year, $current_year, 'README copyright includes current year';
}

# Otherwise simply check that the two copyright dates match each other:
else
{
    is $readme_year, $v_year, 'README and perl -v copyright dates match';
}

done_testing;

sub readme_year
```

```

# returns the latest copyright year from the top-level README file
{

open my $readme, '<', './README' or die "Opening README failed: $!";

# The copyright message is the first paragraph:
local $/ = "";
my $copyright_msg = <$readme>;

my ($year) = $copyright_msg =~ /\.*\b(\d{4,})/s
    or die "Year not found in README copyright message '$copyright_msg'";

$year;
}

```

```

sub v_year
# returns the latest copyright year shown in perl -v
{

my $output = runperl switches => ['-v'];
my ($year) = $output =~ /copyright 1987.*\b(\d{4,})/i
    or die "Copyright statement not found in perl -v output '$output'";

$year;
}

```

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## 1.27 sqlite 3.8.7.4

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## 1.28 hostapd 2.5-devel

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/opt/cola/permits/1010755998\_1700034597.0719445/0/hostapd-2-5-devel-bin-zip/hostapd-2.5-devel/bin/eapol\_test.exe: binary file matches

/opt/cola/permits/1010755998\_1700034597.0719445/0/hostapd-2-5-devel-bin-zip/hostapd-2.5-devel/bin/hostapd\_cli.exe: binary file matches  
/opt/cola/permits/1010755998\_1700034597.0719445/0/hostapd-2-5-devel-bin-zip/hostapd-2.5-devel/bin/wpa\_cli.exe: binary file matches  
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Found in path(s):

\* /bin/grep

## 1.29 dnsmasq 2.73

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## 1.30 util-linux 2.25.2

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```
<one line to give the program's name and a brief idea of what it does.>  
Copyright (C) <year> <name of author>
```

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Also add information on how to contact you by electronic and paper mail.

If the program is interactive, make it output a short notice like this when it starts in an interactive mode:

```
Gnomovision version 69, Copyright (C) year name of author
Gnomovision comes with ABSOLUTELY NO WARRANTY; for details type `show w'.
This is free software, and you are welcome to redistribute it
under certain conditions; type `show c' for details.
```

The hypothetical commands `show w' and `show c' should show the appropriate parts of the General Public License. Of course, the commands you use may be called something other than `show w' and `show c'; they could even be mouse-clicks or menu items--whatever suits your program.

You should also get your employer (if you work as a programmer) or your school, if any, to sign a "copyright disclaimer" for the program, if necessary. Here is a sample; alter the names:

```
Yoyodyne, Inc., hereby disclaims all copyright interest in the program
`Gnomovision' (which makes passes at compilers) written by
James Hacker.
```

```
<signature of Ty Coon>, 1 April 1989
Ty Coon, President of Vice
```

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## 1.35 libjpeg 8b

### 1.35.1 Available under license :

No license file was found, but licenses were detected in source scan.

```
/*
 * jpegint.h
 *
 * Copyright (C) 1991-1997, Thomas G. Lane.
```

\* Modified 1997-2017 by Guido Vollbeding.  
\* This file is part of the Independent JPEG Group's software.  
\* For conditions of distribution and use, see the accompanying README file.  
\*  
\* This file provides common declarations for the various JPEG modules.  
\* These declarations are considered internal to the JPEG library; most  
\* applications using the library shouldn't need to include this file.  
\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jpegint.h

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/\*

\* jinclude.h

\*

\* Copyright (C) 1991-1994, Thomas G. Lane.

\* Modified 2017 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

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\*

\* This file exists to provide a single place to fix any problems with

\* including the wrong system include files. (Common problems are taken

\* care of by the standard jconfig symbols, but on really weird systems

\* you may have to edit this file.)

\*

\* NOTE: this file is NOT intended to be included by applications using the

\* JPEG library. Most applications need only include jpeglib.h.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jinclude.h

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/\*

\* jmemnobs.c

\*

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\*

\* This file provides a really simple implementation of the system-

\* dependent portion of the JPEG memory manager. This implementation

\* assumes that no backing-store files are needed: all required space

\* can be obtained from malloc().

\* This is very portable in the sense that it'll compile on almost anything,

\* but you'd better have lots of main memory (or virtual memory) if you want

\* to process big images.

\* Note that the max\_memory\_to\_use option is ignored by this implementation.

\*/

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\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jmemnobs.c

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/\*

\* wrbmp.c

\*

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\* Modified 2017 by Guido Vollbeding.

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\*

\* This file contains routines to write output images in Microsoft "BMP"

\* format (MS Windows 3.x and OS/2 1.x flavors).

\* Either 8-bit colormapped or 24-bit full-color format can be written.

\* No compression is supported.

\*

\* These routines may need modification for non-Unix environments or

\* specialized applications. As they stand, they assume output to

\* an ordinary stdio stream.

\*

\* This code contributed by James Arthur Boucher.

\*/

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\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/wrbmp.c

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/\*

\* jcmainct.c

\*

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\*

\* This file contains the main buffer controller for compression.

\* The main buffer lies between the pre-processor and the JPEG

\* compressor proper; it holds downsampled data in the JPEG colorspace.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jcmainct.c

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```
/*
 * rdtarga.c
 *
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 * Modified 2017 by Guido Vollbeding.
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 *
 * This file contains routines to read input images in Targa format.
 *
 * These routines may need modification for non-Unix environments or
 * specialized applications. As they stand, they assume input from
 * an ordinary stdio stream. They further assume that reading begins
 * at the start of the file; start_input may need work if the
 * user interface has already read some data (e.g., to determine that
 * the file is indeed Targa format).
 *
 * Based on code contributed by Lee Daniel Crocker.
 */
```

Found in path(s):

```
*/opt/cola/permits/1104792432_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/rdtarga.c
No license file was found, but licenses were detected in source scan.
```

```
/*
 * jdmarker.c
 *
 * Copyright (C) 1991-1998, Thomas G. Lane.
 * Modified 2009-2013 by Guido Vollbeding.
 * This file is part of the Independent JPEG Group's software.
 * For conditions of distribution and use, see the accompanying README file.
 *
 * This file contains routines to decode JPEG datastream markers.
 * Most of the complexity arises from our desire to support input
 * suspension: if not all of the data for a marker is available,
 * we must exit back to the application. On resumption, we reprocess
 * the marker.
 */
```

Found in path(s):

```
*/opt/cola/permits/1104792432_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jdmarker.c
No license file was found, but licenses were detected in source scan.
```

```
/*
 * jmemsys.h
 *
 * Copyright (C) 1992-1997, Thomas G. Lane.
 * This file is part of the Independent JPEG Group's software.
```



\* For conditions of distribution and use, see the accompanying README file.  
\*  
\* This include file defines the interface between the system-independent  
\* and system-dependent portions of the JPEG memory manager. No other  
\* modules need include it. (The system-independent portion is jmemmgr.c;  
\* there are several different versions of the system-dependent portion.)  
\*  
\* This file works as-is for the system-dependent memory managers supplied  
\* in the IJG distribution. You may need to modify it if you write a  
\* custom memory manager. If system-dependent changes are needed in  
\* this file, the best method is to #ifdef them based on a configuration  
\* symbol supplied in jconfig.h, as we have done with USE\_MSDOS\_MEMMGR  
\* and USE\_MAC\_MEMMGR.  
\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jmemsys.h

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/\*

\* cdjpeg.c

\*

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\*

\* This file contains common support routines used by the IJG application

\* programs (cjpeg, djpeg, jpegtran).

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/cdjpeg.c

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/\*

\* rdppm.c

\*

\* Copyright (C) 1991-1997, Thomas G. Lane.

\* Modified 2009-2017 by Bill Allombert, Guido Vollbeding.

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\*

\* This file contains routines to read input images in PPM/PGM format.

\* The extended 2-byte-per-sample raw PPM/PGM formats are supported.

\* The PBMPLUS library is NOT required to compile this software

\* (but it is highly useful as a set of PPM image manipulation programs).

\*

\* These routines may need modification for non-Unix environments or

\* specialized applications. As they stand, they assume input from  
\* an ordinary stdio stream. They further assume that reading begins  
\* at the start of the file; start\_input may need work if the  
\* user interface has already read some data (e.g., to determine that  
\* the file is indeed PPM format).

\*/

/\* Portions

of this code are based on the PBMPLUS library, which is:

\*\*

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\*\*

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\* jversion.h

\*

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\*

\* This file contains software version identification.

\*/

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/\*

\* jcdctmgr.c

\*

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\*

\* This file contains the forward-DCT management logic.

\* This code selects a particular DCT implementation to be used,

\* and it performs related housekeeping chores including coefficient

\* quantization.

\*/

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\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jcdctmgr.c

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/\*

\* jfdctfst.c

\*

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\*

\* This file contains a fast, not so accurate integer implementation of the

\* forward DCT (Discrete Cosine Transform).

\*

\* A 2-D DCT can be done by 1-D DCT on each row followed by 1-D DCT

\* on each column. Direct algorithms are also available, but they are

\* much more complex and seem not to be any faster when reduced to code.

\*

\* This implementation is based on Arai, Agui, and Nakajima's algorithm for

\* scaled DCT. Their original paper (Trans. IEICE E-71(11):1095) is in

\* Japanese, but the algorithm is described in the Pennebaker & Mitchell

\* JPEG textbook (see REFERENCES section in file README). The following code

\* is based directly on figure 4-8 in P&M.

\* While an 8-point DCT cannot be done in less than 11 multiplies, it is

\* possible to arrange the computation so that many of the multiplies are

\* simple scalings of the final outputs. These multiplies can then be

\* folded into the multiplications or divisions by the JPEG quantization

\* table entries. The AA&N method leaves only 5 multiplies and 29 adds

\* to be done in the DCT itself.

\* The primary disadvantage of this method is that with fixed-point math,

\* accuracy is lost due to imprecise representation of the scaled

\* quantization values. The smaller the quantization table entry, the less

\* precise the scaled value, so this implementation does worse with high-

\* quality-setting files than with low-quality ones.

\*/

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\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jfdctfst.c

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/\*

\* jutils.c

\*

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- \* Modified 2009-2011 by Guido Vollbeding.
- \* This file is part of the Independent JPEG Group's software.
- \* For conditions of distribution and use, see the accompanying README file.
- \*
- \* This file contains tables and miscellaneous utility routines needed
- \* for both compression and decompression.
- \* Note we prefix all global names with "j" to minimize conflicts with
- \* a surrounding application.
- \*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jutils.c  
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/\*

\* jdatasrc.c  
\*

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- \* Modified 2009-2015 by Guido Vollbeding.
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- \* For conditions of distribution and use, see the accompanying README file.
- \*
- \* This file contains decompression data source routines for the case of
- \* reading JPEG data from memory or from a file (or any stdio stream).
- \* While these routines are sufficient for most applications,
- \* some will want to use a different source manager.
- \* IMPORTANT: we assume that fread() will correctly transcribe an array of
- \* JOCTETs from 8-bit-wide elements on external storage. If char is wider
- \* than 8 bits on your machine, you may need to do some tweaking.
- \*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jdatasrc.c  
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/\*

\* jdhuft.c  
\*

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- \*
- \* This file contains Huffman entropy decoding routines.
- \* Both sequential and progressive modes are supported in this single module.
- \*
- \* Much of the complexity here has to do with supporting input suspension.
- \* If the data source module demands suspension, we want to be able to back

\* up to the start of the current MCU. To do this, we copy state variables  
\* into local working storage, and update them back to the permanent  
\* storage only upon successful completion of an MCU.  
\*/

Found in path(s):

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The Independent JPEG Group's JPEG software

=====

README for release 9c of 14-Jan-2018

=====

This distribution contains the ninth public release of the Independent JPEG Group's free JPEG software. You are welcome to redistribute this software and to use it for any purpose, subject to the conditions under LEGAL ISSUES, below.

This software is the work of Tom Lane, Guido Vollbeding, Philip Gladstone, Bill Allombert, Jim Boucher, Lee Crocker, Bob Friesenhahn, Ben Jackson, Julian Minguillon, Luis Ortiz, George Phillips, Davide Rossi, Ge' Weijers, and other members of the Independent JPEG Group.

IJG is not affiliated with the ISO/IEC JTC1/SC29/WG1 standards committee (previously known as JPEG, together with ITU-T SG16).

DOCUMENTATION ROADMAP

=====

This file contains the following sections:

OVERVIEW        General description of  
JPEG and the IJG software.  
LEGAL ISSUES    Copyright, lack of warranty, terms of distribution.  
REFERENCES     Where to learn more about JPEG.  
ARCHIVE LOCATIONS    Where to find newer versions of this software.  
ACKNOWLEDGMENTS    Special thanks.  
FILE FORMAT WARS    Software \*not\* to get.  
TO DO           Plans for future IJG releases.

Other documentation files in the distribution are:

User documentation:

install.txt    How to configure and install the IJG software.  
usage.txt     Usage instructions for cjpeg, djpeg, jpegtran,  
rdjpgcom, and wrjpgcom.

\*.1            Unix-style man pages for programs (same info as usage.txt).  
wizard.txt     Advanced usage instructions for JPEG wizards only.  
change.log     Version-to-version change highlights.

Programmer and internal documentation:

libjpeg.txt    How to use the JPEG library in your own programs.  
example.c      Sample code for calling the JPEG library.  
structure.txt  
Overview of the JPEG library's internal structure.  
filelist.txt    Road map of IJG files.  
coderules.txt   Coding style rules --- please read if you contribute code.

Please read at least the files install.txt and usage.txt. Some information can also be found in the JPEG FAQ (Frequently Asked Questions) article. See ARCHIVE LOCATIONS below to find out where to obtain the FAQ article.

If you want to understand how the JPEG code works, we suggest reading one or more of the REFERENCES, then looking at the documentation files (in roughly the order listed) before diving into the code.

## OVERVIEW

=====

This package contains C software to implement JPEG image encoding, decoding, and transcoding. JPEG (pronounced "jay-peg") is a standardized compression method for full-color and grayscale images.

This software implements JPEG baseline, extended-sequential, and progressive compression processes. Provision is made for supporting all variants of these processes, although some uncommon parameter settings aren't implemented yet.

We have made no provision for supporting the hierarchical or lossless processes defined in the standard.

We provide a set of library routines for reading and writing JPEG image files, plus two sample applications "cjpeg" and "djpeg", which use the library to perform conversion between JPEG and some other popular image file formats. The library is intended to be reused in other applications.

In order to support file conversion and viewing software, we have included considerable functionality beyond the bare JPEG coding/decoding capability; for example, the color quantization modules are not strictly part of JPEG decoding, but they are essential for output to colormapped file formats or colormapped displays. These extra functions can be compiled out of the library if not required for a particular application.

We have also included "jpegtran", a utility for lossless transcoding between different JPEG processes, and "rdjpgcom" and "wrjpgcom",

two simple applications for inserting and extracting textual comments in JFIF files.

The emphasis in designing this software has been on achieving portability and flexibility, while also making it fast enough to be useful. In particular, the software is not intended to be read as a tutorial on JPEG. (See the REFERENCES section for introductory material.) Rather, it is intended to be reliable, portable, industrial-strength code. We do not claim to have achieved that goal in every aspect of the software, but we strive for it.

We welcome the use of this software as a component of commercial products. No royalty is required, but we do ask for an acknowledgement in product documentation, as described under LEGAL ISSUES.

## LEGAL ISSUES

=====

In plain English:

1. We don't promise that this software works. (But if you find any bugs, please let us know!)
2. You can use this software for whatever you want. You don't have to pay us.
3. You may not pretend that you wrote this software. If you use it in a program, you must acknowledge somewhere in your documentation that you've used the IJG code.

In legalese:

The authors make NO WARRANTY or representation, either express or implied, with respect to this software, its quality, accuracy, merchantability, or fitness for a particular purpose. This software is provided "AS IS", and you, its user, assume the entire risk as to its quality and accuracy.

This software is copyright (C) 1991-2018, Thomas G. Lane, Guido Vollbeding. All Rights Reserved except as specified below.

Permission is hereby granted to use, copy, modify, and distribute this software (or portions thereof) for any purpose, without fee, subject to these conditions:

(1) If any part of the source code for this software is distributed, then this README file must be included, with this copyright and no-warranty notice unaltered; and any additions, deletions, or changes to the original files must be clearly indicated in accompanying documentation.

(2)

If only executable code is distributed, then the accompanying documentation must state that "this software is based in part on the work of

the Independent JPEG Group".

(3) Permission for use of this software is granted only if the user accepts full responsibility for any undesirable consequences; the authors accept NO LIABILITY for damages of any kind.

These conditions apply to any software derived from or based on the IJG code, not just to the unmodified library. If you use our work, you ought to acknowledge us.

Permission is NOT granted for the use of any IJG author's name or company name in advertising or publicity relating to this software or products derived from it. This software may be referred to only as "the Independent JPEG Group's software".

We specifically permit and encourage the use of this software as the basis of commercial products, provided that all warranty or liability claims are assumed by the product vendor.

The Unix configuration script "configure" was produced with GNU Autoconf.

It is copyright by the Free Software Foundation but is freely distributable.

The same holds for its supporting scripts (config.guess, config.sub, ltmain.sh). Another support script, install-sh, is copyright by X Consortium but is also freely distributable.

The IJG distribution formerly included code to read and write GIF files. To avoid entanglement with the Unisys LZW patent (now expired), GIF reading support has been removed altogether, and the GIF writer has been simplified to produce "uncompressed GIFs". This technique does not use the LZW algorithm; the resulting GIF files are larger than usual, but are readable by all standard GIF decoders.

## REFERENCES

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We recommend reading one or more of these references before trying to understand the innards of the JPEG software.

The best short technical introduction to the JPEG compression algorithm is Wallace, Gregory K. "The JPEG Still Picture Compression Standard", Communications of the ACM, April 1991 (vol. 34 no. 4), pp. 30-44.

(Adjacent articles in that issue discuss MPEG motion picture compression, applications of JPEG, and related topics.) If you don't have the CACM issue handy, a PDF file containing a revised version of Wallace's article is available at <http://www.ijg.org/files/Wallace.JPEG.pdf>. The file (actually



a preprint for an article that appeared in IEEE Trans. Consumer Electronics) omits the sample images that appeared in CACM, but it includes corrections and some added material. Note: the Wallace article is copyright ACM and IEEE, and it may not be used for commercial purposes.

A somewhat less technical, more leisurely introduction to JPEG can be found in "The Data Compression Book" by Mark Nelson and Jean-loup Gailly, published by M&T Books (New York), 2nd ed. 1996, ISBN 1-55851-434-1. This book provides good explanations and example C code for a multitude of compression methods including JPEG. It is an excellent source if you are comfortable reading C code but don't know much about data compression in general. The book's JPEG sample code is far from industrial-strength, but when you are ready to look at a full implementation, you've got one here...

The best currently available description of JPEG is the textbook "JPEG Still Image Data Compression Standard" by William B. Pennebaker and Joan L. Mitchell, published by Van Nostrand Reinhold, 1993, ISBN 0-442-01272-1. Price US\$59.95, 638 pp. The book includes the complete text of the ISO JPEG standards (DIS 10918-1 and draft DIS 10918-2).

Although this is by far the most detailed and comprehensive exposition of JPEG publicly available, we point out that it is still missing an explanation of the most essential properties and algorithms of the underlying DCT technology.

If you think that you know about DCT-based JPEG after reading this book, then you are in delusion. The real fundamentals and corresponding potential of DCT-based JPEG are not publicly known so far, and that is the reason for all the mistaken developments taking place in the image coding domain.

The original JPEG standard is divided into two parts, Part 1 being the actual specification, while Part 2 covers compliance testing methods. Part 1 is titled "Digital Compression and Coding of Continuous-tone Still Images, Part 1: Requirements and guidelines" and has document numbers ISO/IEC IS 10918-1, ITU-T T.81. Part 2 is titled "Digital Compression and Coding of Continuous-tone Still Images, Part 2: Compliance testing" and has document numbers ISO/IEC IS 10918-2, ITU-T T.83.

IJG JPEG 8 introduced an implementation of the JPEG SmartScale extension which is specified in two documents: A contributed document at ITU and ISO with title "ITU-T JPEG-Plus Proposal for Extending ITU-T T.81 for Advanced Image Coding", April 2006, Geneva, Switzerland. The latest version of this document is Revision 3. And a contributed document ISO/IEC JTC1/SC29/WG1 N 5799 with title "Evolution of JPEG", June/July 2011, Berlin, Germany.

IJG JPEG 9 introduces a reversible color transform for improved lossless compression which is described in a contributed document ISO/IEC JTC1/SC29/WG1 N 6080 with title "JPEG 9 Lossless Coding", June/July 2012, Paris, France.

The JPEG standard does not specify all details of an interchangeable file format. For the omitted details we follow the "JFIF" conventions, version 2. JFIF version 1 has been adopted as Recommendation ITU-T T.871 (05/2011) : Information technology - Digital compression and coding of continuous-tone still images: JPEG File Interchange Format (JFIF). It is available as a free download in PDF file format from <http://www.itu.int/rec/T-REC-T.871>. A PDF file of the older JFIF document is available at <http://www.w3.org/Graphics/JPEG/jfif3.pdf>.

The TIFF 6.0 file format specification can be obtained by FTP from <ftp://ftp.sgi.com/graphics/tiff/TIFF6.ps.gz>. The JPEG incorporation scheme found in the TIFF 6.0 spec of 3-June-92 has a number of serious problems. IJG does not recommend use of the TIFF 6.0 design (TIFF Compression tag 6). Instead, we recommend the JPEG design proposed by TIFF Technical Note #2 (Compression tag 7). Copies of this Note can be obtained from <http://www.ijg.org/files/>. It is expected that the next revision of the TIFF spec will replace the 6.0 JPEG design with the Note's design. Although IJG's own code does not support TIFF/JPEG, the free libtiff library uses our library to implement TIFF/JPEG per the Note.

#### ARCHIVE LOCATIONS

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The "official" archive site for this software is [www.ijg.org](http://www.ijg.org). The most recent released version can always be found there in directory "files". This particular version will be archived as <http://www.ijg.org/files/jpegsrc.v9c.tar.gz>, and in Windows-compatible "zip" archive format as <http://www.ijg.org/files/jpegsr9c.zip>.

The JPEG FAQ (Frequently Asked Questions) article is a source of some general information about JPEG. It is available on the World Wide Web at <http://www.faqs.org/faqs/jpeg-faq/> and other news.answers archive sites, including the official news.answers archive at [rtfm.mit.edu: ftp://rtfm.mit.edu/pub/usenet/news.answers/jpeg-faq/](ftp://rtfm.mit.edu/pub/usenet/news.answers/jpeg-faq/). If you don't have Web or FTP access, send e-mail to [mail-server@rtfm.mit.edu](mailto:mail-server@rtfm.mit.edu) with body  
send usenet/news.answers/jpeg-faq/part1  
send usenet/news.answers/jpeg-faq/part2

#### ACKNOWLEDGMENTS

=====

Thank to Juergen Bruder for providing me with a copy of the common DCT

algorithm article, only to find out that I had come to the same result in a more direct and comprehensible way with a more generative approach.

Thank to Istvan Sebestyen and Joan L. Mitchell for inviting me to the ITU JPEG (Study Group 16) meeting in Geneva, Switzerland.

Thank to Thomas Wiegand and Gary Sullivan for inviting me to the Joint Video Team (MPEG & ITU) meeting in Geneva, Switzerland.

Thank to Thomas Richter and Daniel Lee for inviting me to the ISO/IEC JTC1/SC29/WG1 (previously known as JPEG, together with ITU-T SG16) meeting in Berlin, Germany.

Thank to John Korejwa and Massimo Ballerini for inviting me to fruitful consultations in Boston, MA and Milan, Italy.

Thank to Hendrik Elstner, Roland Fassauer, Simone Zuck, Guenther Maier-Gerber, Walter Stoeber, Fred Schmitz, and Norbert Braunagel for corresponding business development.

Thank to Nico Zschach and Dirk Stelling of the technical support team at the Digital Images company in Halle for providing me with extra equipment for configuration tests.

Thank to Richard F. Lyon (then of Foveon Inc.) for fruitful communication about JPEG configuration in Sigma Photo Pro software.

Thank to Andrew Finkenstadt for hosting the [ijg.org](http://ijg.org) site.

Thank to Thomas G. Lane for the original design and development of this singular software package.

Thank to Lars Goehler, Andreas Heinecke, Sebastian Fuss, Yvonne Roebert, Andrej Werner, and Ulf-Dietrich Braumann for support and public relations.

#### FILE FORMAT WARS

=====

The ISO/IEC JTC1/SC29/WG1 standards committee (previously known as JPEG, together with ITU-T SG16) currently promotes different formats containing the name "JPEG" which is misleading because these formats are incompatible with original DCT-based JPEG and are based on faulty technologies. IJG therefore does not and will not support such momentary mistakes (see REFERENCES).

There exist also distributions under the name "OpenJPEG" promoting such

kind of formats which is misleading because they don't support original JPEG images.

We have no sympathy for the promotion of inferior formats. Indeed, one of the original reasons for developing this free software was to help force convergence on common, interoperable format standards for JPEG files. Don't use an incompatible file format!

(In any case, our decoder will remain capable of reading existing JPEG image files indefinitely.)

The ISO committee pretends to be "responsible for the popular JPEG" in their public reports which is not true because they don't respond to actual requirements for the maintenance of the original JPEG specification.

Furthermore, the ISO committee pretends to "ensure interoperability" with their standards which is not true because their "standards" support only application-specific and proprietary use cases and contain mathematically incorrect code.

There are currently different distributions in circulation containing the name "libjpeg" which is misleading because they don't have the features and are incompatible with formats supported by actual IJG libjpeg distributions. One of those fakes is released by members of the ISO committee and just uses the name of libjpeg for misdirection of people, similar to the abuse of the name JPEG as described above, while having nothing in common with actual IJG libjpeg distributions and containing mathematically incorrect code.

The other one claims to be a "derivative" or "fork" of the original libjpeg, but violates the license conditions as described under LEGAL ISSUES above and violates basic C programming properties.

We have no sympathy for the release of misleading, incorrect and illegal distributions derived from obsolete code bases. Don't use an obsolete code base!

According to the UCC (Uniform Commercial Code) law, IJG has the lawful and legal right to foreclose on certain standardization bodies and other institutions or corporations that knowingly perform substantial and systematic deceptive acts and practices, fraud, theft, and damaging of the value of the people of this planet without their knowing, willing and intentional consent.

The titles, ownership, and rights of these institutions and all their assets are now duly secured and held in trust for the free people of this planet. People of the planet, on every country, may have a financial interest in the assets of these former principals, agents, and beneficiaries of the foreclosed institutions and corporations.

IJG asserts what is: that each man, woman, and child has unalienable value and rights granted

and deposited in them by the Creator and not any one of the people is subordinate to any artificial principality, corporate fiction

or the special interest of another without their appropriate knowing,  
willing and intentional consent made by contract or accommodation agreement.  
IJG expresses that which already was.  
The people have already determined and demanded that public administration  
entities, national governments, and their supporting judicial systems must  
be fully transparent, accountable, and liable.  
IJG has secured the value for all concerned free people of the planet.

A partial list of foreclosed institutions and corporations ("Hall of Shame")  
is currently prepared and will be published later.

TO DO

=====

Version 9 is the second release of a new generation JPEG standard  
to overcome the limitations of the original JPEG specification,  
and is the first true source reference JPEG codec.  
More features are being prepared for coming releases...

Please send bug reports, offers of  
help, etc. to [jpeg-info@jpegclub.org](mailto:jpeg-info@jpegclub.org).

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/README

No license file was found, but licenses were detected in source scan.

/\*

\* jdapimin.c

\*

\* Copyright (C) 1994-1998, Thomas G. Lane.

\* Modified 2009-2013 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains application interface code for the decompression half  
\* of the JPEG library. These are the "minimum" API routines that may be  
\* needed in either the normal full-decompression case or the  
\* transcoding-only case.

\*

\* Most of the routines intended to be called directly by an application

\* are in this file or in `jdapistd.c`. But also see `jcomapi.c` for routines

\* shared by compression and decompression, and `jdtrans.c` for the transcoding

\* case.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jdapimin.c

No license file was found, but licenses were detected in source scan.

```
/*
 * jdpostct.c
 *
 * Copyright (C) 1994-1996, Thomas G. Lane.
 * This file is part of the Independent JPEG Group's software.
 * For conditions of distribution and use, see the accompanying README file.
 *
 * This file contains the decompression postprocessing controller.
 * This controller manages the upsampling, color conversion, and color
 * quantization/reduction steps; specifically, it controls the buffering
 * between upsample/color conversion and color quantization/reduction.
 *
 * If no color quantization/reduction is required, then this module has no
 * work to do, and it just hands off to the upsample/color conversion code.
 * An integrated upsample/convert/quantize process would replace this module
 * entirely.
 */
```

Found in path(s):

```
*/opt/cola/permits/1104792432_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jdpostct.c
```

No license file was found, but licenses were detected in source scan.

```
/*
 * wrtle.c
 *
 * Copyright (C) 1991-1996, Thomas G. Lane.
 * Modified 2017 by Guido Vollbeding.
 * This file is part of the Independent JPEG Group's software.
 * For conditions of distribution and use, see the accompanying README file.
 *
 * This file contains routines to write output images in RLE format.
 * The Utah Raster Toolkit library is required (version 3.1 or later).
 *
 * These routines may need modification for non-Unix environments or
 * specialized applications. As they stand, they assume output to
 * an ordinary stdio stream.
 *
 * Based on code contributed by Mike Lijewski,
 * with updates from Robert Hutchinson.
 */
```

Found in path(s):

```
*/opt/cola/permits/1104792432_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/wrtle.c
```

No license file was found, but licenses were detected in source scan.

```
/*
```

```
* jerror.c
*
* Copyright (C) 1991-1998, Thomas G. Lane.
* Modified 2012-2015 by Guido Vollbeding.
* This file is part of the Independent JPEG Group's software.
* For conditions of distribution and use, see the accompanying README file.
*
* This file contains simple error-reporting and trace-message routines.
* These are suitable for Unix-like systems and others where writing to
* stderr is the right thing to do. Many applications will want to replace
* some or all of these routines.
*
* If you define USE_WINDOWS_MESSAGEBOX in jconfig.h or in the makefile,
* you get a Windows-specific hack to display error messages in a dialog box.
* It ain't much, but it beats dropping error messages into the bit bucket,
* which is what happens to output to stderr under most Windows C compilers.
*
* These routines are used by both the compression and decompression code.
*/
```

Found in path(s):

```
*/opt/cola/permits/1104792432_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jerror.c
```

No license file was found, but licenses were detected in source scan.

```
/*
* rdcolmap.c
*
* Copyright (C) 1994-1996, Thomas G. Lane.
* This file is part of the Independent JPEG Group's software.
* For conditions of distribution and use, see the accompanying README file.
*
* This file implements djpeg's "-map file" switch. It reads a source image
* and constructs a colormap to be supplied to the JPEG decompressor.
*
* Currently, these file formats are supported for the map file:
* GIF: the contents of the GIF's global colormap are used.
* PPM (either text or raw flavor): the entire file is read and
* each unique pixel value is entered in the map.
* Note that reading a large PPM file will be horrendously slow.
* Typically, a PPM-format map file should contain just one pixel
* of each desired color. Such a file can be extracted from an
* ordinary image PPM file with ppmtomap(1).
*
* Rescaling a PPM that has a maxval unequal to MAXJSAMPLE is not
* currently implemented.
*/
/* Portions of this code are based on the PBMPLUS library, which is:
**
```

\*\* Copyright (C) 1988 by Jef Poskanzer.  
\*\*  
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\*\* documentation for any purpose and without fee is hereby granted, provided  
\*\* that the above copyright notice appear in all copies and that both that  
\*\* copyright notice and this permission notice appear in supporting  
\*\* documentation. This software is provided "as is" without express or  
\*\* implied warranty.  
\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/rdcolmap.c  
No license file was found, but licenses were detected in source scan.

/\*

\* jcapimin.c

\*

\* Copyright (C) 1994-1998, Thomas G. Lane.  
\* Modified 2003-2010 by Guido Vollbeding.  
\* This file is part of the Independent JPEG Group's software.  
\* For conditions of distribution and use, see the accompanying README file.  
\*  
\* This file contains application interface code for the compression half  
\* of the JPEG library. These are the "minimum" API routines that may be  
\* needed in either the normal full-compression case or the transcoding-only  
\* case.  
\*  
\* Most of the routines intended to be called directly by an application  
\* are in this file or in jcapistd.c. But also see jcparam.c for  
\* parameter-setup helper routines, jcomapi.c for routines shared by  
\* compression and decompression, and jctrans.c for the transcoding case.  
\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jcapimin.c  
No license file was found, but licenses were detected in source scan.

/\*

\* wrjpgcom.c

\*

\* Copyright (C) 1994-1997, Thomas G. Lane.  
\* Modified 2015-2017 by Guido Vollbeding.  
\* This file is part of the Independent JPEG Group's software.  
\* For conditions of distribution and use, see the accompanying README file.  
\*  
\* This file contains a very simple stand-alone application that inserts  
\* user-supplied text as a COM (comment) marker in a JFIF file.  
\* This may be useful as an example of the minimum logic needed to parse



\* JPEG markers.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/wrjpgcom.c

No license file was found, but licenses were detected in source scan.

/\*

\* jcrepct.c

\*

\* Copyright (C) 1994-1996, Thomas G. Lane.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains the compression preprocessing controller.

\* This controller manages the color conversion, downsampling,

\* and edge expansion steps.

\*

\* Most of the complexity here is associated with buffering input rows

\* as required by the downsampler. See the comments at the head of

\* jcsample.c for the downsampler's needs.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jcrepct.c

No license file was found, but licenses were detected in source scan.

/\*

\* transupp.h

\*

\* Copyright (C) 1997-2013, Thomas G. Lane, Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains declarations for image transformation routines and

\* other utility code used by the jpegtran sample application. These are

\* NOT part of the core JPEG library. But we keep these routines separate

\* from jpegtran.c to ease the task of maintaining jpegtran-like programs

\* that have other user interfaces.

\*

\* NOTE: all the routines declared here have very specific requirements

\* about when they are to be executed during the reading and writing of the

\* source and destination files. See the comments in transupp.c, or see

\* jpegtran.c for an example of correct usage.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/transupp.h

No license file was found, but licenses were detected in source scan.

```
/*
 * jmemmgr.c
 *
 * Copyright (C) 1991-1997, Thomas G. Lane.
 * Modified 2011-2012 by Guido Vollbeding.
 * This file is part of the Independent JPEG Group's software.
 * For conditions of distribution and use, see the accompanying README file.
 *
 * This file contains the JPEG system-independent memory management
 * routines. This code is usable across a wide variety of machines; most
 * of the system dependencies have been isolated in a separate file.
 * The major functions provided here are:
 *   * pool-based allocation and freeing of memory;
 *   * policy decisions about how to divide available memory among the
 *     virtual arrays;
 *   * control logic for swapping virtual arrays between main memory and
 *     backing storage.
 * The separate system-dependent file provides the actual backing-storage
 * access code, and it contains the policy decision about how much total
 * main memory to use.
 * This file is
 * system-dependent in the sense that some of its functions
 * are unnecessary in some systems. For example, if there is enough virtual
 * memory so that backing storage will never be used, much of the virtual
 * array control logic could be removed. (Of course, if you have that much
 * memory then you shouldn't care about a little bit of unused code...)
 */
```

Found in path(s):

```
* /opt/cola/permits/1104792432_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jmemmgr.c
```

No license file was found, but licenses were detected in source scan.

; For conditions of distribution and use, see the accompanying README file.

Found in path(s):

```
* /opt/cola/permits/1104792432_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jmemdosa.asm
```

No license file was found, but licenses were detected in source scan.

```
/*
 * jfdctflt.c
 *
 * Copyright (C) 1994-1996, Thomas G. Lane.
 * Modified 2003-2017 by Guido Vollbeding.
 * This file is part of the Independent JPEG Group's software.
 * For conditions of distribution and use, see the accompanying README file.
 *
```

```

* This file contains a floating-point implementation of the
* forward DCT (Discrete Cosine Transform).
*
* This implementation should be more accurate than either of the integer
* DCT implementations. However, it may not give the same results on all
* machines because of differences in roundoff behavior. Speed will depend
* on the hardware's floating point capacity.
*
* A 2-D DCT can be done by 1-D DCT on each row followed by 1-D DCT
* on each column. Direct algorithms are also available, but they are
* much more complex and seem not to be any faster when reduced to code.
*
* This implementation is based on Arai, Agui, and Nakajima's algorithm for
* scaled
DCT. Their original paper (Trans. IEICE E-71(11):1095) is in
* Japanese, but the algorithm is described in the Pennebaker & Mitchell
* JPEG textbook (see REFERENCES section in file README). The following code
* is based directly on figure 4-8 in P&M.
* While an 8-point DCT cannot be done in less than 11 multiplies, it is
* possible to arrange the computation so that many of the multiplies are
* simple scalings of the final outputs. These multiplies can then be
* folded into the multiplications or divisions by the JPEG quantization
* table entries. The AA&N method leaves only 5 multiplies and 29 adds
* to be done in the DCT itself.
* The primary disadvantage of this method is that with a fixed-point
* implementation, accuracy is lost due to imprecise representation of the
* scaled quantization values. However, that problem does not arise if
* we use floating point arithmetic.
*/

```

Found in path(s):

```

* /opt/cola/permits/1104792432_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jfdctflt.c
No license file was found, but licenses were detected in source scan.

```

```

/*
* rdgif.c
*
* Copyright (C) 1991-1997, Thomas G. Lane.
* This file is part of the Independent JPEG Group's software.
* For conditions of distribution and use, see the accompanying README file.
*
* This file contains routines to read input images in GIF format.
*
*****
* NOTE: to avoid entanglements with Unisys' patent on LZW compression, *
* the ability to read GIF files has been removed from the IJG distribution. *
* Sorry about that. *
*****

```

\*  
\* We are required to state that  
\* "The Graphics Interchange Format(c) is the Copyright property of  
\* CompuServe Incorporated. GIF(sm) is a Service Mark property of  
\* CompuServe Incorporated."  
\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/rdgif.c

No license file was found, but licenses were detected in source scan.

/\*

\* jdmerge.c

\*

\* Copyright (C) 1994-1996, Thomas G. Lane.

\* Modified 2013-2017 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains code for merged upsampling/color conversion.

\*

\* This file combines functions from jdsample.c and jdcolor.c;

\* read those files first to understand what's going on.

\*

\* When the chroma components are to be upsampled by simple replication

\* (ie, box filtering), we can save some work in color conversion by

\* calculating all the output pixels corresponding to a pair of chroma

\* samples at one time. In the conversion equations

\*  $R = Y + K1 * Cr$

\*  $G = Y + K2 * Cb + K3 * Cr$

\*  $B = Y + K4 * Cb$

\* only the Y term varies among the group of pixels corresponding to a pair

\* of chroma samples, so the rest of the terms can be calculated just

once.

\* At typical sampling ratios, this eliminates half or three-quarters of the

\* multiplications needed for color conversion.

\*

\* This file currently provides implementations for the following cases:

\* YCC => RGB color conversion only (YCbCr or BG\_YCC).

\* Sampling ratios of 2h1v or 2h2v.

\* No scaling needed at upsample time.

\* Corner-aligned (non-CCIR601) sampling alignment.

\* Other special cases could be added, but in most applications these are

\* the only common cases. (For uncommon cases we fall back on the more

\* general code in jdsample.c and jdcolor.c.)

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jdmerge.c

No license file was found, but licenses were detected in source scan.

/\*

\* jmemansi.c

\*

\* Copyright (C) 1992-1996, Thomas G. Lane.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file provides a simple generic implementation of the system-

\* dependent portion of the JPEG memory manager. This implementation

\* assumes that you have the ANSI-standard library routine tmpfile().

\* Also, the problem of determining the amount of memory available

\* is shoved onto the user.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jmemansi.c

No license file was found, but licenses were detected in source scan.

#### IJG JPEG LIBRARY: FILE LIST

Copyright (C) 1994-2017, Thomas G. Lane, Guido Vollbeding.

This file is part of the Independent JPEG Group's software.

For conditions of distribution and use, see the accompanying README file.

Here is a road map to the files in the IJG JPEG distribution. The distribution includes the JPEG library proper, plus two application programs ("cjpeg" and "djpeg") which use the library to convert JPEG files to and from some other popular image formats. A third application "jpegtran" uses the library to do lossless conversion between different variants of JPEG. There are also two stand-alone applications, "rdjpgcom" and "wrjpgcom".

#### THE JPEG LIBRARY

=====

Include files:

jpeglib.h JPEG library's exported data and function declarations.

jconfig.h Configuration declarations. Note: this file is not present in the distribution; it is generated during installation.

jmorecfg.h Additional

configuration declarations; need not be changed

for a standard installation.

jerror.h Declares JPEG library's error and trace message codes.  
jinclude.h Central include file used by all IJG .c files to reference system include files.  
jpegint.h JPEG library's internal data structures.  
jdct.h Private declarations for forward & reverse DCT subsystems.  
jmemsys.h Private declarations for memory management subsystem.  
jversion.h Version information.

Applications using the library should include jpeglib.h (which in turn includes jconfig.h and jmorecfg.h). Optionally, jerror.h may be included if the application needs to reference individual JPEG error codes. The other include files are intended for internal use and would not normally be included by an application program. (cjpeg/djpeg/etc do use jinclude.h, since its function is to improve portability of the whole IJG distribution. Most other applications will directly include the system include files they want, and hence won't need jinclude.h.)

C source code files:

These files contain most of the functions intended to be called directly by an application program:

jcapi.c Application program interface: core routines for compression.  
jcapistd.c Application program interface: standard compression.  
jdapimin.c Application program interface: core routines for decompression.  
jdapistd.c Application program interface: standard decompression.  
jcomapi.c Application program interface routines common to compression and decompression.  
jcparam.c Compression parameter setting helper routines.  
jctrans.c API and library routines for transcoding compression.  
jdtrans.c API and library routines for transcoding decompression.

Compression side of the library:

jcinit.c Initialization: determines which other modules to use.  
jcmaster.c Master control: setup and inter-pass sequencing logic.  
jcmainct.c Main buffer controller (preprocessor => JPEG compressor).  
jcprepct.c Preprocessor buffer controller.  
jccoefct.c Buffer controller for DCT coefficient buffer.  
jccolor.c Color space conversion.  
jcsample.c Downsampling.  
jcdctmgr.c DCT manager (DCT implementation selection & control).  
jfdctint.c Forward DCT using slow-but-accurate integer method.  
jfdctfst.c Forward DCT using faster, less accurate integer method.  
jfdctflt.c Forward DCT using floating-point arithmetic.

jchuff.c Huffman entropy coding.  
jcarith.c Arithmetic entropy coding.  
jcmarker.c JPEG marker writing.  
jdatadst.c Data destination managers for memory and stdio output.

Decompression side of the library:

jdmaster.c Master control: determines which other modules to use.  
jdinput.c Input controller: controls input processing modules.  
jdmainct.c Main buffer controller (JPEG decompressor => postprocessor).  
jdcoeft.c Buffer controller for DCT coefficient buffer.  
jdpostct.c Postprocessor buffer controller.  
jdmarker.c JPEG marker reading.  
jd Huff.c Huffman entropy decoding.  
jdarith.c Arithmetic entropy decoding.  
jddctmgr.c IDCT manager (IDCT implementation selection & control).  
jidctint.c Inverse DCT using slow-but-accurate integer method.  
jidctfst.c Inverse DCT using faster, less accurate integer method.  
jidctflt.c Inverse DCT using floating-point arithmetic.  
jdsample.c Upsampling.  
jdcolor.c Color space conversion.  
jdmerge.c Merged upsampling/color conversion (faster, lower quality).  
jqant1.c One-pass color quantization using a fixed-spacing colormap.  
jqant2.c Two-pass color quantization using a custom-generated colormap.  
Also handles one-pass quantization to an externally given map.  
jdatasrc.c Data source managers for memory and stdio input.

Support files for both compression and decompression:

jaricom.c Tables for common use in arithmetic entropy encoding and decoding routines.  
jerror.c Standard error handling routines (application replaceable).  
jmemmgr.c System-independent (more or less) memory management code.  
jutils.c Miscellaneous utility routines.

jmemmgr.c relies on a system-dependent memory management module. The IJG distribution includes the following implementations of the system-dependent module:

jmemnobs.c "No backing store": assumes adequate virtual memory exists.  
jmemansi.c Makes temporary files with ANSI-standard routine tmpfile().  
jmemname.c Makes temporary files with program-generated file names.  
jmemdos.c Custom implementation for MS-DOS (16-bit environment only): can use extended and expanded memory as well as temp files.  
jmemmac.c Custom implementation for Apple Macintosh.

Exactly one of the system-dependent modules should be configured into an installed JPEG library (see install.txt for hints about which one to use).  
On unusual systems you may find it worthwhile to make a special system-dependent memory manager.

Non-C source code files:

jmemdosa.asm 80x86 assembly code support for jmemdos.c; used only in MS-DOS-specific configurations of the JPEG library.

## CJPEG/DJPEG/JPEGTRAN

=====

Include files:

cdjpeg.h Declarations shared by cjpeg/djpeg/jpegtran modules.  
cderror.h Additional error and trace message codes for cjpeg et al.  
transupp.h Declarations for jpegtran support routines in transupp.c.

C source code files:

cjpeg.c Main program for cjpeg.  
djpeg.c Main program for djpeg.  
jpegtran.c Main program for jpegtran.  
cdjpeg.c Utility routines used by all three programs.  
rdcolmap.c Code to read a colormap file for djpeg's "-map" switch.  
rdswitch.c Code to process some of cjpeg's more complex switches.  
Also used by jpegtran.  
transupp.c Support code for jpegtran: lossless image manipulations.

Image file reader modules for cjpeg:

rdbmp.c BMP file input.  
rdgif.c GIF file input (now just a stub).  
rdppm.c PPM/PGM file input.  
rdrlc.c Utah RLE file input.  
rdtarga.c Targa file input.

Image file writer modules for djpeg:

wrbmp.c BMP file output.  
wrgif.c GIF file output (a mere shadow of its former self).  
wrppm.c PPM/PGM file output.  
wrrlc.c Utah RLE file output.  
wrtarga.c Targa file output.



## RDJPGCOM/WRJPGCOM

=====

C source

code files:

rdjpgcom.c Stand-alone rdjpgcom application.

wrjpgcom.c Stand-alone wrjpgcom application.

These programs do not depend on the IJG library. They do use jconfig.h and jinclude.h, only to improve portability.

## ADDITIONAL FILES

=====

Documentation (see README for a guide to the documentation files):

README Master documentation file.

\*.txt Other documentation files.

\*.1 Documentation in Unix man page format.

change.log Version-to-version change highlights.

example.c Sample code for calling JPEG library.

Configuration/installation files and programs (see install.txt for more info):

configure Unix shell script to perform automatic configuration.

configure.ac Source file for use with Autoconf to generate configure.

ltmain.sh Support scripts for configure (from GNU libtool).

config.guess

config.sub

depcomp

missing

ar-lib

compile

install-sh Install shell script for those Unix systems lacking one.

Makefile.in Makefile input for configure.

Makefile.am Source file

for use with Automake to generate Makefile.in.

ckconfig.c Program to generate jconfig.h on non-Unix systems.

jconfig.txt Template for making jconfig.h by hand.

mak\*.\* Sample makefiles for particular systems.

jconfig.\* Sample jconfig.h for particular systems.

libjpeg.map Script to generate shared library with versioned symbols.

libjpeg.pc.in libjpeg.pc pkg-config file input for configure.

aclocal.m4 M4 macro definitions for use with Autoconf.

Test files (see install.txt for test procedure):

test\*.\* Source and comparison files for confidence test.

These are binary image files, NOT text files.

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/filelist.txt

No license file was found, but licenses were detected in source scan.

/\*

\* jdapistd.c

\*

\* Copyright (C) 1994-1996, Thomas G. Lane.

\* Modified 2002-2013 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains application interface code for the decompression half

\* of the JPEG library. These are the "standard" API routines that are

\* used in the normal full-decompression case. They are not used by a

\* transcoding-only application. Note that if an application links in

\* jpeg\_start\_decompress, it will end up linking in the entire decompressor.

\* We thus must separate this file from jdapimin.c to avoid linking the

\* whole decompression library into a transcoder.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jdapistd.c

No license file was found, but licenses were detected in source scan.

/\*

\* jerror.h

\*

\* Copyright (C) 1994-1997, Thomas G. Lane.

\* Modified 1997-2012 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file defines the error and message codes for the JPEG library.

\* Edit this file to add new codes, or to translate the message strings to

\* some other language.

\* A set of error-reporting macros are defined too. Some applications using

\* the JPEG library may wish to include this file to get the error codes

\* and/or the macros.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jerror.h

No license file was found, but licenses were detected in source scan.

/\*

\* jidctflt.c

\*

\* Copyright (C) 1994-1998, Thomas G. Lane.

\* Modified 2010-2017 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains a floating-point implementation of the

\* inverse DCT (Discrete Cosine Transform). In the IJG code, this routine

\* must also perform dequantization of the input coefficients.

\*

\* This implementation should be more accurate than either of the integer

\* IDCT implementations. However, it may not give the same results on all

\* machines because of differences in roundoff behavior. Speed will depend

\* on the hardware's floating point capacity.

\*

\* A 2-D IDCT can be done by 1-D IDCT on each column followed by 1-D IDCT

\* on each row (or vice versa, but it's more convenient to emit a row at

\* a time). Direct algorithms are also available, but they

are much more

\* complex and seem not to be any faster when reduced to code.

\*

\* This implementation is based on Arai, Agui, and Nakajima's algorithm for

\* scaled DCT. Their original paper (Trans. IEICE E-71(11):1095) is in

\* Japanese, but the algorithm is described in the Pennebaker & Mitchell

\* JPEG textbook (see REFERENCES section in file README). The following code

\* is based directly on figure 4-8 in P&M.

\* While an 8-point DCT cannot be done in less than 11 multiplies, it is

\* possible to arrange the computation so that many of the multiplies are

\* simple scalings of the final outputs. These multiplies can then be

\* folded into the multiplications or divisions by the JPEG quantization

\* table entries. The AA&N method leaves only 5 multiplies and 29 adds

\* to be done in the DCT itself.

\* The primary disadvantage of this method is that with a fixed-point

\* implementation, accuracy is lost due to imprecise representation of the

\* scaled quantization values. However,

that problem does not arise if

\* we use floating point arithmetic.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jidctflt.c

No license file was found, but licenses were detected in source scan.

```
/*
 * jdatadst.c
 *
 * Copyright (C) 1994-1996, Thomas G. Lane.
 * Modified 2009-2017 by Guido Vollbeding.
 * This file is part of the Independent JPEG Group's software.
 * For conditions of distribution and use, see the accompanying README file.
 *
 * This file contains compression data destination routines for the case of
 * emitting JPEG data to memory or to a file (or any stdio stream).
 * While these routines are sufficient for most applications,
 * some will want to use a different destination manager.
 * IMPORTANT: we assume that fwrite() will correctly transcribe an array of
 * JOCTETs into 8-bit-wide elements on external storage.  If char is wider
 * than 8 bits on your machine, you may need to do some tweaking.
 */
```

Found in path(s):

```
* /opt/cola/permits/1104792432_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jdatadst.c
```

No license file was found, but licenses were detected in source scan.

```
/*
 * jcinit.c
 *
 * Copyright (C) 1991-1997, Thomas G. Lane.
 * Modified 2003-2017 by Guido Vollbeding.
 * This file is part of the Independent JPEG Group's software.
 * For conditions of distribution and use, see the accompanying README file.
 *
 * This file contains initialization logic for the JPEG compressor.
 * This routine is in charge of selecting the modules to be executed and
 * making an initialization call to each one.
 *
 * Logically, this code belongs in jcmaster.c.  It's split out because
 * linking this routine implies linking the entire compression library.
 * For a transcoding-only application, we want to be able to use jcmaster.c
 * without linking in the whole library.
 */
```

Found in path(s):

```
* /opt/cola/permits/1104792432_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jcinit.c
```

No license file was found, but licenses were detected in source scan.

```
/*
 * jmemmac.c
 *
 * Copyright (C) 1992-1997, Thomas G. Lane.
 * This file is part of the Independent JPEG Group's software.
```

\* For conditions of distribution and use, see the accompanying README file.  
 \*  
 \* jmemmac.c provides an Apple Macintosh implementation of the system-  
 \* dependent portion of the JPEG memory manager.  
 \*  
 \* If you use jmemmac.c, then you must define USE\_MAC\_MEMMGR in the  
 \* JPEG\_INTERNALS part of jconfig.h.  
 \*  
 \* jmemmac.c uses the Macintosh toolbox routines NewPtr and DisposePtr  
 \* instead of malloc and free. It accurately determines the amount of  
 \* memory available by using CompactMem. Notice that if left to its  
 \* own devices, this code can chew up all available space in the  
 \* application's zone, with the exception of the rather small "slop"  
 \* factor computed in jpeg\_mem\_available(). The application can ensure  
 \* that more space is left over by reducing max\_memory\_to\_use.  
 \*  
 \* Large images  
 \* are swapped to disk using temporary files and System 7.0+'s  
 \* temporary folder functionality.  
 \*  
 \* Note that jmemmac.c depends on two features of MacOS that were first  
 \* introduced in System 7: FindFolder and the FSSpec-based calls.  
 \* If your application uses jmemmac.c and is run under System 6 or earlier,  
 \* and the jpeg library decides it needs a temporary file, it will abort,  
 \* printing error messages about requiring System 7. (If no temporary files  
 \* are created, it will run fine.)  
 \*  
 \* If you want to use jmemmac.c in an application that might be used with  
 \* System 6 or earlier, then you should remove dependencies on FindFolder  
 \* and the FSSpec calls. You will need to replace FindFolder with some  
 \* other mechanism for finding a place to put temporary files, and you  
 \* should replace the FSSpec calls with their HFS equivalents:  
 \*  
 \* FSpDelete -> HDelete  
 \* FSpGetFInfo -> HGetFInfo  
 \* FSpCreate -> HCreate  
 \* FSpOpenDF -> HOpen  
 \*\*\* Note: not HOpenDF \*\*\*  
 \* FSMakeFSSpec -> (fill in spec by hand.)  
 \*  
 \* (Use HOpen instead of HOpenDF. HOpen is just a glue-interface to PBHOpen,  
 \* which is on all HFS macs. HOpenDF is a System 7 addition which avoids the  
 \* ages-old problem of names starting with a period.)  
 \*  
 \* Contributed by Sam Bushell (jsam@iagu.on.net) and  
 \* Dan Gildor (gyld@in-touch.com).  
 \*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jmemmac.c

No license file was found, but licenses were detected in source scan.

/\*

\* jdcOLOR.c

\*

\* Copyright (C) 1991-1997, Thomas G. Lane.

\* Modified 2011-2017 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains output colorspace conversion routines.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jdcOLOR.c

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## IJG JPEG LIBRARY: CODING RULES

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This file is part of the Independent JPEG Group's software.

For conditions of distribution and use, see the accompanying README file.

Since numerous people will be contributing code and bug fixes, it's important to establish a common coding style. The goal of using similar coding styles is much more important than the details of just what that style is.

In general we follow the recommendations of "Recommended C Style and Coding Standards" revision 6.1 (Cannon et al. as modified by Spencer, Keppel and Brader). This document is available in the IJG FTP archive (see `jpeg/doc/cstyle.ms.tbl.Z`, or `cstyle.txt.Z` for those without `nroff/tbl`).

Block comments should be laid out thusly:

/\*

\* Block comments in this style.

\*/

We indent statements in K&R style, e.g.,

```
if (test) {
    then-part;
} else {
    else-part;
}
```

with two spaces per indentation

level. (This indentation convention is handled automatically by GNU Emacs and many other text editors.)

Multi-word names should be written in lower case with underscores, e.g., multi\_word\_name (not multiWordName). Preprocessor symbols and enum constants are similar but upper case (MULTI\_WORD\_NAME). Names should be unique within the first fifteen characters. (On some older systems, global names must be unique within six characters. We accommodate this without cluttering the source code by using macros to substitute shorter names.)

We use function prototypes everywhere; we rely on automatic source code transformation to feed prototype-less C compilers. Transformation is done by the simple and portable tool 'ansi2knr.c' (courtesy of Ghostscript). ansi2knr is not very bright, so it imposes a format requirement on function declarations: the function name MUST BEGIN IN COLUMN 1. Thus all functions should be written in the following style:

```
LOCAL(int *)
function_name (int a, char
*b)
{
    code...
}
```

Note that each function definition must begin with GLOBAL(type), LOCAL(type), or METHODDEF(type). These macros expand to "static type" or just "type" as appropriate. They provide a readable indication of the routine's usage and can readily be changed for special needs. (For instance, special linkage keywords can be inserted for use in Windows DLLs.)

ansi2knr does not transform method declarations (function pointers in structs). We handle these with a macro JMETHOD, defined as

```
#ifdef HAVE_PROTOTYPES
#define JMETHOD(type,methodname,arglist) type (*methodname) arglist
#else
#define JMETHOD(type,methodname,arglist) type (*methodname) ()
#endif
```

which is used like this:

```
struct function_pointers {
    JMETHOD(void, init_entropy_encoder, (int somearg, jparms *jp));
    JMETHOD(void, term_entropy_encoder, (void));
};
```

Note the set of parentheses surrounding the parameter list.

A similar solution is used for forward and external function declarations (see the EXTERN and JPP macros).

If the code is to work on non-ANSI compilers, we cannot rely on a prototype declaration to coerce actual parameters into the right types. Therefore, use explicit casts on actual parameters whenever the actual parameter type is not identical to the formal parameter. Beware of implicit conversions to "int".

It seems there are some non-ANSI compilers in which the sizeof() operator is defined to return int, yet size\_t is defined as long. Needless to say, this is brain-damaged. Always use the SIZEOF() macro in place of sizeof(), so that the result is guaranteed to be of type size\_t.

The JPEG library is intended to be used within larger programs. Furthermore, we want it to be reentrant so that it can be used by applications that process multiple images concurrently. The following rules support these requirements:

1. Avoid direct use of file I/O, "malloc", error report printouts, etc; pass these through the common routines provided.
2. Minimize global namespace pollution. Functions should be declared static wherever possible. (Note that our method-based calling conventions help this a lot: in many modules only the initialization function will ever need to be called directly, so only that function need be externally visible.) All global function names should begin with "jpeg\_", and should have an abbreviated name (unique in the first six characters) substituted by macro when NEED\_SHORT\_EXTERNAL\_NAMES is set.
3. Don't use global variables; anything that must be used in another module should be in the common data structures.
4. Don't use static variables except for read-only constant tables. Variables that should be private to a module can be placed into private structures (see the system architecture document, structure.txt).
5. Source file names should begin with "j" for files that are part of the library proper; source files that are not part of the library, such as cjpeg.c and djpeg.c, do not begin with "j". Keep source file names to eight characters (plus ".c" or ".h", etc) to make life easy for MS-DOSers. Keep compression and decompression code in separate source files --- some applications may want only one half of the library.

Note: these rules (particularly #4) are not followed religiously in the modules that are used in cjpeg/djpeg but are not part of the JPEG library proper. Those modules are not really intended to be used in other applications.

Found in path(s):



\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/coderules.txt

No license file was found, but licenses were detected in source scan.

/\*

\* ckconfig.c

\*

\* Copyright (C) 1991-1994, Thomas G. Lane.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/ckconfig.c

No license file was found, but licenses were detected in source scan.

/\*

\* jcarith.c

\*

\* Developed 1997-2013 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains portable arithmetic entropy encoding routines for JPEG

\* (implementing the ISO/IEC IS 10918-1 and CCITT Recommendation ITU-T T.81).

\*

\* Both sequential and progressive modes are supported in this single module.

\*

\* Suspension is not currently supported in this module.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jcarith.c

No license file was found, but licenses were detected in source scan.

/\*

\* jcapistd.c

\*

\* Copyright (C) 1994-1996, Thomas G. Lane.

\* Modified 2013 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains application interface code for the compression half

\* of the JPEG library. These are the "standard" API routines that are

\* used in the normal full-compression case. They are not used by a

\* transcoding-only application. Note that if an application links in

\* jpeg\_start\_compress, it will end up linking in the entire compressor.

\* We thus must separate this file from jcapimin.c to avoid linking the

\* whole compression library into a transcoder.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jcapistd.c

No license file was found, but licenses were detected in source scan.

/\*

\* jaricom.c

\*

\* Developed 1997-2011 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains probability estimation tables for common use in

\* arithmetic entropy encoding and decoding routines.

\*

\* This data represents Table D.3 in the JPEG spec (D.2 in the draft),

\* ISO/IEC IS 10918-1 and CCITT Recommendation ITU-T T.81, and Table 24

\* in the JBIG spec, ISO/IEC IS 11544 and CCITT Recommendation ITU-T T.82.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jaricom.c

No license file was found, but licenses were detected in source scan.

/\*

\* jquant2.c

\*

\* Copyright (C) 1991-1996, Thomas G. Lane.

\* Modified 2011 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains 2-pass color quantization (color mapping) routines.

\* These routines provide selection of a custom color map for an image,

\* followed by mapping of the image to that color map, with optional

\* Floyd-Steinberg dithering.

\* It is also possible to use just the second pass to map to an arbitrary

\* externally-given color map.

\*

\* Note: ordered dithering is not supported, since there isn't any fast

\* way to compute intercolor distances; it's unclear that ordered dither's

\* fundamental assumptions even hold with an irregularly spaced color map.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jquant2.c

No license file was found, but licenses were detected in source scan.

```
/*
 * wrtarga.c
 *
 * Copyright (C) 1991-1996, Thomas G. Lane.
 * Modified 2015-2017 by Guido Vollbeding.
 * This file is part of the Independent JPEG Group's software.
 * For conditions of distribution and use, see the accompanying README file.
 *
 * This file contains routines to write output images in Targa format.
 *
 * These routines may need modification for non-Unix environments or
 * specialized applications. As they stand, they assume output to
 * an ordinary stdio stream.
 *
 * Based on code contributed by Lee Daniel Crocker.
 */
```

Found in path(s):

```
* /opt/cola/permits/1104792432_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/wrtarga.c
No license file was found, but licenses were detected in source scan.
```

```
/*
 * cjpeg.c
 *
 * Copyright (C) 1991-1998, Thomas G. Lane.
 * Modified 2003-2013 by Guido Vollbeding.
 * This file is part of the Independent JPEG Group's software.
 * For conditions of distribution and use, see the accompanying README file.
 *
 * This file contains a command-line user interface for the JPEG compressor.
 * It should work on any system with Unix- or MS-DOS-style command lines.
 *
 * Two different command line styles are permitted, depending on the
 * compile-time switch TWO_FILE_COMMANDLINE:
 * cjpeg [options] inputfile outputfile
 * cjpeg [options] [inputfile]
 * In the second style, output is always to standard output, which you'd
 * normally redirect to a file or pipe to some other program. Input is
 * either from a named file or from standard input (typically redirected).
 * The second style is convenient on Unix but is unhelpful on systems that
 * don't support pipes. Also, you MUST use the
 * first style if your system
 * doesn't do binary I/O to stdin/stdout.
 * To simplify script writing, the "-outfile" switch is provided. The syntax
 * cjpeg [options] -outfile outputfile inputfile
 * works regardless of which command line style is used.
```

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/cjpeg.c

No license file was found, but licenses were detected in source scan.

/\*

\* jcomapi.c

\*

\* Copyright (C) 1994-1997, Thomas G. Lane.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains application interface routines that are used for both

\* compression and decompression.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jcomapi.c

No license file was found, but licenses were detected in source scan.

/\*

\* cderror.h

\*

\* Copyright (C) 1994-1997, Thomas G. Lane.

\* Modified 2009-2017 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file defines the error and message codes for the cjpeg/djpeg

\* applications. These strings are not needed as part of the JPEG library

\* proper.

\* Edit this file to add new codes, or to translate the message strings to

\* some other language.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/cderror.h

No license file was found, but licenses were detected in source scan.

/\*

\* jdtrans.c

\*

\* Copyright (C) 1995-1997, Thomas G. Lane.

\* Modified 2000-2009 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains library routines for transcoding decompression,  
\* that is, reading raw DCT coefficient arrays from an input JPEG file.  
\* The routines in jdapimin.c will also be needed by a transcoder.  
\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jdtrans.c  
No license file was found, but licenses were detected in source scan.

/\*

\* rdrle.c

\*

\* Copyright (C) 1991-1996, Thomas G. Lane.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains routines to read input images in Utah RLE format.

\* The Utah Raster Toolkit library is required (version 3.1 or later).

\*

\* These routines may need modification for non-Unix environments or

\* specialized applications. As they stand, they assume input from

\* an ordinary stdio stream. They further assume that reading begins

\* at the start of the file; start\_input may need work if the

\* user interface has already read some data (e.g., to determine that

\* the file is indeed RLE format).

\*

\* Based on code contributed by Mike Lijewski,

\* with updates from Robert Hutchinson.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/rdrle.c  
No license file was found, but licenses were detected in source scan.

/\*

\* jcmarker.c

\*

\* Copyright (C) 1991-1998, Thomas G. Lane.

\* Modified 2003-2013 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains routines to write JPEG datastream markers.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jcmarker.c

No license file was found, but licenses were detected in source scan.

```
/*  
* rdjpgcom.c  
*  
* Copyright (C) 1994-1997, Thomas G. Lane.  
* Modified 2009 by Bill Allombert, Guido Vollbeding.  
* This file is part of the Independent JPEG Group's software.  
* For conditions of distribution and use, see the accompanying README file.  
*  
* This file contains a very simple stand-alone application that displays  
* the text in COM (comment) markers in a JFIF file.  
* This may be useful as an example of the minimum logic needed to parse  
* JPEG markers.  
*/
```

Found in path(s):

```
*/opt/cola/permits/1104792432_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/rdjpgcom.c
```

No license file was found, but licenses were detected in source scan.

```
/*  
* jfdctint.c  
*  
* Copyright (C) 1991-1996, Thomas G. Lane.  
* Modification developed 2003-2015 by Guido Vollbeding.  
* This file is part of the Independent JPEG Group's software.  
* For conditions of distribution and use, see the accompanying README file.  
*  
* This file contains a slow-but-accurate integer implementation of the  
* forward DCT (Discrete Cosine Transform).  
*  
* A 2-D DCT can be done by 1-D DCT on each row followed by 1-D DCT  
* on each column. Direct algorithms are also available, but they are  
* much more complex and seem not to be any faster when reduced to code.  
*  
* This implementation is based on an algorithm described in  
* C. Loeffler, A. Ligtenberg and G. Moschytz, "Practical Fast 1-D DCT  
* Algorithms with 11 Multiplications", Proc. Int'l. Conf. on Acoustics,  
* Speech, and Signal Processing 1989 (ICASSP '89), pp. 988-991.  
* The primary algorithm described there uses 11 multiplies  
and 29 adds.  
* We use their alternate method with 12 multiplies and 32 adds.  
* The advantage of this method is that no data path contains more than one  
* multiplication; this allows a very simple and accurate implementation in  
* scaled fixed-point arithmetic, with a minimal number of shifts.  
*  
* We also provide FDCT routines with various input sample block sizes for  
* direct resolution reduction or enlargement and for direct resolving the
```

\* common 2x1 and 1x2 subsampling cases without additional resampling: NxN  
 \* (N=1...16), 2NxN, and Nx2N (N=1...8) pixels for one 8x8 output DCT block.  
 \*  
 \* For N<8 we fill the remaining block coefficients with zero.  
 \* For N>8 we apply a partial N-point FDCT on the input samples, computing  
 \* just the lower 8 frequency coefficients and discarding the rest.  
 \*  
 \* We must scale the output coefficients of the N-point FDCT appropriately  
 \* to the standard 8-point FDCT level by 8/N per 1-D pass. This scaling  
 \* is folded into the constant multipliers  
 (pass 2) and/or final/initial  
 \* shifting.  
 \*  
 \* CAUTION: We rely on the FIX() macro except for the N=1,2,4,8 cases  
 \* since there would be too many additional constants to pre-calculate.  
 \*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jfdctint.c

No license file was found, but licenses were detected in source scan.

/\*

\* jpegtran.c

\*

\* Copyright (C) 1995-2013, Thomas G. Lane, Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains a command-line user interface for JPEG transcoding.

\* It is very similar to cjpeg.c, and partly to djpeg.c, but provides

\* lossless transcoding between different JPEG file formats. It also

\* provides some lossless and sort-of-lossless transformations of JPEG data.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jpegtran.c

No license file was found, but licenses were detected in source scan.

/\*

\* jddctmgr.c

\*

\* Copyright (C) 1994-1996, Thomas G. Lane.

\* Modified 2002-2013 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains the inverse-DCT management logic.

\* This code selects a particular IDCT implementation to be used,

\* and it performs related housekeeping chores. No code in this file  
\* is executed per IDCT step, only during output pass setup.  
\*  
\* Note that the IDCT routines are responsible for performing coefficient  
\* dequantization as well as the IDCT proper. This module sets up the  
\* dequantization multiplier table needed by the IDCT routine.  
\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jddctmgr.c

No license file was found, but licenses were detected in source scan.

/\*

\* djpeg.c

\*

\* Copyright (C) 1991-1997, Thomas G. Lane.

\* Modified 2009-2015 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains a command-line user interface for the JPEG decompressor.

\* It should work on any system with Unix- or MS-DOS-style command lines.

\*

\* Two different command line styles are permitted, depending on the

\* compile-time switch TWO\_FILE\_COMMANDLINE:

\* djpeg [options] inputfile outputfile

\* djpeg [options] [inputfile]

\* In the second style, output is always to standard output, which you'd

\* normally redirect to a file or pipe to some other program. Input is

\* either from a named file or from standard input (typically redirected).

\* The second style is convenient on Unix but is unhelpful on systems that

\* don't support pipes. Also, you MUST use the

first style if your system

\* doesn't do binary I/O to stdin/stdout.

\* To simplify script writing, the "-outfile" switch is provided. The syntax

\* djpeg [options] -outfile outputfile inputfile

\* works regardless of which command line style is used.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/djpeg.c

No license file was found, but licenses were detected in source scan.

/\*

\* jmorecfg.h

\*

\* Copyright (C) 1991-1997, Thomas G. Lane.

\* Modified 1997-2013 by Guido Vollbeding.



\* This file is part of the Independent JPEG Group's software.  
\* For conditions of distribution and use, see the accompanying README file.  
\*  
\* This file contains additional configuration options that customize the  
\* JPEG software for special applications or support machine-dependent  
\* optimizations. Most users will not need to touch this file.  
\*/

Found in path(s):

\*/opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jmorecfg.h

No license file was found, but licenses were detected in source scan.

/\*

\* jquant1.c

\*

\* Copyright (C) 1991-1996, Thomas G. Lane.

\* Modified 2011 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains 1-pass color quantization (color mapping) routines.

\* These routines provide mapping to a fixed color map using equally spaced

\* color values. Optional Floyd-Steinberg or ordered dithering is available.

\*/

Found in path(s):

\*/opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jquant1.c

No license file was found, but licenses were detected in source scan.

## IJG JPEG LIBRARY: SYSTEM ARCHITECTURE

Copyright (C) 1991-2013, Thomas G. Lane, Guido Vollbeding.

This file is part of the Independent JPEG Group's software.

For conditions of distribution and use, see the accompanying README file.

This file provides an overview of the architecture of the IJG JPEG software; that is, the functions of the various modules in the system and the interfaces between modules. For more precise details about any data structure or calling convention, see the include files and comments in the source code.

We assume that the reader is already somewhat familiar with the JPEG standard.

The README file includes references for learning about JPEG. The file

libjpeg.txt describes the library from the viewpoint of an application

programmer using the library; it's best to read that file before this one.

Also, the file coderules.txt describes the coding style conventions we use.

In this document, JPEG-specific

terminology follows the JPEG standard:

A "component" means a color channel, e.g., Red or Luminance.

A "sample" is a single component value (i.e., one number in the image data).

A "coefficient" is a frequency coefficient (a DCT transform output number).

A "block" is an array of samples or coefficients.

An "MCU" (minimum coded unit) is an interleaved set of blocks of size determined by the sampling factors, or a single block in a noninterleaved scan.

We do not use the terms "pixel" and "sample" interchangeably. When we say pixel, we mean an element of the full-size image, while a sample is an element of the downsampled image. Thus the number of samples may vary across components while the number of pixels does not. (This terminology is not used rigorously throughout the code, but it is used in places where confusion would otherwise result.)

\*\*\* System features \*\*\*

The IJG distribution contains two parts:

- \* A subroutine library for JPEG compression and decompression.

- \* `cjpeg/djpeg`, two sample applications that use the library to transform JFIF JPEG files to and from several other image formats.

`cjpeg/djpeg` are of no great intellectual complexity: they merely add a simple command-line user interface and I/O routines for several uncompressed image formats. This document concentrates on the library itself.

We desire the library to be capable of supporting all JPEG baseline, extended sequential, and progressive DCT processes. The library does not support the hierarchical or lossless processes defined in the standard.

Within these limits, any set of compression parameters allowed by the JPEG spec should be readable for decompression. (We can be more restrictive about what formats we can generate.) Although the system design allows for all parameter values, some uncommon settings are not yet implemented and may never be; nonintegral sampling ratios are the prime example. Furthermore, we treat 8-bit vs. 12-bit data precision as a compile-time switch, not a run-time option, because most machines can store 8-bit pixels much more compactly than 12-bit.

By itself, the library handles only interchange JPEG datastreams --- in particular the widely used JFIF file format. The library can be used by surrounding code to process interchange or abbreviated JPEG datastreams that are embedded in more complex file formats. (For example, `libtiff` uses this library to implement JPEG compression within the TIFF file format.)

The library includes a substantial amount of code that is not covered by the JPEG standard but is necessary for typical applications of JPEG. These

functions preprocess the image before JPEG compression or postprocess it after decompression. They include colorspace conversion, downsampling/upsampling, and color quantization. This code can be omitted if not needed.

A wide range of quality vs. speed tradeoffs are possible in JPEG processing, and even more so in decompression postprocessing. The decompression library provides multiple implementations that cover most of the useful tradeoffs, ranging from very-high-quality down to fast-preview operation. On the compression side we have generally not provided low-quality choices, since compression is normally less time-critical. It should be understood that the low-quality modes may not meet the JPEG standard's accuracy requirements; nonetheless, they are useful for viewers.

\*\*\* Portability issues \*\*\*

Portability is an essential requirement for the library. The key portability issues that show up at the level of system architecture are:

1. Memory usage. We want the code to be able to run on PC-class machines with limited memory. Images should therefore be processed sequentially (in strips), to avoid holding the whole image in memory at once. Where a full-image buffer is necessary, we should be able to use either virtual memory or temporary files.
2. Near/far pointer distinction. To run efficiently on 80x86 machines, the code should distinguish "small" objects (kept in near data space) from "large" ones (kept in far data space). This is an annoying restriction, but fortunately it does not impact code quality for less brain-damaged machines, and the source code clutter turns out to be minimal with sufficient use of pointer typedefs.
3. Data precision. We assume that "char" is at least 8 bits, "short" and "int" at least 16, "long" at least 32. The code will work fine with larger data sizes, although memory may be used inefficiently in some cases. However, the JPEG compressed datastream must ultimately appear on external storage as a sequence of 8-bit bytes if it is to conform to the standard. This may pose a problem on machines where char is wider than 8 bits. The library represents compressed data as an array of values of typedef JOCTET. If no data type exactly 8 bits wide is available, custom data source and data destination modules must be written to unpack and pack the chosen JOCTET datatype into 8-bit external representation.

\*\*\* System overview \*\*\*

The compressor and decompressor are each divided into two main sections: the JPEG compressor or decompressor proper, and the preprocessing or postprocessing functions. The interface between these two sections is the image data that the official JPEG spec regards as its input or output: this data is in the colorspace to be used for compression, and it is downsampled to the sampling factors to be used. The preprocessing and postprocessing steps are responsible for converting a normal image representation to or from this form. (Those few applications that want to deal with YCbCr downsampled data can skip the preprocessing or postprocessing step.)

Looking more closely, the compressor library contains the following main elements:

Preprocessing:

- \* Color space conversion (e.g., RGB to YCbCr).
- \* Edge expansion and downsampling. Optionally, this step can do simple smoothing --- this is often helpful for low-quality source data.

JPEG proper:

- \* MCU assembly, DCT, quantization.
- \* Entropy coding (sequential or progressive, Huffman or arithmetic).

In addition to these modules we need overall control, marker generation, and support code (memory management & error handling). There is also a module responsible for physically writing the output data --- typically this is just an interface to `fwrite()`, but some applications may need to do something else with the data.

The decompressor library contains the following main elements:

JPEG proper:

- \* Entropy decoding (sequential or progressive, Huffman or arithmetic).
- \* Dequantization, inverse DCT, MCU disassembly.

Postprocessing:

- \* Upsampling. Optionally, this step may be able to do more general rescaling of the image.
- \* Color space conversion (e.g., YCbCr to RGB). This step may also provide gamma adjustment [ currently it does not ].
- \* Optional color quantization (e.g., reduction to 256 colors).
- \* Optional color precision reduction (e.g., 24-bit to 15-bit color).

[This feature is not currently implemented.]

We also need overall control, marker parsing, and a data source module.

The support code (memory management & error handling) can be shared with the compression half of the library.

There may be several implementations of each of these elements, particularly in the decompressor, where a wide range of speed/quality tradeoffs is very useful. It must be understood that some of the best speedups involve merging adjacent steps in the pipeline. For example, upsampling, color space conversion, and color quantization might all be done at once when using a low-quality ordered-dither technique. The system architecture is designed to allow such merging where appropriate.

Note: it is convenient to regard edge expansion (padding to block boundaries) as a preprocessing/postprocessing function, even though the JPEG spec includes it in compression/decompression. We do this because downsampling/upsampling can be simplified a little if they work on padded data: it's not necessary to have special cases at the right and bottom edges. Therefore the interface buffer is always an integral number of blocks wide and high, and we expect compression preprocessing to pad the source data properly. Padding will occur only to the next block (block\_size-sample) boundary. In an interleaved-scan situation, additional dummy blocks may be used to fill out MCUs, but the MCU assembly and disassembly logic will create or discard these blocks internally. (This is advantageous for speed reasons, since we avoid DCTing the dummy blocks. It also permits a small reduction in file size, because the compressor can choose dummy block contents so as to minimize their size in compressed form. Finally, it makes the interface buffer specification independent of whether the file is actually interleaved or not.) Applications that wish to deal directly with the downsampled data must provide similar buffering and padding for odd-sized images.

\*\*\* Poor man's object-oriented programming \*\*\*

It should be clear by now that we have a lot of quasi-independent processing steps, many of which have several possible behaviors. To avoid cluttering the code with lots of switch statements, we use a simple form of object-style programming to separate out the different possibilities.

For example, two different color quantization algorithms could be implemented as two separate modules that present the same external interface; at runtime, the calling code will access the proper module indirectly through an "object".

We can get the limited features we need while staying within portable C. The basic tool is a function pointer. An "object" is just a struct containing one or more function pointer fields, each of which corresponds to a method name in real object-oriented languages. During initialization we fill in the function pointers with references to whichever module we have determined

we need to use in this run. Then invocation of the module is done by indirecting through a function pointer; on most machines this is no more expensive than a switch statement, which would be the only other way of making the required run-time choice. The really significant benefit, of course, is keeping the source code clean and well structured.

We can also arrange to have private storage that varies between different implementations of the same kind of object. We do this by making all the module-specific object structs be separately allocated entities, which will be accessed via pointers in the master compression or decompression struct. The "public" fields or methods for a given kind of object are specified by a commonly known struct. But a module's initialization code can allocate a larger struct that contains the common struct as its first member, plus additional private fields. With appropriate pointer casting, the module's internal functions can access these private fields.

(For a simple example, see `jdatadst.c`, which implements the external interface specified by struct `jpeg_destination_mgr`, but adds extra fields.)

(Of course this would all be a lot easier if we were using C++, but we are not yet prepared to assume that everyone has a C++ compiler.)

An important benefit of this scheme is that it is easy to provide multiple versions of any method, each tuned to a particular case. While a lot of precalculation might be done to select an optimal implementation of a method, the cost per invocation is constant. For example, the upsampling step might have a "generic" method, plus one or more "hardwired" methods for the most popular sampling factors; the hardwired methods would be faster because they'd use straight-line code instead of for-loops. The cost to determine which method to use is paid only once, at startup, and the selection criteria are hidden from the callers of the method.

This plan differs a little bit from usual object-oriented structures, in that only one instance of each object class will exist during execution. The reason for having the class structure is that on different runs we may create different instances (choose to execute different modules). You can think of the term "method" as denoting the common interface presented by a particular set of interchangeable functions, and "object" as denoting a group of related methods, or the total shared interface behavior of a group of modules.

\*\*\* Overall control structure \*\*\*

We previously mentioned the need for overall control logic in the compression and decompression libraries. In IJG implementations prior to v5, overall control was mostly provided by "pipeline control" modules, which proved to be large, unwieldy, and hard to understand. To improve the situation, the

control logic has been subdivided into multiple modules. The control modules consist of:

1. Master control for module selection and initialization. This has two responsibilities:

1A. Startup

initialization at the beginning of image processing.

The individual processing modules to be used in this run are selected and given initialization calls.

1B. Per-pass control. This determines how many passes will be performed and calls each active processing module to configure itself appropriately at the beginning of each pass. End-of-pass processing, where necessary, is also invoked from the master control module.

Method selection is partially distributed, in that a particular processing module may contain several possible implementations of a particular method, which it will select among when given its initialization call. The master control code need only be concerned with decisions that affect more than one module.

2. Data buffering control. A separate control module exists for each inter-processing-step data buffer. This module is responsible for invoking the processing steps that write or read that data buffer.

Each

buffer controller sees the world as follows:

```
input data => processing step A => buffer => processing step B => output data
      |           |           |
      ----- controller -----
```

The controller knows the dataflow requirements of steps A and B: how much data they want to accept in one chunk and how much they output in one chunk. Its function is to manage its buffer and call A and B at the proper times.

A data buffer control module may itself be viewed as a processing step by a higher-level control module; thus the control modules form a binary tree with elementary processing steps at the leaves of the tree.

The control modules are objects. A considerable amount of flexibility can be had by replacing implementations of a control module. For example:

\* Merging of adjacent steps in the pipeline is done by replacing a control module and its pair of processing-step modules with a single processing-step module.

(Hence the possible merges are determined by the tree of control modules.)

\* In some processing modes, a given interstep buffer need only be a "strip" buffer large enough to accommodate the desired data chunk sizes. In other modes, a full-image buffer is needed and several passes are required. The control module determines which kind of buffer is used and manipulates virtual array buffers as needed. One or both processing steps may be unaware of the multi-pass behavior.

In theory, we might be able to make all of the data buffer controllers interchangeable and provide just one set of implementations for all. In practice, each one contains considerable special-case processing for its particular job. The buffer controller concept should be regarded as an overall system structuring principle, not as a complete description of the task performed by any one controller.

\*\*\* Compression object structure \*\*\*

Here is a sketch of the logical structure of the JPEG compression library:

```

                                |-- Colospace conversion
|-- Preprocessing controller --|
|                                |-- Downsampling
Main controller --|
|                                |-- Forward DCT, quantize
|-- Coefficient controller --|
|                                |-- Entropy encoding
```

This sketch also describes the flow of control (subroutine calls) during typical image data processing. Each of the components shown in the diagram is an "object" which may have several different implementations available. One or more source code files contain the actual implementation(s) of each object.

The objects shown above are:

\* Main controller: buffer controller for the subsampled-data buffer, which holds the preprocessed input data. This controller invokes preprocessing to fill the subsampled-data buffer, and JPEG compression to empty it. There is usually no need for a full-image buffer here; a strip buffer is adequate.

\* Preprocessing controller: buffer controller for the downsampling input data buffer, which lies between colorspace conversion and downsampling. Note that a unified conversion/downsampling module would probably replace this controller entirely.

\* Colospace conversion: converts application image data into the desired JPEG color space; also changes the data from pixel-interleaved layout to



separate component planes. Processes one pixel row at a time.

\* Downsampling: performs reduction of chroma components as required. Optionally may perform pixel-level smoothing as well. Processes a "row group" at a time, where a row group is defined as  $V_{max}$  pixel rows of each component before downsampling, and  $V_k$  sample rows afterwards (remember  $V_k$  differs across components). Some downsampling or smoothing algorithms may require context rows above and below the current row group; the preprocessing controller is responsible for supplying these rows via proper buffering. The downsampler is responsible for edge expansion at the right edge (i.e., extending each sample row to a multiple of `block_size` samples); but the preprocessing controller is responsible for vertical edge expansion (i.e., duplicating the bottom sample row as needed to make a multiple of `block_size` rows).

\* Coefficient controller: buffer controller for the DCT-coefficient data. This controller handles MCU assembly, including insertion of dummy DCT blocks when needed at the right or bottom edge. When performing Huffman-code optimization or emitting a multiscan JPEG file, this controller is responsible for buffering the full image. The equivalent of one fully interleaved MCU row of subsampled data is processed per call, even when the JPEG file is noninterleaved.

\* Forward DCT and quantization: Perform DCT, quantize, and emit coefficients. Works on one or more DCT blocks at a time. (Note: the coefficients are now emitted in normal array order, which the entropy encoder is expected to convert to zigzag order as necessary. Prior versions of the IJG code did the conversion to zigzag order within the quantization step.)

\* Entropy encoding: Perform Huffman or arithmetic entropy coding and emit the coded data to the data destination module. Works on one MCU per call. For progressive JPEG, the same DCT blocks are fed to the entropy coder during each pass, and the coder must emit the appropriate subset of coefficients.

In addition to the above objects, the compression library includes these objects:

\* Master control: determines the number of passes required, controls overall and per-pass initialization of the other modules.

\* Marker writing: generates JPEG markers (except for `RSTn`, which is emitted by the entropy encoder when needed).

\* Data destination manager: writes the output JPEG datastream to its final destination (e.g., a file). The destination manager supplied

with the library knows how to write to a stdio stream or to a memory buffer; for other behaviors, the surrounding application may provide its own destination manager.

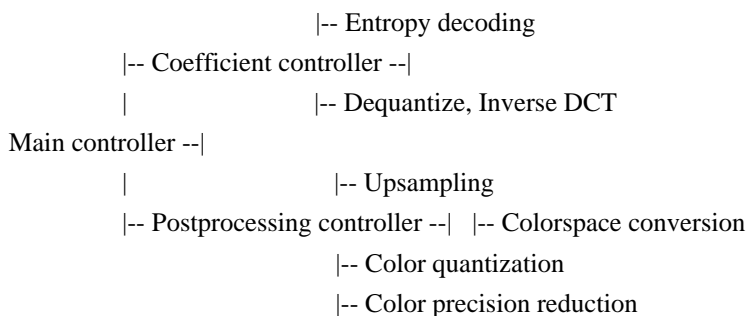
- \* Memory manager: allocates and releases memory, controls virtual arrays (with backing store management, where required).
- \* Error handler: performs formatting and output of error and trace messages; determines handling of nonfatal errors. The surrounding application may override some or all of this object's methods to change error handling.
- \* Progress monitor: supports output of "percent-done" progress reports. This object represents an optional callback to the surrounding application: if wanted, it must be supplied by the application.

The error handler, destination manager, and progress monitor objects are defined as separate objects in order to simplify application-specific customization of the JPEG library. A surrounding application may override individual methods or supply its own all-new implementation of one of these objects. The object interfaces for these objects are therefore treated as part of the application interface of the library, whereas the other objects are internal to the library.

The error handler and memory manager are shared by JPEG compression and decompression; the progress monitor, if used, may be shared as well.

\*\*\* Decompression object structure \*\*\*

Here is a sketch of the logical structure of the JPEG decompression library:



As before, this diagram also represents typical control flow. The objects shown are:

- \* Main controller: buffer controller for the subsampled-data buffer, which holds the output of JPEG decompression proper. This controller's primary

task is to feed the postprocessing procedure. Some upsampling algorithms may require context rows above and below the current row group; when this is true, the main controller is responsible for managing its buffer so as to make context rows available. In the current design, the main buffer is always a strip buffer; a full-image buffer is never required.

\* Coefficient controller: buffer controller for the DCT-coefficient data.

This controller handles MCU disassembly, including deletion of any dummy DCT blocks at the right or bottom edge. When reading a multiscan JPEG file, this controller is responsible for buffering the full image.

(Buffering DCT coefficients, rather than samples, is necessary to support progressive JPEG.) The equivalent of one fully interleaved MCU row of subsampled data is processed per call, even when the source JPEG file is noninterleaved.

\* Entropy decoding: Read coded data from the data source module and perform Huffman or arithmetic entropy decoding. Works on one MCU per call.

For progressive JPEG decoding, the coefficient controller supplies the prior coefficients of each MCU (initially all zeroes), which the entropy decoder modifies in each scan.

\* Dequantization and inverse DCT: like it says. Note that the coefficients buffered by the coefficient controller have NOT been dequantized; we merge dequantization and inverse DCT into a single step for speed reasons. When scaled-down output is asked for, simplified DCT algorithms may be used that need fewer coefficients and emit fewer samples per DCT block, not the full 8x8. Works on one DCT block at a time.

\* Postprocessing controller: buffer controller for the color quantization input buffer, when quantization is in use. (Without quantization, this controller just calls the upsampler.) For two-pass quantization, this controller is responsible for buffering the full-image data.

\* Upsampling: restores chroma components to full size. (May support more general output rescaling, too. Note that if undersized DCT outputs have been emitted by the DCT module, this module must adjust so that properly sized outputs are created.) Works on one row group at a time. This module also calls the color conversion module, so its top level is effectively a buffer controller for the upsampling->color conversion buffer. However, in all but the highest-quality operating modes, upsampling and color conversion are likely to be merged into a single step.

\* Colorspace conversion: convert from JPEG color space to output color space, and change data layout from separate component planes to pixel-interleaved. Works on one pixel row at a time.

\* Color quantization: reduce the data to colormapped form, using either an externally specified colormap or an internally generated one. This module is not used for full-color output. Works on one pixel row at a time; may require two passes to generate a color map. Note that the output will always be a single component representing colormap indexes. In the current design, the output values are JSAMPLEs, so an 8-bit compilation cannot quantize to more than 256 colors. This is unlikely to be a problem in practice.

\* Color reduction: this module handles color precision reduction, e.g., generating 15-bit color (5 bits/primary) from JPEG's 24-bit output. Not quite clear yet how this should be handled... should we merge it with colorspace conversion???

Note that some high-speed operating modes might condense the entire postprocessing sequence to a single module (upsample, color convert, and quantize in one step).

In addition to the above objects, the decompression library includes these objects:

\* Master control: determines the number of passes required, controls overall and per-pass initialization of the other modules. This is subdivided into input and output control: jdinput.c controls only input-side processing, while jdmaster.c handles overall initialization and output-side control.

\* Marker reading: decodes JPEG markers (except for RSTn).

\* Data source manager: supplies the input JPEG datastream. The source manager supplied with the library knows how to read from a stdio stream or from a memory buffer; for other behaviors, the surrounding application may provide its own source manager.

\* Memory manager: same as for compression library.

\* Error handler: same as for compression library.

\* Progress monitor: same as for compression library.

As with compression, the data source manager, error handler, and progress monitor are candidates for replacement by a surrounding application.

\*\*\* Decompression input and output separation \*\*\*

To support efficient incremental display of progressive

JPEG files, the decompressor is divided into two sections that can run independently:

1. Data input includes marker parsing, entropy decoding, and input into the coefficient controller's DCT coefficient buffer. Note that this processing is relatively cheap and fast.
2. Data output reads from the DCT coefficient buffer and performs the IDCT and all postprocessing steps.

For a progressive JPEG file, the data input processing is allowed to get arbitrarily far ahead of the data output processing. (This occurs only if the application calls `jpeg_consume_input()`; otherwise input and output run in lockstep, since the input section is called only when the output section needs more data.) In this way the application can avoid making extra display passes when data is arriving faster than the display pass can run. Furthermore, it is possible to abort an output pass without losing anything, since the coefficient buffer is read-only as far as the output section is concerned. See `libjpeg.txt` for more detail.

A full-image coefficient array is only created if the JPEG file has multiple scans (or if the application specifies buffered-image mode anyway). When reading a single-scan file, the coefficient controller normally creates only a one-MCU buffer, so input and output processing must run in lockstep in this case. `jpeg_consume_input()` is effectively a no-op in this situation.

The main impact of dividing the decompressor in this fashion is that we must be very careful with shared variables in the `cinfo` data structure. Each variable that can change during the course of decompression must be classified as belonging to data input or data output, and each section must look only at its own variables. For example, the data output section may not depend on any of the variables that describe the current scan in the JPEG file, because these may change as the data input section advances into a new scan.

The progress monitor is (somewhat arbitrarily) defined to treat input of the file as one pass when buffered-image mode is not used, and to ignore data input work completely when buffered-image mode is used. Note that the library has no reliable way to predict the number of passes when dealing with a progressive JPEG file, nor can it predict the number of output passes in buffered-image mode. So the work estimate is inherently bogus anyway.

No comparable division is currently made in the compression library, because there isn't any real need for it.

\*\*\* Data formats \*\*\*

Arrays of pixel sample values use the following data structure:

```
typedef something JSAMPLE; a pixel component value, 0..MAXJSAMPLE
typedef JSAMPLE *JSAMPROW; ptr to a row of samples
typedef JSAMPROW *JSAMPARRAY; ptr to a list of rows
typedef JSAMPARRAY *JSAMPIMAGE; ptr to a list of color-component arrays
```

The basic element type JSAMPLE will typically be one of unsigned char, (signed) char, or short. Short will be used if samples wider than 8 bits are to be supported (this is a compile-time option). Otherwise, unsigned char is used if possible. If the compiler only supports signed chars, then it is necessary to mask off the value when reading. Thus, all reads of JSAMPLE values must be coded as "GETJSAMPLE(value)", where the macro will be defined as "((value) & 0xFF)" on signed-char machines and "(int) (value)" elsewhere.

With these conventions, JSAMPLE values can be assumed to be  $\geq 0$ . This helps simplify correct rounding during downsampling, etc. The JPEG standard's specification that sample values run from -128..127 is accommodated by subtracting 128 from the sample value in the DCT step. Similarly, during decompression the output of the IDCT step will be immediately shifted back to 0..255. (NB: different values are required when 12-bit samples are in use. The code is written in terms of MAXJSAMPLE and CENTERJSAMPLE, which will be defined as 255 and 128 respectively in an 8-bit implementation, and as 4095 and 2048 in a 12-bit implementation.)

We use a pointer per row, rather than a two-dimensional JSAMPLE array. This choice costs only a small amount of memory and has several benefits:

- \* Code using the data structure doesn't need to know the allocated width of the rows. This simplifies edge expansion/compression, since we can work in an array that's wider than the logical picture width.
- \* Indexing doesn't require multiplication; this is a performance win on many machines.
- \* Arrays with more than 64K total elements can be supported even on machines where malloc() cannot allocate chunks larger than 64K.
- \* The rows forming a component array may be allocated at different times without extra copying. This trick allows some speedups in smoothing steps that need access to the previous and next rows.

Note that each color component is stored in a separate array; we don't use the traditional layout in which the components of a pixel are stored together.

This simplifies coding of modules that work on each component independently,

because they don't need to know how many components there are. Furthermore, we can read or write each component to a temporary file independently, which

is helpful when dealing with noninterleaved JPEG files.

In general, a specific sample value is accessed by code such as

```
GETJSAMPLE(image[colorcomponent][row][col])
```

where col is measured from the image left edge, but row is measured from the first sample row currently in memory. Either of the first two indexings can be precomputed by copying the relevant pointer.

Since most image-processing applications prefer to work on images in which the components of a pixel are stored together, the data passed to or from the surrounding application uses the traditional convention: a single pixel is represented by N consecutive JSAMPLE values, and an image row is an array of (# of color components)\*(image width) JSAMPLEs. One or more rows of data can be represented by a pointer of type JSAMPARRAY in this scheme.

This scheme is converted to component-wise storage inside the JPEG library. (Applications that want to skip JPEG preprocessing or postprocessing will have to contend with component-wise storage.)

Arrays of DCT-coefficient values use the following data structure:

```
typedef short JCOEF; a 16-bit signed integer
typedef JCOEF JBLOCK[DCTSIZE2]; an 8x8 block of coefficients
typedef JBLOCK *JBLOCKROW; ptr to one horizontal row of 8x8 blocks
typedef JBLOCKROW *JBLOCKARRAY; ptr to a list of such rows
typedef JBLOCKARRAY *JBLOCKIMAGE; ptr to a list of color component arrays
```

The underlying type is at least a 16-bit signed integer; while "short" is big enough on all machines of interest, on some machines it is preferable to use "int" for speed reasons, despite the storage cost. Coefficients are grouped into 8x8 blocks (but we always use #defines DCTSIZE and DCTSIZE2 rather than "8" and "64").

The contents of a coefficient block may be in either "natural" or zigzagged order,

and may be true values or divided by the quantization coefficients, depending on where the block is in the processing pipeline. In the current library, coefficient blocks are kept in natural order everywhere; the entropy codecs zigzag or dezigzag the data as it is written or read. The blocks contain quantized coefficients everywhere outside the DCT/IDCT subsystems. (This latter decision may need to be revisited to support variable quantization a la JPEG Part 3.)

Notice that the allocation unit is now a row of 8x8 coefficient blocks, corresponding to block\_size rows of samples. Otherwise the structure is much the same as for samples, and for the same reasons.

On machines where malloc() can't handle a request bigger than 64Kb, this data structure limits us to rows of less than 512 JBLOCKS, or a picture width of 4000+ pixels. This seems an acceptable restriction.

On 80x86 machines, the bottom-level pointer types (JSAMPROW and JBLOCKROW) must be declared as "far" pointers, but the upper levels can be "near" (implying that the pointer lists are allocated in the DS segment). We use a #define symbol FAR, which expands to the "far" keyword when compiling on 80x86 machines and to nothing elsewhere.

\*\*\* Suspendable processing \*\*\*

In some applications it is desirable to use the JPEG library as an incremental, memory-to-memory filter. In this situation the data source or destination may be a limited-size buffer, and we can't rely on being able to empty or refill the buffer at arbitrary times. Instead the application would like to have control return from the library at buffer overflow/underrun, and then resume compression or decompression at a later time.

This scenario is supported for simple cases. (For anything more complex, we recommend that the application "bite the bullet" and develop real multitasking capability.) The libjpeg.txt file goes into more detail about the usage and limitations of this capability; here we address the implications for library structure.

The essence of the problem is that the entropy codec (coder or decoder) must be prepared to stop at arbitrary times. In turn, the controllers that call the entropy codec must be able to stop before having produced or consumed all the data that they normally would handle in one call. That part is reasonably straightforward: we make the controller call interfaces include "progress counters" which indicate the number of data chunks successfully processed, and we require callers to test the counter rather than just assume all of the data was processed.

Rather than trying to restart at an arbitrary point, the current Huffman codecs are designed to restart at the beginning of the current MCU after a suspension due to buffer overflow/underrun. At the start of each call, the codec's internal state is loaded from permanent storage (in the JPEG object structures) into local variables. On successful completion of the MCU, the permanent state is updated. (This copying is not very expensive, and may even lead to \*improved\* performance if the local variables can be registerized.) If a suspension occurs, the codec simply returns without updating the state,



thus effectively reverting to the start of the MCU. Note that this implies leaving some data unprocessed in the source/destination buffer (ie, the compressed partial MCU). The data source/destination module interfaces are specified so as to make this possible. This also implies that the data buffer must be large enough to hold a worst-case compressed MCU; a couple thousand bytes should be enough.

In a successive-approximation AC refinement scan, the progressive Huffman decoder has to be able to undo assignments of newly nonzero coefficients if it suspends before the MCU is complete, since decoding requires distinguishing previously-zero and previously-nonzero coefficients. This is a bit tedious but probably won't have much effect on performance. Other variants of Huffman decoding need not worry about this, since they will just store the same values again if forced to repeat the MCU.

This approach would probably not work for an arithmetic codec, since its modifiable state is quite large and couldn't be copied cheaply. Instead it would have to suspend and resume exactly at the point of the buffer end.

The JPEG marker reader is designed to cope with suspension at an arbitrary point. It does so by backing up to the start of the marker parameter segment, so the data buffer must be big enough to hold the largest marker of interest. Again, a couple KB should be adequate. (A special "skip" convention is used to bypass COM and APPn markers, so these can be larger than the buffer size without causing problems; otherwise a 64K buffer would be needed in the worst case.)

The JPEG marker writer currently does *\*not\** cope with suspension. We feel that this is not necessary; it is much easier simply to require the application to ensure there is enough buffer space before starting. (An empty 2K buffer is more than sufficient for the header markers; and ensuring there are a dozen or two bytes available before calling `jpeg_finish_compress()` will suffice for the trailer.) This would not work for writing multi-scan JPEG files, but we simply do not intend to support that capability with suspension.

\*\*\* Memory manager services \*\*\*

The JPEG library's memory manager controls allocation and deallocation of memory, and it manages large "virtual" data arrays on machines where the operating system does not provide virtual memory. Note that the same memory manager serves both compression and decompression operations.

In all cases, allocated objects are tied to a particular compression or decompression master record, and they will be released when that master

record is destroyed.

The memory manager does not provide explicit deallocation of objects. Instead, objects are created in "pools" of free storage, and a whole pool can be freed at once. This approach helps prevent storage-leak bugs, and it speeds up operations whenever malloc/free are slow (as they often are).

The pools can be regarded as lifetime identifiers for objects. Two pools/lifetimes are defined:

- \* JPOOL\_PERMANENT lasts until master record is destroyed
- \* JPOOL\_IMAGE lasts until done with image (JPEG datastream)

Permanent lifetime is used for parameters and tables that should be carried across from one datastream to another; this includes all application-visible parameters. Image lifetime is used for everything else. (A third lifetime, JPOOL\_PASS = one processing pass, was originally planned. However it was dropped as not being worthwhile. The actual usage patterns are such that the peak memory usage would be about the same anyway; and having per-pass storage substantially complicates the virtual memory allocation rules --- see below.)

The memory manager deals with three kinds of object:

1. "Small" objects. Typically these require no more than 10K-20K total.
2. "Large" objects. These may require tens to hundreds of K depending on image size. Semantically they behave the same as small objects, but we distinguish them for two reasons:
  - \* On MS-DOS machines, large objects are referenced by FAR pointers, small objects by NEAR pointers.
  - \* Pool allocation heuristics may differ for large and small objects.Note that individual "large" objects cannot exceed the size allowed by type size\_t, which may be 64K or less on some machines.
3. "Virtual" objects. These are large 2-D arrays of JSAMPLEs or JBLOCKs (typically large enough for the entire image being processed). The memory manager provides stripwise access to these arrays. On machines without virtual memory, the rest of the array may be swapped out to a temporary file.

(Note: JSAMPARRAY and JBLOCKARRAY data structures are a combination of large objects for the data proper and small objects for the row pointers. For convenience and speed, the memory manager provides single routines to create these structures. Similarly, virtual arrays include a small control block and a JSAMPARRAY or JBLOCKARRAY working buffer, all created with one call.)

In the present implementation, virtual arrays are only permitted to have image lifespan. (Permanent lifespan would not be reasonable, and pass lifespan is not very useful since a virtual array's raison d'etre is to store data for multiple passes through the image.) We also expect that only "small" objects will be given permanent lifespan, though this restriction is not required by

the memory manager.

In a non-virtual-memory machine, some performance benefit can be gained by making the in-memory buffers for virtual arrays be as large as possible. (For small images, the buffers might fit entirely in memory, so blind swapping would be very wasteful.) The memory manager will adjust the height of the buffers to fit within a prespecified maximum memory usage. In order to do this in a reasonably optimal fashion, the manager needs to allocate all of the virtual arrays at once. Therefore, there isn't a one-step allocation routine for virtual arrays; instead, there is a "request" routine that simply allocates the control block, and a "realize" routine (called just once) that determines space allocation and creates all of the actual buffers. The realize routine must allow for space occupied by non-virtual large objects. (We don't bother to factor in the space needed for small objects, on the grounds that it isn't worth the trouble.)

To support all this, we establish the following protocol for doing business with the memory manager:

1. Modules must request virtual arrays (which may have only image lifespan) during the initial setup phase, i.e., in their `jinit_XXX` routines.
2. All "large" objects (including JSAMPARRAYs and JBLOCKARRAYs) must also be allocated during initial setup.
3. `realize_virt_arrays` will be called at the completion of initial setup.

The above conventions ensure that sufficient information is available for it to choose a good size for virtual array buffers.

Small objects of any lifespan may be allocated at any time. We expect that the total space used for small objects will be small enough to be negligible in the `realize_virt_arrays` computation.

In a virtual-memory machine, we simply pretend that the available space is infinite, thus causing `realize_virt_arrays` to decide that it can allocate all the virtual arrays as full-size in-memory buffers. The overhead of the virtual-array access protocol is very small when no swapping occurs.

A virtual array can be specified to be "pre-zeroed"; when this flag is set, never-yet-written sections of the array are set to zero before being made available to the caller. If this flag is not set, never-written sections of the array contain garbage. (This feature exists primarily because the equivalent logic would otherwise be needed in `jdcoefct.c` for progressive JPEG mode; we may as well make it available for possible other uses.)

The first write pass on a virtual array is required to occur in top-to-bottom order; read passes, as well as any write passes after the first one, may access the array in any order. This restriction exists partly to simplify the virtual array control logic, and partly because some file systems may not

support seeking beyond the current end-of-file in a temporary file. The main implication of this restriction is that rearrangement of rows (such as converting top-to-bottom data order to bottom-to-top) must be handled while reading data out of the virtual array, not while putting it in.

\*\*\* Memory manager internal structure \*\*\*

To isolate system dependencies as much as possible, we have broken the memory manager into two parts. There is a reasonably system-independent "front end" (jmemmgr.c) and a "back end" that contains only the code likely to change across systems. All of the memory management methods outlined above are implemented by the front end.

The back end provides the following routines for use by the front end (none of these routines are known to the rest of the JPEG code):

jpeg\_mem\_init, jpeg\_mem\_term system-dependent initialization/shutdown

jpeg\_get\_small, jpeg\_free\_small interface to malloc and free library routines (or their equivalents)

jpeg\_get\_large, jpeg\_free\_large interface to FAR malloc/free in MSDOS machines; else usually the same as jpeg\_get\_small/jpeg\_free\_small

jpeg\_mem\_available estimate available memory

jpeg\_open\_backing\_store create a backing-store object

read\_backing\_store, manipulate a backing-store object  
write\_backing\_store,  
close\_backing\_store

On some systems there will be more than one type of backing-store object (specifically, in MS-DOS a backing store file might be an area of extended memory as well as a disk file). jpeg\_open\_backing\_store is responsible for choosing how to implement a given object. The read/write/close routines are method pointers in the structure that describes a given object; this lets them be different for different object types.

It may be necessary to ensure that backing store objects are explicitly released upon abnormal program termination. For example, MS-DOS won't free extended memory by itself. To support this, we will expect the main program or surrounding application to arrange to call self\_destruct (typically via jpeg\_destroy) upon abnormal termination. This may require a SIGINT signal handler or equivalent. We don't want to have the back end module install its

own signal handler, because that would pre-empt the surrounding application's ability to control signal handling.

The IJG distribution includes several memory manager back end implementations. Usually the same back end should be suitable for all applications on a given system, but it is possible for an application to supply its own back end at need.

\*\*\* Implications of DNL marker \*\*\*

Some JPEG files may use a DNL marker to postpone definition of the image height

(this would be useful for a fax-like scanner's output, for instance).

In these files the SOF marker claims the image height is 0, and you only find out the true image height at the end of the first scan.

We could read these files as follows:

1. Upon seeing zero image height, replace it by 65535 (the maximum allowed).
2. When the DNL is found, update the image height in the global image descriptor.

This implies that control modules must avoid making copies of the image height, and must re-test for termination after each MCU row. This would be easy enough to do.

In cases where image-size data structures are allocated, this approach will result in very inefficient use of virtual memory or much-larger-than-necessary temporary files. This seems acceptable for something that probably won't be a mainstream usage. People might have to forgo use of memory-hogging options (such as two-pass color quantization or noninterleaved JPEG files) if they want efficient conversion of such files.

(One could improve efficiency by demanding a user-supplied upper bound for the height, less than 65536; in most cases it could be much less.)

The standard also permits the SOF marker to overestimate the image height, with a DNL to give the true, smaller height at the end of the first scan.

This would solve the space problems if the overestimate wasn't too great.

However, it implies that you don't even know whether DNL will be used.

This leads to a couple of very serious objections:

1. Testing for a DNL marker must occur in the inner loop of the decompressor's Huffman decoder; this implies a speed penalty whether the feature is used or not.
2. There is no way to hide the last-minute change in image height from an application using the decoder. Thus *every* application using the IJG library would suffer a complexity penalty whether it cared about DNL or not.

We currently do not support DNL because of these problems.

A different approach is to insist that DNL-using files be preprocessed by a separate program that reads ahead to the DNL, then goes back and fixes the SOF marker. This is a much simpler solution and is probably far more efficient. Even if one wants piped input, buffering the first scan of the JPEG file needs a lot smaller temp file than is implied by the maximum-height method. For this approach we'd simply treat DNL as a no-op in the decompressor (at most, check that it matches the SOF image height).

We will not worry about making the compressor capable of outputting DNL. Something similar to the first scheme above could be applied if anyone ever wants to make that work.

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/structure.txt

No license file was found, but licenses were detected in source scan.

/\*

\* jcsample.c

\*

\* Copyright (C) 1991-1996, Thomas G. Lane.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains downsampling routines.

\*

\* Downsampling input data is counted in "row groups". A row group

\* is defined to be max\_v\_samp\_factor pixel rows of each component,

\* from which the downsampler produces v\_samp\_factor sample rows.

\* A single row group is processed in each call to the downsampler module.

\*

\* The downsampler is responsible for edge-expansion of its output data

\* to fill an integral number of DCT blocks horizontally. The source buffer

\* may be modified if it is helpful for this purpose (the source buffer is

\* allocated wide enough to correspond to the desired output width).

\* The caller (the prep controller) is responsible for vertical padding.

\*

\* The downsampler may request

"context rows" by setting need\_context\_rows

\* during startup. In this case, the input arrays will contain at least

\* one row group's worth of pixels above and below the passed-in data;

\* the caller will create dummy rows at image top and bottom by replicating

\* the first or last real pixel row.

\*

\* An excellent reference for image resampling is

\* Digital Image Warping, George Wolberg, 1990.

\* Pub. by IEEE Computer Society Press, Los Alamitos, CA. ISBN 0-8186-8944-7.

\*

\* The downsampling algorithm used here is a simple average of the source  
\* pixels covered by the output pixel. The hi-falutin sampling literature  
\* refers to this as a "box filter". In general the characteristics of a box  
\* filter are not very good, but for the specific cases we normally use (1:1  
\* and 2:1 ratios) the box is equivalent to a "triangle filter" which is not  
\* nearly so bad. If you intend to use other sampling ratios, you'd be well  
\* advised to improve this code.

\*

\* A simple input-smoothing  
\* capability is provided. This is mainly intended  
\* for cleaning up color-dithered GIF input files (if you find it inadequate,  
\* we suggest using an external filtering program such as pnmconvol). When  
\* enabled, each input pixel P is replaced by a weighted sum of itself and its  
\* eight neighbors. P's weight is  $1-8*SF$  and each neighbor's weight is SF,  
\* where  $SF = (\text{smoothing\_factor} / 1024)$ .  
\* Currently, smoothing is only supported for 2h2v sampling factors.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jcsample.c

No license file was found, but licenses were detected in source scan.

/\*

\* cdjpeg.h

\*

\* Copyright (C) 1994-1997, Thomas G. Lane.  
\* This file is part of the Independent JPEG Group's software.  
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\*

\* This file contains common declarations for the sample applications  
\* cjpeg and djpeg. It is NOT used by the core JPEG library.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/cdjpeg.h

No license file was found, but licenses were detected in source scan.

/\*

\* jccolor.c

\*

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\*

\* This file contains input colorspace conversion routines.

\*/

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\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jccolor.c

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## USING THE IJG JPEG LIBRARY

Copyright (C) 1994-2013, Thomas G. Lane, Guido Vollbeding.

This file is part of the Independent JPEG Group's software.

For conditions of distribution and use, see the accompanying README file.

This file describes how to use the IJG JPEG library within an application program. Read it if you want to write a program that uses the library.

The file `example.c` provides heavily commented skeleton code for calling the JPEG library. Also see `jpeglib.h` (the include file to be used by application programs) for full details about data structures and function parameter lists.

The library source code, of course, is the ultimate reference.

Note that there have been *major* changes from the application interface presented by IJG version 4 and earlier versions. The old design had several inherent limitations, and it had accumulated a lot of cruft as we added features while trying to minimize application-interface changes. We have sacrificed backward compatibility in the version 5 rewrite, but we think the improvements justify this.

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Progressive JPEG support  
Buffered-image mode  
Abbreviated datastreams and multiple images  
Special markers  
Raw (downsampled) image data  
Really raw data: DCT coefficients  
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Memory management  
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You should read at least the overview and basic usage sections before trying to program with the library.

The sections on advanced features can be read if and when you need them.

## OVERVIEW

=====

Functions provided by the library

-----

The IJG JPEG library provides C code to read and write JPEG-compressed image files. The surrounding application program receives or supplies image data a scanline at a time, using a straightforward uncompressed image format. All details of color conversion and other preprocessing/postprocessing can be handled by the library.

The library includes a substantial amount of code that is not covered by the JPEG standard but is necessary for typical applications of JPEG. These functions preprocess the image before JPEG compression or postprocess it after decompression. They include colorspace conversion, downsampling/upsampling, and color quantization. The application indirectly selects use of this code by specifying the format in which it wishes to supply or receive image data. For example, if colormapped output is requested, then the decompression library automatically invokes color quantization.

A wide range of quality vs. speed tradeoffs are possible in JPEG processing, and even more so in decompression postprocessing. The decompression library provides multiple implementations that cover most of the useful tradeoffs, ranging from very-high-quality down to fast-preview operation. On the compression side we have generally not provided low-quality choices, since compression is normally less time-critical. It should be understood that the low-quality modes may not meet the JPEG standard's accuracy requirements;

nonetheless, they are useful for viewers.

A word about functions *\*not\** provided by the library. We handle a subset of the ISO JPEG standard; most baseline, extended-sequential, and progressive JPEG processes are supported. (Our subset includes all features now in common use.) Unsupported ISO options include:

- \* Hierarchical storage
- \* Lossless JPEG
- \* DNL marker
- \* Nonintegral subsampling ratios

We

support 8-bit to 12-bit data precision, but this is a compile-time choice rather than a run-time choice; hence it is difficult to use different precisions in a single application.

By itself, the library handles only interchange JPEG datastreams --- in particular the widely used JFIF file format. The library can be used by surrounding code to process interchange or abbreviated JPEG datastreams that are embedded in more complex file formats. (For example, this library is used by the free LIBTIFF library to support JPEG compression in TIFF.)

Outline of typical usage

-----

The rough outline of a JPEG compression operation is:

```
Allocate and initialize a JPEG compression object
Specify the destination for the compressed data (eg, a file)
Set parameters for compression, including image size & colorspace
jpeg_start_compress(...);
while (scan lines remain to be written)
    jpeg_write_scanlines(...);
jpeg_finish_compress(...);
Release the JPEG compression
object
```

A JPEG compression object holds parameters and working state for the JPEG library. We make creation/destruction of the object separate from starting or finishing compression of an image; the same object can be re-used for a series of image compression operations. This makes it easy to re-use the same parameter settings for a sequence of images. Re-use of a JPEG object also has important implications for processing abbreviated JPEG datastreams, as discussed later.

The image data to be compressed is supplied to `jpeg_write_scanlines()` from in-memory buffers. If the application is doing file-to-file compression, reading image data from the source file is the application's responsibility.

The library emits compressed data by calling a "data destination manager", which typically will write the data into a file; but the application can provide its own destination manager to do something else.

Similarly, the rough outline of a JPEG decompression operation is:

```
Allocate and initialize
a JPEG decompression object
Specify the source of the compressed data (eg, a file)
Call jpeg_read_header() to obtain image info
Set parameters for decompression
jpeg_start_decompress(...);
while (scan lines remain to be read)
    jpeg_read_scanlines(...);
jpeg_finish_decompress(...);
Release the JPEG decompression object
```

This is comparable to the compression outline except that reading the datastream header is a separate step. This is helpful because information about the image's size, colorspace, etc is available when the application selects decompression parameters. For example, the application can choose an output scaling ratio that will fit the image into the available screen size.

The decompression library obtains compressed data by calling a data source manager, which typically will read the data from a file; but other behaviors can be obtained with a custom source manager. Decompressed data is delivered into in-memory buffers passed to `jpeg_read_scanlines()`.

It is possible to abort an incomplete compression or decompression operation by calling `jpeg_abort()`; or, if you do not need to retain the JPEG object, simply release it by calling `jpeg_destroy()`.

JPEG compression and decompression objects are two separate struct types. However, they share some common fields, and certain routines such as `jpeg_destroy()` can work on either type of object.

The JPEG library has no static variables: all state is in the compression or decompression object. Therefore it is possible to process multiple compression and decompression operations concurrently, using multiple JPEG objects.

Both compression and decompression can be done in an incremental memory-to-memory fashion, if suitable source/destination managers are used. See the section on "I/O suspension" for more details.

## BASIC LIBRARY USAGE

=====  
Data formats  
-----

Before diving into procedural details, it is helpful to understand the image data format that the JPEG library expects or returns.

The standard input image format is a rectangular array of pixels, with each pixel having the same number of "component" or "sample" values (color channels). You must specify how many components there are and the colorspace interpretation of the components. Most applications will use RGB data (three components per pixel) or grayscale data (one component per pixel). PLEASE NOTE THAT RGB DATA IS THREE SAMPLES PER PIXEL, GRAYSCALE ONLY ONE. A remarkable number of people manage to miss this, only to find that their programs don't work with grayscale JPEG files.

There is no provision for colormapped input. JPEG files are always full-color or full grayscale (or sometimes another colorspace such as CMYK). You can feed in a colormapped image by expanding it to full-color format. However JPEG often doesn't work very well with source data that has been colormapped, because of dithering noise. This is discussed in more detail in the JPEG FAQ and the other references mentioned in the README file.

Pixels are stored by scanlines, with each scanline running from left to right. The component values for each pixel are adjacent in the row; for example, R,G,B,R,G,B,R,G,B,... for 24-bit RGB color. Each scanline is an array of data type JSAMPLE --- which is typically "unsigned char", unless you've changed jmorecfg.h. (You can also change the RGB pixel layout, say to B,G,R order, by modifying jmorecfg.h. But see the restrictions listed in that file before doing so.)

A 2-D array of pixels is formed by making a list of pointers to the starts of scanlines; so the scanlines need not be physically adjacent in memory. Even if you process just one scanline at a time, you must make a one-element pointer array to conform to this structure. Pointers to JSAMPLE rows are of type JSAMPROW, and the pointer to the pointer array is of type JSAMPARRAY.

The library accepts or supplies one or more complete scanlines per call. It is not possible to process part of a row at a time. Scanlines are always processed top-to-bottom. You can process an entire image in one call if you have it all in memory, but usually it's simplest to process one scanline at a time.

For best results, source data values should have the precision specified by

`BITS_IN_JSAMPLE` (normally 8 bits). For instance, if you choose to compress data that's only 6 bits/channel, you should left-justify each value in a byte before passing it to the compressor. If you need to compress data that has more than 8 bits/channel, compile with `BITS_IN_JSAMPLE = 9 to 12`. (See "Library compile-time options", later.)

The data format returned by the decompressor is the same in all details, except that colormapped output is supported. (Again, a JPEG file is never colormapped. But you can ask the decompressor to perform on-the-fly color quantization to deliver colormapped output.) If you request colormapped output then the returned data array contains a single `JSAMPLE` per pixel; its value is an index into a color map. The color map is represented as a 2-D `JSAMPARRAY` in which each row holds the values of one color component, that is, `colormap[i][j]` is the value of the *i*'th color component for pixel value (map index) *j*. Note that since the colormap indexes are stored in `JSAMPLE`s, the maximum number of colors is limited by the size of `JSAMPLE` (ie, at most 256 colors for an 8-bit JPEG library).

#### Compression details

-----

Here we revisit the JPEG compression outline given in the overview.

##### 1. Allocate and initialize a JPEG compression object.

A JPEG compression object is a "struct `jpeg_compress_struct`". (It also has a bunch of subsidiary structures which are allocated via `malloc()`, but the application doesn't control those directly.) This struct can be just a local variable in the calling routine, if a single routine is going to execute the whole JPEG compression sequence. Otherwise it can be static or allocated from `malloc()`.

You will also need a structure representing a JPEG error handler. The part of this that the library cares about is a "struct `jpeg_error_mgr`". If you are providing your own error handler, you'll typically want to embed the `jpeg_error_mgr` struct in a larger structure; this is discussed later under "Error handling". For now we'll assume you are just using the default error handler. The default error handler will print JPEG error/warning messages on `stderr`, and it will call `exit()` if a fatal error occurs.

You must initialize the error handler structure, store a pointer to it into the JPEG object's "err" field, and then call `jpeg_create_compress()` to initialize the rest of the JPEG object.

Typical code for this step, if you are using the default error handler, is

```
struct jpeg_compress_struct cinfo;
struct jpeg_error_mgr jerr;
...
cinfo.err = jpeg_std_error(&jerr);
jpeg_create_compress(&cinfo);
```

`jpeg_create_compress` allocates a small amount of memory, so it could fail if you are out of memory. In that case it will exit via the error handler; that's why the error handler must be initialized first.

## 2. Specify the destination for the compressed data (eg, a file).

As previously mentioned, the JPEG library delivers compressed data to a "data destination" module. The library includes one data destination module which knows how to write to a stdio stream. You can use your own destination module if you want to do something else, as discussed later.

If you use the standard destination module, you must open the target stdio stream beforehand. Typical code for this step looks like:

```
FILE * outfile;
...
if ((outfile = fopen(filename, "wb")) == NULL) {
    fprintf(stderr, "can't open %s\n", filename);
    exit(1);
}
jpeg_stdio_dest(&cinfo, outfile);
```

where the last line invokes the standard destination module.

**WARNING:** it is critical that the binary compressed data be delivered to the output file unchanged. On non-Unix systems the stdio library may perform newline translation or otherwise corrupt binary data. To suppress this behavior, you may need to use a "b" option to `fopen` (as shown above), or use `setmode()` or another routine to put the stdio stream in binary mode. See `cjpeg.c` and `djpeg.c` for code that has been found to work on many systems.

You can select the data destination after setting other parameters (step 3), if that's more convenient. You may not change the destination between calling `jpeg_start_compress()` and `jpeg_finish_compress()`.

## 3. Set parameters for compression, including image size & colorspace.

You must supply information about the source image by setting the following fields in the JPEG object (cinfo structure):

image\_width Width of image, in pixels  
image\_height Height of image, in pixels  
input\_components Number of color channels (samples per pixel)  
in\_color\_space Color space of source image

The image dimensions are, hopefully, obvious. JPEG supports image dimensions of 1 to 64K pixels in either direction. The input color space is typically RGB

or grayscale, and input\_components is 3 or 1 accordingly. (See "Special color spaces", later, for more info.) The in\_color\_space field must be assigned one of the J\_COLOR\_SPACE enum constants, typically JCS\_RGB or JCS\_GRAYSCALE.

JPEG has a large number of compression parameters that determine how the image is encoded. Most applications don't need or want to know about all these parameters. You can set all the parameters to reasonable defaults by calling jpeg\_set\_defaults(); then, if there are particular values you want to change, you can do so after that. The "Compression parameter selection" section tells about all the parameters.

You must set in\_color\_space correctly before calling jpeg\_set\_defaults(), because the defaults depend on the source image colorspace. However the other three source image parameters need not be valid until you call jpeg\_start\_compress(). There's no harm in calling jpeg\_set\_defaults() more than once, if that happens to be convenient.

Typical

code for a 24-bit RGB source image is

```
cinfo.image_width = Width; /* image width and height, in pixels */  
cinfo.image_height = Height;  
cinfo.input_components = 3; /* # of color components per pixel */  
cinfo.in_color_space = JCS_RGB; /* colorspace of input image */
```

```
jpeg_set_defaults(&cinfo);  
/* Make optional parameter settings here */
```

4. jpeg\_start\_compress(...);

After you have established the data destination and set all the necessary source image info and other parameters, call jpeg\_start\_compress() to begin a compression cycle. This will initialize internal state, allocate working storage, and emit the first few bytes of the JPEG datastream header.

Typical code:

```
jpeg_start_compress(&cinfo, TRUE);
```

The "TRUE" parameter ensures that a complete JPEG interchange datastream will be written. This is appropriate in most cases. If you think you might want to use an abbreviated datastream, read the section on abbreviated datastreams, below.

Once you have called `jpeg_start_compress()`, you may not alter any JPEG parameters or other fields of the JPEG object until you have completed the compression cycle.

```
5. while (scan lines remain to be written)
   jpeg_write_scanlines(...);
```

Now write all the required image data by calling `jpeg_write_scanlines()` one or more times. You can pass one or more scanlines in each call, up to the total image height. In most applications it is convenient to pass just one or a few scanlines at a time. The expected format for the passed data is discussed under "Data formats", above.

Image data should be written in top-to-bottom scanline order. The JPEG spec contains some weasel wording about how top and bottom are application-defined terms (a curious interpretation of the English language...) but if you want your files to be compatible with everyone else's, you WILL use top-to-bottom order. If the source data must be read in bottom-to-top order, you can use the JPEG library's virtual array mechanism to invert the data efficiently.

Examples

of this can be found in the sample application `cjpeg`.

The library maintains a count of the number of scanlines written so far in the `next_scanline` field of the JPEG object. Usually you can just use this variable as the loop counter, so that the loop test looks like "while (`cinfo.next_scanline < cinfo.image_height`)".

Code for this step depends heavily on the way that you store the source data. `example.c` shows the following code for the case of a full-size 2-D source array containing 3-byte RGB pixels:

```
JSAMPROW row_pointer[1]; /* pointer to a single row */
int row_stride; /* physical row width in buffer */

row_stride = image_width * 3; /* JSAMPLEs per row in image_buffer */
```



```

while (cinfo.next_scanline < cinfo.image_height) {
    row_pointer[0] = & image_buffer[cinfo.next_scanline * row_stride];
    jpeg_write_scanlines(&cinfo, row_pointer, 1);
}

```

jpeg\_write\_scanlines() returns the number of scanlines actually written.

This will normally be equal to the number

passed in, so you can usually

ignore the return value. It is different in just two cases:

- \* If you try to write more scanlines than the declared image height, the additional scanlines are ignored.

- \* If you use a suspending data destination manager, output buffer overrun will cause the compressor to return before accepting all the passed lines.

This feature is discussed under "I/O suspension", below. The normal stdio destination manager will NOT cause this to happen.

In any case, the return value is the same as the change in the value of next\_scanline.

## 6. jpeg\_finish\_compress(...);

After all the image data has been written, call jpeg\_finish\_compress() to complete the compression cycle. This step is ESSENTIAL to ensure that the last bufferload of data is written to the data destination.

jpeg\_finish\_compress() also releases working memory associated with the JPEG object.

Typical code:

```
jpeg_finish_compress(&cinfo);
```

If using the stdio destination manager,

don't forget to close the output

stdio stream (if necessary) afterwards.

If you have requested a multi-pass operating mode, such as Huffman code optimization, jpeg\_finish\_compress() will perform the additional passes using data buffered by the first pass. In this case jpeg\_finish\_compress() may take quite a while to complete. With the default compression parameters, this will not happen.

It is an error to call jpeg\_finish\_compress() before writing the necessary total number of scanlines. If you wish to abort compression, call jpeg\_abort() as discussed below.

After completing a compression cycle, you may dispose of the JPEG object as discussed next, or you may use it to compress another image. In that case return to step 2, 3, or 4 as appropriate. If you do not change the

destination manager, the new datastream will be written to the same target. If you do not change any JPEG parameters, the new datastream will be written with the same parameters as before. Note that you can change the input image dimensions freely between cycles, but if you change the input colorspace, you should call `jpeg_set_defaults()` to adjust for the new colorspace; and then you'll need to repeat all of step 3.

#### 7. Release the JPEG compression object.

When you are done with a JPEG compression object, destroy it by calling `jpeg_destroy_compress()`. This will free all subsidiary memory (regardless of the previous state of the object). Or you can call `jpeg_destroy()`, which works for either compression or decompression objects --- this may be more convenient if you are sharing code between compression and decompression cases. (Actually, these routines are equivalent except for the declared type of the passed pointer. To avoid gripes from ANSI C compilers, `jpeg_destroy()` should be passed a `j_common_ptr`.)

If you allocated the `jpeg_compress_struct` structure from `malloc()`, freeing it is your responsibility --- `jpeg_destroy()` won't. Ditto for the error handler structure.

Typical code:

```
jpeg_destroy_compress(&cinfo);
```

#### 8.

Aborting.

If you decide to abort a compression cycle before finishing, you can clean up in either of two ways:

\* If you don't need the JPEG object any more, just call `jpeg_destroy_compress()` or `jpeg_destroy()` to release memory. This is legitimate at any point after calling `jpeg_create_compress()` --- in fact, it's safe even if `jpeg_create_compress()` fails.

\* If you want to re-use the JPEG object, call `jpeg_abort_compress()`, or call `jpeg_abort()` which works on both compression and decompression objects. This will return the object to an idle state, releasing any working memory. `jpeg_abort()` is allowed at any time after successful object creation.

Note that cleaning up the data destination, if required, is your responsibility; neither of these routines will call `term_destination()`. (See "Compressed data handling", below, for more about that.)

jpeg\_destroy() and jpeg\_abort() are the only safe calls to make on a JPEG object that has reported an error by calling error\_exit (see "Error handling" for more info). The internal state of such an object is likely to be out of whack. Either of these two routines will return the object to a known state.

## Decompression details

-----

Here we revisit the JPEG decompression outline given in the overview.

### 1. Allocate and initialize a JPEG decompression object.

This is just like initialization for compression, as discussed above, except that the object is a "struct jpeg\_decompress\_struct" and you call jpeg\_create\_decompress(). Error handling is exactly the same.

Typical code:

```
struct jpeg_decompress_struct cinfo;
struct jpeg_error_mgr jerr;
...
cinfo.err = jpeg_std_error(&jerr);
jpeg_create_decompress(&cinfo);
```

(Both here and in the IJG code, we usually use variable name "cinfo" for both compression and decompression objects.)

### 2. Specify the source of the compressed data (eg, a file).

As previously mentioned, the JPEG library reads compressed data from a "data source" module. The library includes one data source module which knows how to read from a stdio stream. You can use your own source module if you want to do something else, as discussed later.

If you use the standard source module, you must open the source stdio stream beforehand. Typical code for this step looks like:

```
FILE * infile;
...
if ((infile = fopen(filename, "rb")) == NULL) {
    fprintf(stderr, "can't open %s\n", filename);
    exit(1);
}
```

```
jpeg_stdio_src(&cinfo, infile);
```

where the last line invokes the standard source module.

**WARNING:** it is critical that the binary compressed data be read unchanged. On non-Unix systems the stdio library may perform newline translation or otherwise corrupt binary data. To suppress this behavior, you may need to use a "b" option to fopen (as shown above), or use setmode() or another routine to put the stdio stream in binary mode. See cjpeg.c and djpeg.c for code that has been found to work on many systems.

You may not

change the data source between calling jpeg\_read\_header() and jpeg\_finish\_decompress(). If you wish to read a series of JPEG images from a single source file, you should repeat the jpeg\_read\_header() to jpeg\_finish\_decompress() sequence without reinitializing either the JPEG object or the data source module; this prevents buffered input data from being discarded.

3. Call jpeg\_read\_header() to obtain image info.

Typical code for this step is just

```
jpeg_read_header(&cinfo, TRUE);
```

This will read the source datastream header markers, up to the beginning of the compressed data proper. On return, the image dimensions and other info have been stored in the JPEG object. The application may wish to consult this information before selecting decompression parameters.

More complex code is necessary if

\* A suspending data source is used --- in that case jpeg\_read\_header() may return before it has read all the header data. See "I/O suspension", below. The normal stdio source manager will NOT cause this to happen.

\* Abbreviated JPEG files are to be processed --- see the section on abbreviated datastreams. Standard applications that deal only in interchange JPEG files need not be concerned with this case either.

It is permissible to stop at this point if you just wanted to find out the image dimensions and other header info for a JPEG file. In that case, call jpeg\_destroy() when you are done with the JPEG object, or call jpeg\_abort() to return it to an idle state before selecting a new data source and reading another header.

4. Set parameters for decompression.

jpeg\_read\_header() sets appropriate default decompression parameters based on the properties of the image (in particular, its colorspace). However, you may well want to alter these defaults before beginning the decompression. For example, the default is to produce full color output from a color file. If you want colormapped output you must ask for it. Other options allow the returned image to be scaled and allow various speed/quality tradeoffs to be selected. "Decompression parameter selection", below, gives details.

If the defaults are appropriate, nothing need be done at this step.

Note that all default values are set by each call to jpeg\_read\_header(). If you reuse a decompression object, you cannot expect your parameter settings to be preserved across cycles, as you can for compression. You must set desired parameter values each time.

#### 5. jpeg\_start\_decompress(...);

Once the parameter values are satisfactory, call jpeg\_start\_decompress() to begin decompression. This will initialize internal state, allocate working memory, and prepare for returning data.

Typical code is just

```
jpeg_start_decompress(&cinfo);
```

If you have requested a multi-pass operating mode, such as 2-pass color quantization, jpeg\_start\_decompress() will do everything needed before data output can begin. In this case jpeg\_start\_decompress() may take quite a while to complete. With a single-scan (non progressive) JPEG file and default decompression parameters, this will not happen; jpeg\_start\_decompress() will return quickly.

After this call, the final output image dimensions, including any requested scaling, are available in the JPEG object; so is the selected colormap, if colormapped output has been requested. Useful fields include

output\_width image width and height, as scaled  
output\_height  
out\_color\_components # of color components in out\_color\_space  
output\_components # of color components returned per pixel  
colormap the selected colormap, if any  
actual\_number\_of\_colors number of entries in colormap

output\_components is 1 (a colormap index) when quantizing colors; otherwise it

equals `out_color_components`. It is the number of JSAMPLE values that will be emitted per pixel in the output arrays.

Typically you will need to allocate data buffers to hold the incoming image. You will need `output_width * output_components` JSAMPLEs per scanline in your output buffer, and a total of `output_height` scanlines will be returned.

Note: if you are using the JPEG library's internal memory manager to allocate data buffers (as `djpeg` does), then the manager's protocol requires that you request large buffers \*before\* calling `jpeg_start_decompress()`. This is a little tricky since the `output_XXX` fields are not normally valid then. You can make them valid by calling `jpeg_calc_output_dimensions()` after setting the relevant parameters (scaling, output color space, and quantization flag).

```
6. while (scan lines remain to be read)
    jpeg_read_scanlines(...);
```

Now you can read the decompressed image data by calling `jpeg_read_scanlines()` one or more times. At each call, you pass in the maximum number of scanlines to be read (ie, the height of your working buffer); `jpeg_read_scanlines()` will return up to that many lines. The return value is the number of lines actually read. The format of the returned data is discussed under "Data formats", above. Don't forget that grayscale and color JPEGs will return different data formats!

Image data is returned in top-to-bottom scanline order. If you must write out the image in bottom-to-top order, you can use the JPEG library's virtual array mechanism to invert the data efficiently. Examples of this can be found in the sample application `djpeg`.

The library maintains a count of the number of scanlines returned so far in the `output_scanline` field of the JPEG object. Usually you can just use this variable as the loop counter, so that the loop test looks like "`while (cinfo.output_scanline < cinfo.output_height)`". (Note that the test should NOT be against `image_height`, unless you never use scaling. The `image_height` field is the height of the original unscaled image.) The return value always equals the change in the value of `output_scanline`.

If you don't use a suspending data source, it is safe to assume that `jpeg_read_scanlines()` reads at least one scanline per call, until the bottom of the image has been reached.

If you use a buffer larger than one scanline, it is NOT safe to assume that `jpeg_read_scanlines()` fills it. (The current implementation returns only a

few scanlines per call, no matter how large a buffer you pass.) So you must always provide a loop that calls `jpeg_read_scanlines()` repeatedly until the whole image has been read.

#### 7. `jpeg_finish_decompress(...)`;

After all the image data has been read, call `jpeg_finish_decompress()` to complete the decompression cycle. This causes working memory associated with the JPEG object to be released.

Typical code:

```
jpeg_finish_decompress(&cinfo);
```

If using the stdio source manager, don't forget to close the source stdio stream if necessary.

It is an error to call `jpeg_finish_decompress()` before reading the correct total number of scanlines. If you wish to abort decompression, call `jpeg_abort()` as discussed below.

After completing a decompression cycle, you may dispose of the JPEG object as discussed next, or you may use it to decompress another image. In that case return to step 2 or 3 as appropriate. If you do not change the source manager, the next image will be read from the same source.

#### 8. Release the JPEG decompression object.

When you are done with a JPEG decompression object, destroy it by calling `jpeg_destroy_decompress()` or `jpeg_destroy()`. The previous discussion of destroying compression objects applies here too.

Typical code:

```
jpeg_destroy_decompress(&cinfo);
```

#### 9. Aborting.

You can abort a decompression cycle by calling `jpeg_destroy_decompress()` or `jpeg_destroy()` if you don't need the JPEG object any more, or `jpeg_abort_decompress()` or `jpeg_abort()` if you want to reuse the object. The previous discussion of aborting compression cycles applies here too.

Mechanics of usage: include files, linking, etc

-----

Applications using the JPEG library should include the header file `jpeglib.h` to obtain declarations of data types and routines. Before including `jpeglib.h`, include system headers that define at least the typedefs `FILE` and `size_t`. On ANSI-conforming systems, including `<stdio.h>` is sufficient; on older Unix systems, you may need `<sys/types.h>` to define `size_t`.

If the application needs to refer to individual JPEG library error codes, also include `jerror.h` to define those symbols.

`jpeglib.h` indirectly includes the files `jconfig.h` and `jmorecfg.h`. If you are installing the JPEG header files in a system directory, you will want to install all four files: `jpeglib.h`, `jerror.h`, `jconfig.h`, `jmorecfg.h`.

The most convenient way to include the JPEG code into your executable program is to prepare a library file ("`libjpeg.a`", or a corresponding name on non-Unix machines) and reference it at your link step. If you use only half of the library (only compression or only decompression), only that much code will be included from the library, unless your linker is hopelessly brain-damaged. The supplied makefiles build `libjpeg.a` automatically (see `install.txt`).

While you can build the JPEG library as a shared library if the whim strikes you, we don't really recommend it. The trouble with shared libraries is that at some point you'll probably try to substitute a new version of the library without recompiling the calling applications. That generally doesn't work because the parameter struct declarations usually change with each new version. In other words, the library's API is *\*not\** guaranteed binary compatible across versions; we only try to ensure source-code compatibility. (In hindsight, it might have been smarter to hide the parameter structs from applications and introduce a ton of access functions instead. Too late now, however.)

On some systems your application may need to set up a signal handler to ensure that temporary files are deleted if the program is interrupted. This is most critical if you are on MS-DOS and use the `jmemdos.c` memory manager back end; it will try to grab extended memory for temporary files, and that space will NOT be freed automatically. See `cjpeg.c` or `djpeg.c` for an example signal handler.

It may be worth pointing out that the core JPEG library does not actually require the `stdio` library: only the default source/destination managers and error handler need it. You can use the library in a `stdio`-less environment if you replace those modules and use `jmemnobs.c` (or another memory manager of your own devising). More info about the minimum system library requirements



may be found in `jinclude.h`.

## ADVANCED FEATURES

=====

### Compression parameter selection

-----

This section describes all the optional parameters you can set for JPEG compression, as well as the "helper" routines provided to assist in this task. Proper setting of some parameters requires detailed understanding of the JPEG standard; if you don't know what a parameter is for, it's best not to mess with it! See REFERENCES in the README file for pointers to more info about JPEG.

It's a good idea to call `jpeg_set_defaults()` first, even if you plan to set all the parameters; that way your code is more likely to work with future JPEG libraries that have additional parameters. For the same reason, we recommend you use a helper routine where one is provided, in preference to twiddling `cinfo` fields directly.

The helper routines are:

`jpeg_set_defaults (j_compress_ptr cinfo)`

This routine sets all JPEG parameters to reasonable defaults, using only the input image's color space (field `in_color_space`, which must already be set in `cinfo`). Many applications will only need to use this routine and perhaps `jpeg_set_quality()`.

`jpeg_set_colorspace (j_compress_ptr cinfo, J_COLOR_SPACE colorspace)`

Sets the JPEG file's colorspace (field `jpeg_color_space`) as specified, and sets other color-space-dependent parameters appropriately. See "Special color spaces", below, before using this. A large number of parameters, including all per-component parameters, are set by this routine; if you want to twiddle individual parameters you should call `jpeg_set_colorspace()` before rather than after.

`jpeg_default_colorspace (j_compress_ptr cinfo)`

Selects an appropriate JPEG colorspace based on `cinfo->in_color_space`, and calls `jpeg_set_colorspace()`. This is actually a subroutine of `jpeg_set_defaults()`. It's broken out in case you want to change just the colorspace-dependent JPEG parameters.

`jpeg_set_quality (j_compress_ptr cinfo, int quality, boolean force_baseline)`

Constructs JPEG quantization tables appropriate for the indicated

quality setting. The quality value is expressed on the 0..100 scale recommended by IJG (cjpeg's "-quality" switch uses this routine). Note that the exact mapping from quality values to tables may change in future IJG releases as more is learned about DCT quantization. If the force\_baseline parameter is TRUE, then the quantization table entries are constrained to the range 1..255 for full JPEG baseline compatibility.

In the current implementation, this only makes a difference for quality settings below 25, and it effectively prevents very small/low quality files from being generated. The IJG decoder is capable of reading the non-baseline files generated at low quality settings when force\_baseline is FALSE, but other decoders may not be.

jpeg\_set\_linear\_quality (j\_compress\_ptr cinfo, int scale\_factor,  
boolean force\_baseline)

Same as jpeg\_set\_quality() except that the generated tables are the sample tables given in the JPEG spec section K.1, multiplied by the specified scale factor (which is expressed as a percentage; thus scale\_factor = 100 reproduces the spec's tables). Note that larger scale factors give lower quality. This entry point is useful for conforming to the Adobe PostScript DCT conventions, but we do not recommend linear scaling as a user-visible quality scale otherwise. force\_baseline again constrains the computed table entries to 1..255.

int jpeg\_quality\_scaling  
(int quality)

Converts a value on the IJG-recommended quality scale to a linear scaling percentage. Note that this routine may change or go away in future releases --- IJG may choose to adopt a scaling method that can't be expressed as a simple scalar multiplier, in which case the premise of this routine collapses. Caveat user.

jpeg\_default\_qtables (j\_compress\_ptr cinfo, boolean force\_baseline)  
Set default quantization tables with linear q\_scale\_factor[] values (see below).

jpeg\_add\_quant\_table (j\_compress\_ptr cinfo, int which\_tbl,  
const unsigned int \*basic\_table,  
int scale\_factor, boolean force\_baseline)

Allows an arbitrary quantization table to be created. which\_tbl indicates which table slot to fill. basic\_table points to an array of 64 unsigned ints given in normal array order. These values are multiplied by scale\_factor/100 and then clamped to the range 1..65535 (or to 1..255 if force\_baseline is TRUE).

CAUTION: prior to library version

6a, jpeg\_add\_quant\_table expected

the basic table to be given in JPEG zigzag order. If you need to write code that works with either older or newer versions of this

routine, you must check the library version number. Something like  
"#if JPEG\_LIB\_VERSION >= 61" is the right test.

jpeg\_simple\_progression (j\_compress\_ptr cinfo)

Generates a default scan script for writing a progressive-JPEG file.

This is the recommended method of creating a progressive file,  
unless you want to make a custom scan sequence. You must ensure that  
the JPEG color space is set correctly before calling this routine.

Compression parameters (cinfo fields) include:

boolean arith\_code

If TRUE, use arithmetic coding.

If FALSE, use Huffman coding.

int block\_size

Set DCT block size. All N from 1 to 16 are possible.

Default is 8 (baseline format).

Larger values produce higher compression,  
smaller values produce higher quality.

An exact DCT stage is possible with 1 or 2.

With the default quality

of 75 and default Luminance qtable

the DCT+Quantization stage is lossless for value 1.

Note that values other than 8 require a SmartScale capable decoder,  
introduced with IJG JPEG 8. Setting the block\_size parameter for  
compression works with version 8c and later.

J\_DCT\_METHOD dct\_method

Selects the algorithm used for the DCT step. Choices are:

JDCT\_ISLOW: slow but accurate integer algorithm

JDCT\_IFAST: faster, less accurate integer method

JDCT\_FLOAT: floating-point method

JDCT\_DEFAULT: default method (normally JDCT\_ISLOW)

JDCT\_FASTEST: fastest method (normally JDCT\_IFAST)

The FLOAT method is very slightly more accurate than the ISLOW method,  
but may give different results on different machines due to varying  
roundoff behavior. The integer methods should give the same results  
on all machines. On machines with sufficiently fast FP hardware, the  
floating-point method may also be the fastest. The IFAST method is  
considerably less accurate than the other two; its

use is not

recommended if high quality is a concern. JDCT\_DEFAULT and  
JDCT\_FASTEST are macros configurable by each installation.

unsigned int scale\_num, scale\_denom

Scale the image by the fraction scale\_num/scale\_denom. Default is

1/1, or no scaling. Currently, the supported scaling ratios are M/N with all N from 1 to 16, where M is the destination DCT size, which is 8 by default (see `block_size` parameter above). (The library design allows for arbitrary scaling ratios but this is not likely to be implemented any time soon.)

`J_COLOR_SPACE` `jpeg_color_space`

`int num_components`

The JPEG color space and corresponding number of components; see "Special color spaces", below, for more info. We recommend using `jpeg_set_colorspace()` if you want to change these.

`J_COLOR_TRANSFORM` `color_transform`

Internal color transform identifier, writes LSE marker if nonzero (requires decoder with inverse color transform support, introduced with IJG JPEG 9).

Two values are currently possible:

`JCT_NONE` and `JCT_SUBTRACT_GREEN`.

Set this value for lossless RGB application \*before\* calling `jpeg_set_colorspace()`, because entropy table assignment in `jpeg_set_colorspace()` depends on `color_transform`.

`boolean optimize_coding`

`TRUE` causes the compressor to compute optimal Huffman coding tables for the image. This requires an extra pass over the data and therefore costs a good deal of space and time. The default is `FALSE`, which tells the compressor to use the supplied or default Huffman tables. In most cases optimal tables save only a few percent of file size compared to the default tables. Note that when this is `TRUE`, you need not supply Huffman tables at all, and any you do supply will be overwritten.

`unsigned int restart_interval`

`int restart_in_rows`

To emit restart markers in the JPEG file, set one of these nonzero.

Set `restart_interval` to specify the exact interval in MCU blocks.

Set `restart_in_rows` to specify the interval in MCU rows. (If `restart_in_rows`

is not 0, then `restart_interval` is set after the

image width in MCUs is computed.) Defaults are zero (no restarts).

One restart marker per MCU row is often a good choice.

NOTE: the overhead of restart markers is higher in grayscale JPEG files than in color files, and MUCH higher in progressive JPEGs.

If you use restarts, you may want to use larger intervals in those cases.

`const jpeg_scan_info * scan_info`

`int num_scans`

By default, scan\_info is NULL; this causes the compressor to write a single-scan sequential JPEG file. If not NULL, scan\_info points to an array of scan definition records of length num\_scans. The compressor will then write a JPEG file having one scan for each scan definition record. This is used to generate noninterleaved or progressive JPEG files. The library checks that the scan array defines a valid JPEG scan sequence. (jpeg\_simple\_progression creates a suitable scan definition array for progressive JPEG.) This is discussed further under "Progressive JPEG support".

boolean do\_fancy\_downsampling

If TRUE, use direct DCT scaling with DCT size > 8 for downsampling of chroma components.

If FALSE, use only DCT size <= 8 and simple separate downsampling.

Default is TRUE.

For better image stability in multiple generation compression cycles it is preferable that this value matches the corresponding do\_fancy\_upsampling value in decompression.

int smoothing\_factor

If non-zero, the input image is smoothed; the value should be 1 for minimal smoothing to 100 for maximum smoothing. Consult jcsample.c for details of the smoothing algorithm. The default is zero.

boolean write\_JFIF\_header

If TRUE, a JFIF APP0 marker is emitted. jpeg\_set\_defaults() and jpeg\_set\_colorspace() set this TRUE if a JFIF-legal JPEG color space (ie, YCbCr or grayscale) is selected, otherwise FALSE.

UINT8 JFIF\_major\_version

UINT8 JFIF\_minor\_version

The version number to be written into the JFIF marker.

jpeg\_set\_defaults() initializes the version to

1.01 (major=minor=1).

You should set it to 1.02 (major=1, minor=2) if you plan to write any JFIF 1.02 extension markers.

UINT8 density\_unit

UINT16 X\_density

UINT16 Y\_density

The resolution information to be written into the JFIF marker;

not used otherwise. density\_unit may be 0 for unknown,

1 for dots/inch, or 2 for dots/cm. The default values are 0,1,1

indicating square pixels of unknown size.

boolean write\_Adobe\_marker

If TRUE, an Adobe APP14 marker is emitted. jpeg\_set\_defaults() and

jpeg\_set\_colorspace() set this TRUE if JPEG color space RGB, CMYK, or YCCK is selected, otherwise FALSE. It is generally a bad idea to set both write\_JFIF\_header and write\_Adobe\_marker. In fact, you probably shouldn't change the default settings at all --- the default behavior ensures that the JPEG file's color space can be recognized by the decoder.

JQUANT\_TBL \* quant\_tbl\_ptrs[NUM\_QUANT\_TBLS]  
Pointers to coefficient quantization tables, one per table slot, or NULL if no table is defined for a slot. Usually these should be set via one of the above helper routines; jpeg\_add\_quant\_table() is general enough to define any quantization table. The other routines will set up table slot 0 for luminance quality and table slot 1 for chrominance.

int q\_scale\_factor[NUM\_QUANT\_TBLS]  
Linear quantization scaling factors (percentage, initialized 100) for use with jpeg\_default\_qtables().  
See rdswitch.c and cjpeg.c for an example of usage.  
Note that the q\_scale\_factor[] fields are the "linear" scales, so you have to convert from user-defined ratings via jpeg\_quality\_scaling().  
Here is an example code which corresponds to cjpeg -quality 90,70:

```
jpeg_set_defaults(cinfo);

/* Set luminance quality 90. */
cinfo->q_scale_factor[0] = jpeg_quality_scaling(90);
/* Set chrominance quality 70. */
cinfo->q_scale_factor[1] = jpeg_quality_scaling(70);

jpeg_default_qtables(cinfo, force_baseline);
```

CAUTION: You must also set 1x1 subsampling for efficient separate color quality selection, since the default value used by library is 2x2:

```
cinfo->comp_info[0].v_samp_factor = 1;
cinfo->comp_info[0].h_samp_factor = 1;
```

JHUFF\_TBL \* dc\_huff\_tbl\_ptrs[NUM\_HUFF\_TBLS]  
JHUFF\_TBL \* ac\_huff\_tbl\_ptrs[NUM\_HUFF\_TBLS]  
Pointers to Huffman coding tables, one per table slot, or NULL if no table is defined for a slot. Slots 0 and 1 are filled with the JPEG sample tables by jpeg\_set\_defaults(). If you need to allocate more table structures, jpeg\_alloc\_huff\_table() may be used.  
Note that optimal Huffman tables can be computed for an image

by setting `optimize_coding`, as discussed above; there's seldom any need to mess with providing your own Huffman tables.

The actual dimensions of the JPEG image that will be written to the file are given by the following fields. These are computed from the input image dimensions and the compression parameters by `jpeg_start_compress()`. You can also call `jpeg_calc_jpeg_dimensions()` to obtain the values that will result from the current parameter settings. This can be useful if you are trying to pick a scaling ratio that will get close to a desired target size.

`JDIMENSION jpeg_width` Actual dimensions of output image.  
`JDIMENSION jpeg_height`

Per-component parameters are stored in the struct `cinfo.comp_info[i]` for component number `i`. Note that components here refer to components of the JPEG color space, \*not\* the source image color space. A suitably large `comp_info[]` array is allocated by `jpeg_set_defaults()`; if you choose not to use that routine, it's up to you to allocate the array.

`int component_id`

The one-byte identifier code to be recorded in the JPEG file for this component. For the standard color spaces, we recommend you leave the default values alone.

`int h_samp_factor`

`int v_samp_factor`

Horizontal and vertical sampling factors for the component; must be 1..4 according to the JPEG standard. Note that larger sampling factors indicate a higher-resolution component; many people find this behavior quite unintuitive. The default values are 2,2 for luminance components and 1,1 for chrominance components, except for grayscale where 1,1 is used.

`int quant_tbl_no`

Quantization table number for component. The default value is 0 for luminance components and 1 for chrominance components.

`int dc_tbl_no`

`int ac_tbl_no`

DC and AC entropy coding table numbers. The default values are 0 for luminance components and 1 for chrominance components.

`int component_index`

Must equal the component's index in `comp_info[]`. (Beginning in

release v6, the compressor library will fill this in automatically;  
you don't have to.)

## Decompression parameter selection

-----

Decompression parameter selection is somewhat simpler than compression parameter selection, since all of the JPEG internal parameters are recorded in the source file and need not be supplied by the application. (Unless you are working with abbreviated files, in which case see "Abbreviated datastreams", below.) Decompression parameters control the postprocessing done on the image to deliver it in a format suitable for the application's use. Many of the parameters control speed/quality tradeoffs, in which faster decompression may be obtained at the price of a poorer-quality image. The defaults select the highest quality (slowest) processing.

The following fields in the JPEG object are set by `jpeg_read_header()` and may be useful to the application in choosing decompression parameters:

JDIMENSION `image_width` Width and height of image  
JDIMENSION `image_height`  
int `num_components` Number of color components  
J\_COLOR\_SPACE `jpeg_color_space` Colorspace of image  
boolean `saw_JFIF_marker` TRUE if a JFIF APP0 marker was seen  
UINT8 `JFIF_major_version` Version information from JFIF marker  
UINT8 `JFIF_minor_version`  
UINT8 `density_unit` Resolution data from JFIF marker  
UINT16 `X_density`  
UINT16 `Y_density`  
boolean `saw_Adobe_marker` TRUE if an Adobe APP14 marker was seen  
  
UINT8 `Adobe_transform` Color transform code from Adobe marker

The JPEG color space, unfortunately, is something of a guess since the JPEG standard proper does not provide a way to record it. In practice most files adhere to the JFIF or Adobe conventions, and the decoder will recognize these correctly. See "Special color spaces", below, for more info.

The decompression parameters that determine the basic properties of the returned image are:

J\_COLOR\_SPACE `out_color_space`  
Output color space. `jpeg_read_header()` sets an appropriate default based on `jpeg_color_space`; typically it will be RGB or grayscale.



The application can change this field to request output in a different colorspace. For example, set it to JCS\_GRAYSCALE to get grayscale output from a color file. (This is useful for previewing: grayscale output is faster than full color since the color components need not be processed.) Note that not all possible color space transforms are currently implemented; you may need to extend jdcoder.c if you want an unusual conversion.

unsigned int scale\_num, scale\_denom

Scale the image by the fraction scale\_num/scale\_denom. Currently, the supported scaling ratios are M/N with all M from 1 to 16, where N is the source DCT size, which is 8 for baseline JPEG. (The library design allows for arbitrary scaling ratios but this is not likely to be implemented any time soon.) The values are initialized by jpeg\_read\_header() with the source DCT size. For baseline JPEG this is 8/8. If you change only the scale\_num value while leaving the other unchanged, then this specifies the DCT scaled size to be applied on the given input. For baseline JPEG this is equivalent to M/8 scaling, since the source DCT size for baseline JPEG is 8. Smaller scaling ratios permit significantly faster decoding since fewer pixels need be processed and a simpler IDCT method can be used.

boolean quantize\_colors

If set TRUE, colormapped output will be delivered. Default is FALSE, meaning that full-color output will be delivered.

The next three parameters are relevant only if quantize\_colors is TRUE.

int desired\_number\_of\_colors

Maximum number of colors to use in generating a library-supplied color map (the actual number of colors is returned in a different field). Default 256. Ignored when the application supplies its own color map.

boolean two\_pass\_quantize

If TRUE, an extra pass over the image is made to select a custom color map for the image. This usually looks a lot better than the one-size-fits-all colormap that is used otherwise. Default is TRUE. Ignored when the application supplies its own color map.

J\_DITHER\_MODE dither\_mode

Selects color dithering method. Supported values are:

JDITHER\_NONE no dithering: fast, very low quality

JDITHER\_ORDERED ordered dither: moderate speed and quality

JDITHER\_FS Floyd-Steinberg dither: slow, high quality

Default is JDITHER\_FS. (At present, ordered dither is implemented only in the

single-pass, standard-colormap case. If you ask for ordered dither when `two_pass_quantize` is TRUE or when you supply an external color map, you'll get F-S dithering.)

When `quantize_colors` is TRUE, the target color map is described by the next two fields. `colormap` is set to NULL by `jpeg_read_header()`. The application can supply a color map by setting `colormap` non-NULL and setting `actual_number_of_colors` to the map size. Otherwise, `jpeg_start_decompress()` selects a suitable color map and sets these two fields itself.

[Implementation restriction: at present, an externally supplied colormap is only accepted for 3-component output color spaces.]

#### JSAMPARRAY colormap

The color map, represented as a 2-D pixel array of `out_color_components` rows and `actual_number_of_colors` columns. Ignored if not quantizing.

CAUTION: if the JPEG library creates its own colormap, the storage pointed to by this field is released by `jpeg_finish_decompress()`.

Copy the colormap somewhere else first, if you want to save it.

#### int actual\_number\_of\_colors

The number of colors in the color map.

Additional decompression parameters that the application may set include:

#### J\_DCT\_METHOD dct\_method

Selects the algorithm used for the DCT step. Choices are the same as described above for compression.

#### boolean do\_fancy\_upsampling

If TRUE, use direct DCT scaling with DCT size > 8 for upsampling of chroma components.

If FALSE, use only DCT size <= 8 and simple separate upsampling.

Default is TRUE.

For better image stability in multiple generation compression cycles it is preferable that this value matches the corresponding `do_fancy_downsampling` value in compression.

#### boolean do\_block\_smoothing

If TRUE, interblock smoothing is applied in early stages of decoding progressive JPEG files; if FALSE, not. Default is TRUE. Early progression stages look "fuzzy" with smoothing, "blocky" without.

In any case, block smoothing ceases to be applied after the first few AC coefficients are known

to full accuracy, so it is relevant only

when using buffered-image mode for progressive images.

#### boolean enable\_1pass\_quant

boolean enable\_external\_quant

boolean enable\_2pass\_quant

These are significant only in buffered-image mode, which is described in its own section below.

The output image dimensions are given by the following fields. These are computed from the source image dimensions and the decompression parameters by jpeg\_start\_decompress(). You can also call jpeg\_calc\_output\_dimensions() to obtain the values that will result from the current parameter settings.

This can be useful if you are trying to pick a scaling ratio that will get close to a desired target size. It's also important if you are using the JPEG library's memory manager to allocate output buffer space, because you are supposed to request such buffers \*before\* jpeg\_start\_decompress().

JDIMENSION output\_width Actual dimensions of output image.

JDIMENSION output\_height

int out\_color\_components Number of color components in out\_color\_space.

int output\_components Number of color components returned.

int rec\_outbuf\_height Recommended height of scanline buffer.

When quantizing colors, output\_components is 1, indicating a single color map index per pixel. Otherwise it equals out\_color\_components. The output arrays are required to be output\_width \* output\_components JSAMPLEs wide.

rec\_outbuf\_height is the recommended minimum height (in scanlines) of the buffer passed to jpeg\_read\_scanlines(). If the buffer is smaller, the library will still work, but time will be wasted due to unnecessary data copying. In high-quality modes, rec\_outbuf\_height is always 1, but some faster, lower-quality modes set it to larger values (typically 2 to 4).

If you are going to ask for a high-speed processing mode, you may as well go to the trouble of honoring rec\_outbuf\_height so as to avoid data copying. (An output buffer larger than rec\_outbuf\_height lines is OK, but won't provide any material speed improvement over that height.)

Special color spaces

-----

The JPEG standard itself is "color blind" and doesn't specify any particular color space. It is customary to convert color data to a luminance/chrominance color space before compressing, since this permits greater compression. The existing JPEG file interchange format standards specify YCbCr or GRAYSCALE data (JFIF version 1), GRAYSCALE, RGB, YCbCr, CMYK, or YCCK (Adobe), or BG\_RGB or BG\_YCC (big gamut color spaces, JFIF version 2). For special applications such as multispectral images, other color spaces can be used,

but it must be understood that such files will be unportable.

The JPEG library can handle the most common colorspace conversions (namely RGB  $\Leftrightarrow$  YCbCr and CMYK  $\Leftrightarrow$  YCCK). It can also deal with data of an unknown color space, passing it through without conversion. If you deal extensively with an unusual color space, you can easily extend the library to understand additional color spaces and perform appropriate conversions.

For compression, the source data's color space is specified by field `in_color_space`. This is transformed to the JPEG file's color space given by `jpeg_color_space`. `jpeg_set_defaults()` chooses a reasonable JPEG color space depending on `in_color_space`, but you can override this by calling `jpeg_set_colorspace()`. Of course you must select a supported transformation. `jpegcolor.c` currently supports the following transformations:

RGB  $\Rightarrow$  YCbCr

RGB  $\Rightarrow$  GRAYSCALE

RGB  $\Rightarrow$  BG\_YCC

YCbCr  $\Rightarrow$  GRAYSCALE

YCbCr  $\Rightarrow$  BG\_YCC

CMYK  $\Rightarrow$  YCCK

plus the null transforms: GRAYSCALE  $\Rightarrow$  GRAYSCALE, RGB  $\Rightarrow$  RGB, BG\_RGB  $\Rightarrow$  BG\_RGB, YCbCr  $\Rightarrow$  YCbCr, BG\_YCC  $\Rightarrow$  BG\_YCC, CMYK  $\Rightarrow$  CMYK, YCCK  $\Rightarrow$  YCCK, and UNKNOWN  $\Rightarrow$  UNKNOWN.

The file interchange format standards (JFIF and Adobe) specify APPn markers that indicate the color space of the JPEG file. It is important to ensure that these are written correctly, or omitted if the JPEG file's color space is not one of the ones supported by the interchange standards.

`jpeg_set_colorspace()` will set the compression parameters to include or omit the APPn markers properly, so long as it is told the truth about the JPEG color space. For example, if you are writing some random 3-component color space without conversion, don't try to fake out the library by setting `in_color_space` and `jpeg_color_space` to `JCS_YCbCr`; use `JCS_UNKNOWN`. You may want to write an APPn marker of your own devising to identify the colorspace --- see "Special markers", below.

When told that the color space is UNKNOWN, the library will default to using luminance-quality compression parameters for all color components. You may well want to change these parameters. See the source code for `jpeg_set_colorspace()`, in `jpegparam.c`, for details.

For decompression, the JPEG file's color space is given in `jpeg_color_space`, and this is transformed to the output color space `out_color_space`. `jpeg_read_header's` setting of `jpeg_color_space` can be relied on if the file conforms to JFIF

or Adobe conventions, but otherwise it is no better than a guess. If you know the JPEG file's color space for certain, you can override `jpeg_read_header`'s guess by setting `jpeg_color_space`. `jpeg_read_header` also selects a default output color space based on (its guess of) `jpeg_color_space`; set `out_color_space` to override this. Again, you must select a supported transformation. `jdcolor.c` currently supports

YCbCr => RGB

YCbCr => GRAYSCALE

BG\_YCC => RGB

BG\_YCC => GRAYSCALE

RGB => GRAYSCALE

GRAYSCALE => RGB

YCCK => CMYK

as well as the null transforms. (Since `GRAYSCALE=>RGB` is provided, an application can force grayscale JPEGs to look like color JPEGs if it only wants to handle one case.)

The two-pass color quantizer, `jquant2.c`, is specialized to handle RGB data (it weights distances appropriately for RGB colors). You'll need to modify the code if you want to use it for non-RGB output color spaces. Note that `jquant2.c` is used to map to an application-supplied colormap as well as for the normal two-pass colormap selection process.

CAUTION: it appears that Adobe Photoshop writes inverted data in CMYK JPEG files: 0 represents 100% ink coverage, rather than 0% ink as you'd expect. This is arguably a bug in Photoshop, but if you need to work with Photoshop CMYK files, you will have to deal with it in your application. We cannot "fix" this in the library by inverting the data during the `CMYK<=>YCCK` transform, because that would break other applications, notably Ghostscript. Photoshop versions prior to 3.0 write EPS files containing JPEG-encoded CMYK data in the same inverted-YCCK representation used in bare JPEG files, but the surrounding PostScript code performs an inversion using the PS image operator. I am told that Photoshop 3.0 will write uninverted YCCK in EPS/JPEG files, and will omit the PS-level inversion. (But the data polarity used in bare JPEG files will not change in 3.0.) In either case, the JPEG library must not invert the data itself, or else Ghostscript would read these EPS files incorrectly.

#### Error handling

-----

When the default error handler is used, any error detected inside the JPEG routines will cause a message to be printed on `stderr`, followed by `exit()`. You can supply your own error handling routines to override this behavior and to control the treatment of nonfatal warnings and trace/debug messages.

The file `example.c` illustrates the most common case, which is to have the application regain control after an error rather than exiting.

The JPEG library never writes any message directly; it always goes through the error handling routines. Three classes of messages are recognized:

- \* Fatal errors: the library cannot continue.
- \* Warnings: the library can continue, but the data is corrupt, and a damaged output image is likely to result.
- \* Trace/informational messages. These come with a trace level indicating the importance of the message; you can control the verbosity of the program by adjusting the maximum trace level that will be displayed.

You may, if you wish, simply replace the entire JPEG error handling module (`jerror.c`) with your own code. However, you can avoid code duplication by only replacing some of the routines depending on the behavior you need. This is accomplished by calling `jpeg_std_error()` as usual, but then overriding some of the method pointers in the `jpeg_error_mgr` struct, as illustrated by `example.c`.

All of the error handling routines will receive a pointer to the JPEG object (a `j_common_ptr` which points to either a `jpeg_compress_struct` or a `jpeg_decompress_struct`; if you need to tell which, test the `is_decompressor` field). This struct includes a pointer to the error manager struct in its "err" field. Frequently, custom error handler routines will need to access additional data which is not known to the JPEG library or the standard error handler. The most convenient way to do this is to embed either the JPEG object or the `jpeg_error_mgr` struct in a larger structure that contains additional fields; then casting the passed pointer provides access to the additional fields. Again, see `example.c` for one way to do it. (Beginning with IJG version 6b, there is also a void pointer "client\_data" in each JPEG object, which the application can also use to find related data. The library does not touch `client_data` at all.)

The individual methods that you might wish to override are:

`error_exit (j_common_ptr cinfo)`

Receives control for a fatal error. Information sufficient to generate the error message has been stored in `cinfo->err`; call `output_message` to display it. Control must NOT return to the caller; generally this routine will `exit()` or `longjmp()` somewhere. Typically you would override this routine to get rid of the `exit()` default behavior. Note that if you continue processing, you should clean up the JPEG object with `jpeg_abort()` or `jpeg_destroy()`.

`output_message (j_common_ptr cinfo)`

Actual output of any JPEG message.

Override this to send messages somewhere other than stderr. Note that this method does not know how to generate a message, only where to send it.

`format_message (j_common_ptr cinfo, char * buffer)`

Constructs a readable error message string based on the error info stored in `cinfo->err`. This method is called by `output_message`. Few applications should need to override this method. One possible reason for doing so is to implement dynamic switching of error message language.

`emit_message (j_common_ptr cinfo, int msg_level)`

Decide whether or not to emit a warning or trace message; if so, calls `output_message`. The main reason for overriding this method would be to abort on warnings. `msg_level` is -1 for warnings, 0 and up for trace messages.

Only `error_exit()` and `emit_message()` are called from the rest of the JPEG library; the other two are internal to the error handler.

The actual message texts are stored in an array of strings which is pointed to by the field `err->jpeg_message_table`.

The messages are numbered from 0 to `err->last_jpeg_message`, and it is these code numbers that are used in the JPEG library code. You could replace the message texts (for instance, with messages in French or German) by changing the message table pointer. See `jerror.h` for the default texts. CAUTION: this table will almost certainly change or grow from one library version to the next.

It may be useful for an application to add its own message texts that are handled by the same mechanism. The error handler supports a second "add-on" message table for this purpose. To define an addon table, set the pointer `err->addon_message_table` and the message numbers `err->first_addon_message` and `err->last_addon_message`. If you number the addon messages beginning at 1000 or so, you won't have to worry about conflicts with the library's built-in messages. See the sample applications `cjpeg/djpeg` for an example of using addon messages (the addon messages are defined in `cderror.h`).

Actual

invocation of the error handler is done via macros defined in `jerror.h`:

`ERREXITn(...)` for fatal errors

`WARNMSn(...)` for corrupt-data warnings

`TRACEMSn(...)` for trace and informational messages.

These macros store the message code and any additional parameters into the error handler struct, then invoke the `error_exit()` or `emit_message()` method.

The variants of each macro are for varying numbers of additional parameters.

The additional parameters are inserted into the generated message using standard `printf()` format codes.

See jerror.h and jerror.c for further details.

#### Compressed data handling (source and destination managers)

-----

The JPEG compression library sends its compressed data to a "destination manager" module. The default destination manager just writes the data to a memory buffer or to a stdio stream, but you can provide your own manager to do something else. Similarly, the decompression library calls a "source manager" to obtain the compressed data; you can provide your own source manager if you want the data to come from somewhere other than a memory buffer or a stdio stream.

In both cases, compressed data is processed a bufferload at a time: the destination or source manager provides a work buffer, and the library invokes the manager only when the buffer is filled or emptied. (You could define a one-character buffer to force the manager to be invoked for each byte, but that would be rather inefficient.) The buffer's size and location are controlled by the manager, not by the library. For example, the memory source manager just makes the buffer pointer and length point to the original data in memory. In this case the buffer-reload procedure will be invoked only if the decompressor ran off the end of the datastream, which would indicate an erroneous datastream.

The work buffer is defined as an array of datatype JOCTET, which is generally "char" or "unsigned char". On a machine where char is not exactly 8 bits wide, you must define JOCTET as a wider data type and then modify the data source and destination modules to transcribe the work arrays into 8-bit units on external storage.

A data destination manager struct contains a pointer and count defining the next byte to write in the work buffer and the remaining free space:

```
JOCTET * next_output_byte; /* => next byte to write in buffer */
size_t free_in_buffer;    /* # of byte spaces remaining in buffer */
```

The library increments the pointer and decrements the count until the buffer is filled. The manager's empty\_output\_buffer method must reset the pointer and count. The manager is expected to remember the buffer's starting address and total size in private fields not visible to the library.

A data destination manager provides three methods:

```
init_destination (j_compress_ptr cinfo)
```



Initialize destination. This is called by `jpeg_start_compress()` before any data is actually written. It must initialize `next_output_byte` and `free_in_buffer`. `free_in_buffer` must be initialized to a positive value.

`empty_output_buffer (j_compress_ptr cinfo)`

This is called whenever the buffer has filled (`free_in_buffer` reaches zero). In typical applications, it should write out the \*entire\* buffer (use the saved start address and buffer length; ignore the current state of `next_output_byte` and `free_in_buffer`). Then reset the pointer & count to the start of the buffer, and return TRUE indicating that the buffer has been dumped. `free_in_buffer` must be set to a positive value when TRUE is returned. A FALSE return should only be used when I/O suspension is desired (this operating mode is discussed in the next section).

`term_destination (j_compress_ptr cinfo)`

Terminate destination --- called by `jpeg_finish_compress()` after all data has been written. In most applications, this must flush any data remaining in the buffer. Use either `next_output_byte` or `free_in_buffer` to determine how much data is in the buffer.

`term_destination()` is NOT called by `jpeg_abort()` or `jpeg_destroy()`. If you want the destination manager to be cleaned up during an abort, you must do it yourself.

You will also need code to create a `jpeg_destination_mgr` struct, fill in its method pointers, and insert a pointer to the struct into the "dest" field of the JPEG compression object. This can be done in-line in your setup code if you like, but it's probably cleaner to provide a separate routine similar to the `jpeg_stdio_dest()` or `jpeg_mem_dest()` routines of the supplied destination managers.

Decompression source managers follow a parallel design, but with some additional frammishes. The source manager struct contains a pointer and count defining the next byte to read from the work buffer and the number of bytes remaining:

```
const JOCTET * next_input_byte; /* => next byte to read from buffer */
size_t bytes_in_buffer;      /* # of bytes remaining in buffer */
```

The library increments the pointer and decrements the count until the buffer is emptied. The manager's `fill_input_buffer` method must reset the pointer and count. In most applications, the manager must remember the buffer's starting address and total size in private fields not visible to the library.

A data source manager provides five methods:

`init_source (j_decompress_ptr cinfo)`

Initialize source. This is called by `jpeg_read_header()` before any data is actually read. Unlike `init_destination()`, it may leave `bytes_in_buffer` set to 0 (in which case a `fill_input_buffer()` call will occur immediately).

`fill_input_buffer (j_decompress_ptr cinfo)`

This is called whenever `bytes_in_buffer` has reached zero and more data is wanted. In typical applications, it should read fresh data into the buffer (ignoring the current state of `next_input_byte` and `bytes_in_buffer`), reset the pointer & count to the start of the buffer, and return TRUE indicating that the buffer has been reloaded. It is not necessary to fill the buffer entirely, only to obtain at least one more byte. `bytes_in_buffer` MUST be set to a positive value if TRUE is returned. A FALSE return should only be used when I/O suspension is desired (this mode is discussed in the next section).

`skip_input_data (j_decompress_ptr cinfo, long num_bytes)`

Skip `num_bytes` worth of data. The buffer pointer and count should be advanced over `num_bytes` input bytes, refilling the buffer as needed. This is used to skip over a potentially large amount of uninteresting data (such as an APPn marker). In some applications it may be possible to optimize away the reading of the skipped data, but it's not clear that being smart is worth much trouble; large skips are uncommon. `bytes_in_buffer` may be zero on return. A zero or negative skip count should be treated as a no-op.

`resync_to_restart (j_decompress_ptr cinfo, int desired)`

This routine is called only when the decompressor has failed to find a restart (RSTn) marker where one is expected. Its mission is to find a suitable point for resuming decompression. For most applications, we recommend that you just use the default resync procedure, `jpeg_resync_to_restart()`. However, if you are able to back up in the input data stream, or if you have a-priori knowledge about the likely location of restart markers, you may be able to do better. Read the `read_restart_marker()` and `jpeg_resync_to_restart()` routines in `jdmarker.c` if you think you'd like to implement your own resync procedure.

`term_source (j_decompress_ptr cinfo)`

Terminate source --- called by `jpeg_finish_decompress()` after all data has been read. Often a no-op.

For both `fill_input_buffer()` and `skip_input_data()`, there is no such thing as an EOF return. If the end of the file has been reached, the routine has a choice of exiting via `ERREXIT()` or inserting fake data into the buffer. In most cases, generating a warning message and inserting a fake EOI marker is the best course of action --- this will allow the decompressor to output however much of the image is there. In pathological cases, the decompressor may swallow the EOI and again demand data ... just keep feeding it fake EOIs. `jdatasrc.c` illustrates the recommended error recovery behavior.

`term_source()` is NOT called by `jpeg_abort()` or `jpeg_destroy()`. If you want the source manager to be cleaned up during an abort, you must do it yourself.

You will also need code to create a `jpeg_source_mgr` struct, fill in its method pointers, and insert a pointer to the struct into the "src" field of the JPEG decompression object. This can be done in-line in your setup code if you like, but it's probably cleaner to provide a separate routine similar to the `jpeg_stdio_src()` or `jpeg_mem_src()` routines of the supplied source managers.

For more information, consult the memory and stdio source and destination managers in `jdatasrc.c` and `jdatadst.c`.

#### I/O suspension

-----

Some applications need to use the JPEG library as an incremental memory-to-memory

filter: when the compressed data buffer is filled or emptied, they want control to return to the outer loop, rather than expecting that the buffer can be emptied or reloaded within the data source/destination manager subroutine. The library supports this need by providing an "I/O suspension" mode, which we describe in this section.

The I/O suspension mode is not a panacea: nothing is guaranteed about the maximum amount of time spent in any one call to the library, so it will not eliminate response-time problems in single-threaded applications. If you need guaranteed response time, we suggest you "bite the bullet" and implement a real multi-tasking capability.

To use I/O suspension, cooperation is needed between the calling application and the data source or destination manager; you will always need a custom source/destination manager. (Please read the previous section if you haven't already.) The basic idea is that the `empty_output_buffer()` or `fill_input_buffer()` routine is a no-op, merely returning `FALSE` to indicate that it has done nothing. Upon seeing this, the JPEG library suspends operation and returns to its caller. The surrounding application is

responsible for emptying or refilling the work buffer before calling the JPEG library again.

Compression suspension:

For compression suspension, use an `empty_output_buffer()` routine that returns `FALSE`; typically it will not do anything else. This will cause the compressor to return to the caller of `jpeg_write_scanlines()`, with the return value indicating that not all the supplied scanlines have been accepted. The application must make more room in the output buffer, adjust the output buffer pointer/count appropriately, and then call `jpeg_write_scanlines()` again, pointing to the first unconsumed scanline.

When forced to suspend, the compressor will backtrack to a convenient stopping point (usually the start of the current MCU); it will regenerate some output data when restarted. Therefore, although `empty_output_buffer()` is only called when the buffer is filled, you should NOT write out the entire buffer after a suspension. Write only the data up to the current position of `next_output_byte/free_in_buffer`. The data beyond that point will be regenerated after resumption.

Because of the backtracking behavior, a good-size output buffer is essential for efficiency; you don't want the compressor to suspend often. (In fact, an overly small buffer could lead to infinite looping, if a single MCU required more data than would fit in the buffer.) We recommend a buffer of at least several Kbytes. You may want to insert explicit code to ensure that you don't call `jpeg_write_scanlines()` unless there is a reasonable amount of space in the output buffer; in other words, flush the buffer before trying to compress more data.

The compressor does not allow suspension while it is trying to write JPEG markers at the beginning and end of the file. This means that:

- \* At the beginning of a compression operation, there must be enough free space in the output buffer to hold the header markers (typically 600 or so bytes). The recommended buffer size is bigger than this anyway, so this is not a problem as long as you start with an empty buffer. However, this restriction might catch you if you insert large special markers, such as a JFIF thumbnail image, without flushing the buffer afterwards.
- \* When you call `jpeg_finish_compress()`, there must be enough space in the output buffer to emit any buffered data and the final EOI marker. In the current implementation, half a dozen bytes should suffice for this, but for safety's sake we recommend ensuring that at least 100 bytes are free before calling `jpeg_finish_compress()`.

A more significant restriction is that `jpeg_finish_compress()` cannot suspend. This means you cannot use suspension with multi-pass operating modes, namely

Huffman code optimization and multiple-scan output. Those modes write the whole file during `jpeg_finish_compress()`, which will certainly result in buffer overrun. (Note that this restriction applies only to compression, not decompression. The decompressor supports input suspension in all of its operating modes.)

Decompression suspension:

For decompression suspension, use a `fill_input_buffer()` routine that simply returns `FALSE` (except perhaps during error recovery, as discussed below). This will cause the decompressor to return to its caller with an indication that suspension has occurred. This can happen at four places:

- \* `jpeg_read_header()`: will return `JPEG_SUSPENDED`.
- \* `jpeg_start_decompress()`: will return `FALSE`, rather than its usual `TRUE`.
- \* `jpeg_read_scanlines()`: will return the number of scanlines already completed (possibly 0).
- \* `jpeg_finish_decompress()`: will return `FALSE`, rather than its usual `TRUE`.

The surrounding application must recognize these cases, load more data into the input buffer, and repeat the call. In the case of `jpeg_read_scanlines()`, increment the passed pointers past any scanlines successfully read.

Just as with compression, the decompressor will typically backtrack to a convenient restart point before suspending. When `fill_input_buffer()` is called, `next_input_byte/bytes_in_buffer` point to the current restart point, which is where the decompressor will backtrack to if `FALSE` is returned. The data beyond that position must NOT be discarded if you suspend; it needs to be re-read upon resumption. In most implementations, you'll need to shift this data down to the start of your work buffer and then load more data after it. Again, this behavior means that a several-Kbyte work buffer is essential for decent performance; furthermore, you should load a reasonable amount of new data before resuming decompression. (If you loaded, say, only one new byte each time around, you could waste a LOT of cycles.)

The `skip_input_data()` source manager routine requires special care in a suspension scenario.

This routine is NOT granted the ability to suspend the decompressor; it can decrement `bytes_in_buffer` to zero, but no more. If the requested skip distance exceeds the amount of data currently in the input buffer, then `skip_input_data()` must set `bytes_in_buffer` to zero and record the additional skip distance somewhere else. The decompressor will immediately call `fill_input_buffer()`, which should return `FALSE`, which will cause a suspension return. The surrounding application must then arrange to discard the recorded number of bytes before it resumes loading the input buffer. (Yes, this design is rather baroque, but it avoids complexity in the far more common case where a non-suspending source manager is used.)

If the input data has been exhausted, we recommend that you emit a warning and insert dummy EOI markers just as a non-suspending data source manager would do. This can be handled either in the surrounding application logic or within `fill_input_buffer()`; the latter is probably more efficient. If `fill_input_buffer()` knows that no more data is available, it can set the pointer/count to point to a dummy EOI marker and then return `TRUE` just as though it had read more data in a non-suspending situation.

The decompressor does not attempt to suspend within standard JPEG markers; instead it will backtrack to the start of the marker and reprocess the whole marker next time. Hence the input buffer must be large enough to hold the longest standard marker in the file. Standard JPEG markers should normally not exceed a few hundred bytes each (DHT tables are typically the longest). We recommend at least a 2K buffer for performance reasons, which is much larger than any correct marker is likely to be. For robustness against damaged marker length counts, you may wish to insert a test in your application for the case that the input buffer is completely full and yet the decoder has suspended without consuming any data --- otherwise, if this situation did occur, it would lead to an endless loop. (The library can't provide this test since it has no idea whether "the buffer is full", or even whether there is a fixed-size input buffer.)

The input buffer would need to be 64K to allow for arbitrary COM or APPn markers, but these are handled specially: they are either saved into allocated memory, or skipped over by calling `skip_input_data()`. In the former case, suspension is handled correctly, and in the latter case, the problem of buffer overrun is placed on `skip_input_data`'s shoulders, as explained above. Note that if you provide your own marker handling routine for large markers, you should consider how to deal with buffer overflow.

Multiple-buffer management:

In some applications it is desirable to store the compressed data in a linked list of buffer areas, so as to avoid data copying. This can be handled by having `empty_output_buffer()` or `fill_input_buffer()` set the pointer and count to reference the next available buffer; `FALSE` is returned only if no more buffers are available. Although seemingly straightforward, there is a pitfall in this approach: the backtrack that occurs when `FALSE` is returned could back up into an earlier buffer. For example, when `fill_input_buffer()` is called, the current pointer & count indicate the backtrack restart point. Since `fill_input_buffer()` will set the pointer and count to refer to a new buffer, the restart position must be saved somewhere else. Suppose a second call to `fill_input_buffer()` occurs in the same library call, and no additional input data is available, so `fill_input_buffer` must return `FALSE`. If the JPEG library has not moved the pointer/count forward in the current

buffer, then \*the correct restart point is the saved position in the prior buffer\*. Prior buffers may be discarded only after the library establishes a restart point within a later buffer. Similar remarks apply for output into a chain of buffers.

The library will never attempt to backtrack over a `skip_input_data()` call, so any skipped data can be permanently discarded. You still have to deal with the case of skipping not-yet-received data, however.

It's much simpler to use only a single buffer; when `fill_input_buffer()` is called, move any unconsumed data (beyond the current pointer/count) down to the beginning of this buffer and then load new data into the remaining buffer space. This approach requires a little more data copying but is far easier to get right.

### Progressive JPEG support

-----

Progressive JPEG rearranges the stored data into a series of scans of increasing quality. In situations where a JPEG file is transmitted across a slow communications link, a decoder can generate a low-quality image very quickly from the first scan, then gradually improve the displayed quality as more scans are received. The final image after all scans are complete is identical to that of a regular (sequential) JPEG file of the same quality setting. Progressive JPEG files are often slightly smaller than equivalent sequential JPEG files, but the possibility of incremental display is the main reason for using progressive JPEG.

The IJG encoder library generates progressive JPEG files when given a suitable "scan script" defining how to divide the data into scans. Creation of progressive JPEG files is otherwise transparent to the encoder. Progressive JPEG files can also be read transparently by the decoder library. If the decoding application simply uses the library as defined above, it will receive a final decoded image without any indication that the file was progressive. Of course, this approach does not allow incremental display. To perform incremental display, an application needs to use the decoder library's "buffered-image" mode, in which it receives a decoded image multiple times.

Each displayed scan requires about as much work to decode as a full JPEG image of the same size, so the decoder must be fairly fast in relation to the data transmission rate in order to make incremental display useful. However, it is possible to skip displaying the image and simply add the incoming bits to the decoder's coefficient buffer. This is fast because only Huffman

decoding need be done, not IDCT, upsampling, colorspace conversion, etc. The IJG decoder library allows the application to switch dynamically between displaying the image and simply absorbing the incoming bits. A properly coded application can automatically adapt the number of display passes to suit the time available as the image is received. Also, a final higher-quality display cycle can be performed from the buffered data after the end of the file is reached.

#### Progressive compression:

To create a progressive JPEG file (or a multiple-scan sequential JPEG file), set the scan\_info cinfo field to point to an array of scan descriptors, and perform compression as usual. Instead of constructing your own scan list, you can call the jpeg\_simple\_progression() helper routine to create a recommended

progression sequence; this method should be used by all applications that don't want to get involved in the nitty-gritty of progressive scan sequence design. (If you want to provide user control of scan sequences, you may wish to borrow the scan script reading code found in rdswitch.c, so that you can read scan script files just like cjpeg's.)

When scan\_info is not NULL, the compression library will store DCT'd data into a buffer array as jpeg\_write\_scanlines() is called, and will emit all the requested scans during jpeg\_finish\_compress(). This implies that multiple-scan output cannot be created with a suspending data destination manager, since jpeg\_finish\_compress() does not support suspension. We should also note that the compressor currently forces Huffman optimization mode when creating a progressive JPEG file, because the default Huffman tables are unsuitable for progressive files.

#### Progressive decompression:

When buffered-image mode is not used, the decoder library will read all of a multi-scan file during jpeg\_start\_decompress(), so that it can provide a final decoded image. (Here "multi-scan" means either progressive or multi-scan sequential.) This makes multi-scan files transparent to the decoding application. However, existing applications that used suspending input with version 5 of the IJG library will need to be modified to check for a suspension return from jpeg\_start\_decompress().

To perform incremental display, an application must use the library's buffered-image mode. This is described in the next section.

#### Buffered-image mode

-----

In buffered-image mode, the library stores the partially decoded image in a



coefficient buffer, from which it can be read out as many times as desired. This mode is typically used for incremental display of progressive JPEG files, but it can be used with any JPEG file. Each scan of a progressive JPEG file adds more data (more detail) to the buffered image. The application can display in lockstep with the source file (one display pass per input scan), or it can allow input processing to outrun display processing. By making input and display processing run independently, it is possible for the application to adapt progressive display to a wide range of data transmission rates.

The basic control flow for buffered-image decoding is

```
jpeg_create_decompress()
set data source
jpeg_read_header()
set overall decompression parameters
cinfo.buffered_image = TRUE; /* select buffered-image mode */
jpeg_start_decompress()
for (each output pass) {
    adjust output decompression parameters if required
    jpeg_start_output() /* start a new output pass */
    for (all scanlines in image) {
        jpeg_read_scanlines()
        display scanlines
    }
    jpeg_finish_output() /* terminate output pass */
}
jpeg_finish_decompress()
jpeg_destroy_decompress()
```

This differs from ordinary unbuffered decoding in that there is an additional level of looping. The application can choose how many output passes to make and how to display each pass.

The simplest approach to displaying progressive images is to do one display pass for each scan appearing in the input file. In this case the outer loop condition is typically

```
while (! jpeg_input_complete(&cinfo))
```

and the start-output call should read

```
jpeg_start_output(&cinfo, cinfo.input_scan_number);
```

The second parameter to `jpeg_start_output()` indicates which scan of the input file is to be displayed; the scans are numbered starting at 1 for this purpose. (You can use a loop counter starting at 1 if you like, but using the library's input scan counter is easier.) The library automatically reads data as necessary to complete each requested scan, and `jpeg_finish_output()` advances to the next scan or end-of-image marker (hence `input_scan_number`

will be incremented by the time control arrives back at jpeg\_start\_output(). With this technique, data is read from the input file only as needed, and input and output processing run in lockstep.

After reading the final scan and reaching the end of the input file, the buffered image remains available; it can be read additional times by repeating the jpeg\_start\_output()/jpeg\_read\_scanlines()/jpeg\_finish\_output() sequence. For example, a useful technique is to use fast one-pass color quantization for display passes made while the image is arriving, followed by a final display pass using two-pass quantization for highest quality. This is done by changing the library parameters before the final output pass. Changing parameters between passes is discussed in detail below.

In general the last scan of a progressive file cannot be recognized as such until after it is read, so a post-input display pass is the best approach if you want special processing in the final pass.

When done with the image, be sure to call jpeg\_finish\_decompress() to release the buffered image (or just use jpeg\_destroy\_decompress()).

If input data arrives faster than it can be displayed, the application can cause the library to decode input data in advance of what's needed to produce output. This is done by calling the routine jpeg\_consume\_input().

The return value is one of the following:

JPEG\_REACHED\_SOS: reached an SOS marker (the start of a new scan)

JPEG\_REACHED\_EOI: reached the EOI marker (end of image)

JPEG\_ROW\_COMPLETED: completed reading one MCU row of compressed data

JPEG\_SCAN\_COMPLETED: completed reading last MCU row of current scan

JPEG\_SUSPENDED: suspended before completing any of the above

(JPEG\_SUSPENDED can occur only if a suspending data source is used.) This

routine can be called at any time after initializing the JPEG object. It

reads some additional data and returns when one of the indicated significant

events occurs. (If called after the EOI marker is reached, it will

immediately return JPEG\_REACHED\_EOI without attempting to read more data.)

The library's output processing will automatically call jpeg\_consume\_input() whenever

the output processing overtakes the input; thus, simple lockstep display requires no direct calls to jpeg\_consume\_input(). But by adding calls to jpeg\_consume\_input(), you can absorb data in advance of what is being displayed. This has two benefits:

- \* You can limit buildup of unprocessed data in your input buffer.
- \* You can eliminate extra display passes by paying attention to the state of the library's input processing.

The first of these benefits only requires interspersing calls to

jpeg\_consume\_input() with your display operations and any other processing you may be doing. To avoid wasting cycles due to backtracking, it's best to call jpeg\_consume\_input() only after a hundred or so new bytes have arrived. This is discussed further under "I/O suspension", above. (Note: the JPEG library currently is not thread-safe. You must not call jpeg\_consume\_input() from one thread of control if a different library routine is working on the same JPEG object in another thread.)

When input arrives fast enough that more than one new scan is available before you start a new output pass, you may as well skip the output pass corresponding to the completed scan. This occurs for free if you pass cinfo.input\_scan\_number as the target scan number to jpeg\_start\_output(). The input\_scan\_number field is simply the index of the scan currently being consumed by the input processor. You can ensure that this is up-to-date by emptying the input buffer just before calling jpeg\_start\_output(): call jpeg\_consume\_input() repeatedly until it returns JPEG\_SUSPENDED or JPEG\_REACHED\_EOI.

The target scan number passed to jpeg\_start\_output() is saved in the cinfo.output\_scan\_number field. The library's output processing calls jpeg\_consume\_input() whenever the current input scan number and row within that scan is less than or equal to the current output scan number and row. Thus, input processing can "get ahead" of the output processing but is not allowed to "fall behind".

You can achieve several different effects by manipulating this interlock rule. For example, if you pass a target scan number greater than the current input scan number, the output processor will wait until that scan starts to arrive before producing any output. (To avoid an infinite loop, the target scan number is automatically reset to the last scan number when the end of image is reached. Thus, if you specify a large target scan number, the library will just absorb the entire input file and then perform an output pass. This is effectively the same as what jpeg\_start\_decompress() does when you don't select buffered-image mode.) When you pass a target scan number equal to the current input scan number, the image is displayed no faster than the current input scan arrives. The final possibility is to pass a target scan number less than the current input scan number; this disables the input/output interlock and causes the output processor to simply display whatever it finds in the image buffer, without waiting for input. (However, the library will not accept a target scan number less than one, so you can't avoid waiting for the first scan.)

When data is arriving faster than the output display processing can advance through the image, jpeg\_consume\_input() will store data into the buffered image beyond the point at which the output processing is reading data out again. If the input arrives fast enough, it may "wrap around" the buffer to the point where the input is more than one whole scan ahead of the output.

If the output processing simply proceeds through its display pass without paying attention to the input, the effect seen on-screen is that the lower part of the image is one or more scans better in quality than the upper part. Then, when the next output scan is started, you have a choice of what target scan number to use. The recommended choice is to use the current input scan number at that time, which implies that you've skipped the output scans corresponding to the input scans that were completed while you processed the previous output scan. In this way, the decoder automatically adapts its speed to the arriving data, by skipping output scans as necessary to keep up with the arriving data.

When using this strategy, you'll want to be sure that you perform a final output pass after receiving all the data; otherwise your last display may not be full quality across the whole screen. So the right outer loop logic is something like this:

```
do {
    absorb any waiting input by calling jpeg_consume_input()
    final_pass = jpeg_input_complete(&cinfo);
    adjust output decompression parameters if required
    jpeg_start_output(&cinfo, cinfo.input_scan_number);
    ...
    jpeg_finish_output()
} while (! final_pass);
```

rather than quitting as soon as `jpeg_input_complete()` returns TRUE. This arrangement makes it simple to use higher-quality decoding parameters for the final pass. But if you don't want to use special parameters for the

final pass, the right loop logic is like this:

```
for (;;) {
    absorb any waiting input by calling jpeg_consume_input()
    jpeg_start_output(&cinfo, cinfo.input_scan_number);
    ...
    jpeg_finish_output()
    if (jpeg_input_complete(&cinfo) &&
        cinfo.input_scan_number == cinfo.output_scan_number)
        break;
}
```

In this case you don't need to know in advance whether an output pass is to be the last one, so it's not necessary to have reached EOF before starting the final output pass; rather, what you want to test is whether the output pass was performed in sync with the final input scan. This form of the loop will avoid an extra output pass whenever the decoder is able (or nearly able) to keep up with the incoming data.

When the data transmission speed is high, you might begin a display pass, then find that much or all of the file has arrived before you can complete the pass. (You can detect this by noting the `JPEG_REACHED_EOI` return code

from `jpeg_consume_input()`,  
or equivalently by testing `jpeg_input_complete()`.)

In this situation you may wish to abort the current display pass and start a new one using the newly arrived information. To do so, just call `jpeg_finish_output()` and then start a new pass with `jpeg_start_output()`.

A variant strategy is to abort and restart display if more than one complete scan arrives during an output pass; this can be detected by noting `JPEG_REACHED_SOS` returns and/or examining `cinfo.input_scan_number`. This idea should be employed with caution, however, since the display process might never get to the bottom of the image before being aborted, resulting in the lower part of the screen being several passes worse than the upper. In most cases it's probably best to abort an output pass only if the whole file has arrived and you want to begin the final output pass immediately.

When receiving data across a communication link, we recommend always using the current input scan number for the output target scan number;

if a

higher-quality final pass is to be done, it should be started (aborting any incomplete output pass) as soon as the end of file is received. However, many other strategies are possible. For example, the application can examine the parameters of the current input scan and decide whether to display it or not. If the scan contains only chroma data, one might choose not to use it as the target scan, expecting that the scan will be small and will arrive quickly. To skip to the next scan, call `jpeg_consume_input()` until it returns `JPEG_REACHED_SOS` or `JPEG_REACHED_EOI`. Or just use the next higher number as the target scan for `jpeg_start_output()`; but that method doesn't let you inspect the next scan's parameters before deciding to display it.

In buffered-image mode, `jpeg_start_decompress()` never performs input and thus never suspends. An application that uses input suspension with buffered-image mode must be prepared for suspension returns from these routines:

- \* `jpeg_start_output()`  
performs input only if you request 2-pass quantization and the target scan isn't fully read yet. (This is discussed below.)
  - \* `jpeg_read_scanlines()`, as always, returns the number of scanlines that it was able to produce before suspending.
  - \* `jpeg_finish_output()` will read any markers following the target scan, up to the end of the file or the SOS marker that begins another scan. (But it reads no input if `jpeg_consume_input()` has already reached the end of the file or a SOS marker beyond the target output scan.)
  - \* `jpeg_finish_decompress()` will read until the end of file, and thus can suspend if the end hasn't already been reached (as can be tested by calling `jpeg_input_complete()`).
- `jpeg_start_output()`, `jpeg_finish_output()`, and `jpeg_finish_decompress()` all return `TRUE` if they completed their tasks, `FALSE` if they had to suspend.

In the event of a FALSE return, the application must load more input data and repeat the call. Applications that use non-suspending data sources need not check the return values of these three routines.

It is possible to change decoding parameters between output passes in the buffered-image mode. The decoder library currently supports only very limited changes of parameters. ONLY THE FOLLOWING parameter changes are allowed after jpeg\_start\_decompress() is called:

- \* dct\_method can be changed before each call to jpeg\_start\_output(). For example, one could use a fast DCT method for early scans, changing to a higher quality method for the final scan.
- \* dither\_mode can be changed before each call to jpeg\_start\_output(); of course this has no impact if not using color quantization. Typically one would use ordered dither for initial passes, then switch to Floyd-Steinberg dither for the final pass. Caution: changing dither mode can cause more memory to be allocated by the library. Although the amount of memory involved is not large (a scanline or so), it may cause the initial max\_memory\_to\_use specification to be exceeded, which in the worst case would result in an out-of-memory failure.
- \* do\_block\_smoothing can be changed before each call to jpeg\_start\_output(). This setting is relevant only when decoding a progressive JPEG image. During the first DC-only scan, block smoothing provides a very "fuzzy" look instead of the very "blocky" look seen without it; which is better seems a matter of personal taste. But block smoothing is nearly always a win during later stages, especially when decoding a successive-approximation image: smoothing helps to hide the slight blockiness that otherwise shows up on smooth gradients until the lowest coefficient bits are sent.
- \* Color quantization mode can be changed under the rules described below. You \*cannot\* change between full-color and quantized output (because that would alter the required I/O buffer sizes), but you can change which quantization method is used.

When generating color-quantized output, changing quantization method is a

very useful way of switching between high-speed and high-quality display.

The library allows you to change among its three quantization methods:

1. Single-pass quantization to a fixed color cube.  
Selected by cinfo.two\_pass\_quantize = FALSE and cinfo.colormap = NULL.
2. Single-pass quantization to an application-supplied colormap.  
Selected by setting cinfo.colormap to point to the colormap (the value of two\_pass\_quantize is ignored); also set cinfo.actual\_number\_of\_colors.
3. Two-pass quantization to a colormap chosen specifically for the image.  
Selected by cinfo.two\_pass\_quantize = TRUE and cinfo.colormap = NULL.  
(This is the default setting selected by jpeg\_read\_header, but it is probably NOT what you want for the first pass of progressive display!)

These methods offer successively better quality and lesser speed. However, only the first method is available for quantizing in non-RGB color spaces.

IMPORTANT: because the different quantizer methods have very different working-storage requirements, the library requires you to indicate which one(s) you intend to use before you call `jpeg_start_decompress()`. (If we did not require this, the `max_memory_to_use` setting would be a complete fiction.) You do this by setting one or more of these three `cinfo` fields to TRUE:

- `enable_1pass_quant` Fixed color cube colormap
- `enable_external_quant` Externally-supplied colormap
- `enable_2pass_quant` Two-pass custom colormap

All three are initialized FALSE by `jpeg_read_header()`. But `jpeg_start_decompress()` automatically sets TRUE the one selected by the current `two_pass_quantize` and `colormap` settings, so you only need to set the enable flags for any other quantization methods you plan to change to later.

After setting the enable flags correctly at `jpeg_start_decompress()` time, you can change to any enabled quantization method by setting `two_pass_quantize` and `colormap` properly just before calling `jpeg_start_output()`. The following special rules apply:

1. You must explicitly set `cinfo.colormap` to NULL when switching to 1-pass or 2-pass mode from a different mode, or when you want the 2-pass quantizer to be re-run to generate a new colormap.
2. To switch to an external colormap, or to change to a different external colormap than was used on the prior pass, you must call `jpeg_new_colormap()` after setting `cinfo.colormap`.

NOTE: if you want to use the same colormap as was used in the prior pass, you should not do either of these things. This will save some nontrivial switchover costs.

(These requirements exist because `cinfo.colormap` will always be non-NULL after completing a prior output pass, since both the 1-pass and 2-pass quantizers set it to point to their output colormaps. Thus you have to do one of these two things to notify the library that something has changed. Yup, it's a bit klugy, but it's necessary to do it this way for backwards compatibility.)

Note that in buffered-image mode, the library generates any requested colormap during `jpeg_start_output()`, not during `jpeg_start_decompress()`.

When using two-pass quantization, `jpeg_start_output()` makes a pass over the buffered image to determine the optimum color map; it therefore may take a significant amount of time, whereas ordinarily it does little work. The progress monitor hook is called during this pass, if defined. It is also important to realize that if the specified target scan number is greater than or equal to the current input scan number, `jpeg_start_output()` will attempt

to consume input as it makes this pass. If you use a suspending data source, you need to check for a FALSE return from jpeg\_start\_output() under these conditions. The combination of 2-pass quantization and a not-yet-fully-read target scan is the only case in which jpeg\_start\_output() will consume input.

Application authors who support buffered-image mode may be tempted to use it for all JPEG images, even single-scan ones. This will work, but it is inefficient: there is

no need to create an image-sized coefficient buffer for single-scan images. Requesting buffered-image mode for such an image wastes memory. Worse, it can cost time on large images, since the buffered data has to be swapped out or written to a temporary file. If you are concerned about maximum performance on baseline JPEG files, you should use buffered-image mode only when the incoming file actually has multiple scans. This can be tested by calling jpeg\_has\_multiple\_scans(), which will return a correct result at any time after jpeg\_read\_header() completes.

It is also worth noting that when you use jpeg\_consume\_input() to let input processing get ahead of output processing, the resulting pattern of access to the coefficient buffer is quite nonsequential. It's best to use the memory manager jmemnobs.c if you can (ie, if you have enough real or virtual main memory). If not, at least make sure that max\_memory\_to\_use is set as high as possible. If the JPEG memory manager has to use a temporary file, you will probably see a lot of disk traffic and poor performance. (This could be improved with additional work on the memory manager, but we haven't gotten around to it yet.)

In some applications it may be convenient to use jpeg\_consume\_input() for all input processing, including reading the initial markers; that is, you may wish to call jpeg\_consume\_input() instead of jpeg\_read\_header() during startup. This works, but note that you must check for JPEG\_REACHED\_SOS and JPEG\_REACHED\_EOI return codes as the equivalent of jpeg\_read\_header's codes. Once the first SOS marker has been reached, you must call jpeg\_start\_decompress() before jpeg\_consume\_input() will consume more input; it'll just keep returning JPEG\_REACHED\_SOS until you do. If you read a tables-only file this way, jpeg\_consume\_input() will return JPEG\_REACHED\_EOI without ever returning JPEG\_REACHED\_SOS; be sure to check for this case. If this happens, the decompressor will not read any more input until you call jpeg\_abort() to reset it. It is OK to call jpeg\_consume\_input() even when not using buffered-image mode, but in that case it's basically a no-op after the initial markers have been read: it will just return JPEG\_SUSPENDED.

Abbreviated datastreams and multiple images  
-----



A JPEG compression or decompression object can be reused to process multiple images. This saves a small amount of time per image by eliminating the "create" and "destroy" operations, but that isn't the real purpose of the feature. Rather, reuse of an object provides support for abbreviated JPEG datastreams. Object reuse can also simplify processing a series of images in a single input or output file. This section explains these features.

A JPEG file normally contains several hundred bytes worth of quantization and Huffman tables. In a situation where many images will be stored or transmitted with identical tables, this may represent an annoying overhead.

The JPEG

standard therefore permits tables to be omitted. The standard defines three classes of JPEG datastreams:

- \* "Interchange" datastreams contain an image and all tables needed to decode the image. These are the usual kind of JPEG file.
- \* "Abbreviated image" datastreams contain an image, but are missing some or all of the tables needed to decode that image.
- \* "Abbreviated table specification" (henceforth "tables-only") datastreams contain only table specifications.

To decode an abbreviated image, it is necessary to load the missing table(s) into the decoder beforehand. This can be accomplished by reading a separate tables-only file. A variant scheme uses a series of images in which the first image is an interchange (complete) datastream, while subsequent ones are abbreviated and rely on the tables loaded by the first image. It is assumed that once the decoder has read a table, it will remember that table until a new definition for the same table number is encountered.

It

is the application designer's responsibility to figure out how to associate the correct tables with an abbreviated image. While abbreviated datastreams can be useful in a closed environment, their use is strongly discouraged in any situation where data exchange with other applications might be needed. Caveat designer.

The JPEG library provides support for reading and writing any combination of tables-only datastreams and abbreviated images. In both compression and decompression objects, a quantization or Huffman table will be retained for the lifetime of the object, unless it is overwritten by a new table definition.

To create abbreviated image datastreams, it is only necessary to tell the compressor not to emit some or all of the tables it is using. Each quantization and Huffman table struct contains a boolean field "sent\_table", which normally is initialized to FALSE. For each table used by the image, the header-writing process emits the table and sets sent\_table = TRUE unless it is already TRUE. (In normal usage, this prevents outputting the same table

definition multiple times, as would otherwise occur because the chroma components typically share tables.) Thus, setting this field to TRUE before calling `jpeg_start_compress()` will prevent the table from being written at all.

If you want to create a "pure" abbreviated image file containing no tables, just call "`jpeg_suppress_tables(&cinfo, TRUE)`" after constructing all the tables. If you want to emit some but not all tables, you'll need to set the individual `sent_table` fields directly.

To create an abbreviated image, you must also call `jpeg_start_compress()` with a second parameter of FALSE, not TRUE. Otherwise `jpeg_start_compress()` will force all the `sent_table` fields to FALSE. (This is a safety feature to prevent abbreviated images from being created accidentally.)

To create a tables-only file, perform the same parameter setup that you normally would, but instead of calling `jpeg_start_compress()` and so on, call `jpeg_write_tables(&cinfo)`. This will write an abbreviated datastream containing only SOI, DQT and/or DHT markers, and EOI. All the quantization and Huffman tables that are currently defined in the compression object will be emitted unless their `sent_tables` flag is already TRUE, and then all the `sent_tables` flags will be set TRUE.

A sure-fire way to create matching tables-only and abbreviated image files is to proceed as follows:

```
create JPEG compression object
set JPEG parameters
set destination to tables-only file
jpeg_write_tables(&cinfo);
set destination to image file
jpeg_start_compress(&cinfo, FALSE);
write data...
jpeg_finish_compress(&cinfo);
```

Since the JPEG parameters are not altered between writing the table file and the abbreviated image file, the same tables are sure to be used. Of course, you can repeat the `jpeg_start_compress() ... jpeg_finish_compress()` sequence many times to produce many abbreviated image files matching the table file.

You cannot suppress output of the computed Huffman tables when Huffman optimization is selected. (If you could, there'd be no way to decode the image...) Generally, you don't want to set `optimize_coding = TRUE` when you are trying to produce abbreviated files.

In some cases you might want to compress an image using tables which are

not stored in the application, but are defined in an interchange or tables-only file readable by the application. This can be done by setting up a JPEG decompression object to read the specification file, then copying the tables into your compression object. See `jpeg_copy_critical_parameters()` for an example of copying quantization tables.

To read abbreviated image files, you simply need to load the proper tables into the decompression object before trying to read the abbreviated image. If the proper tables are stored in the application program, you can just allocate the table structs and fill in their contents directly. For example, to load a fixed quantization table into table slot "n":

```
if (cinfo.quant_tbl_ptrs[n] == NULL)
    cinfo.quant_tbl_ptrs[n] = jpeg_alloc_quant_table((j_common_ptr) &cinfo);
quant_ptr = cinfo.quant_tbl_ptrs[n]; /* quant_ptr is JQUANT_TBL* */
for (i = 0; i < 64; i++) {
    /* Qtable[] is desired quantization table, in natural array order */
    quant_ptr->quantval[i] = Qtable[i];
}
```

Code to load a fixed Huffman table is typically (for AC table "n"):

```
if (cinfo.ac_huff_tbl_ptrs[n] == NULL)
    cinfo.ac_huff_tbl_ptrs[n] = jpeg_alloc_huff_table((j_common_ptr) &cinfo);
huff_ptr = cinfo.ac_huff_tbl_ptrs[n]; /* huff_ptr is JHUFF_TBL* */
for (i = 1; i <= 16; i++) {
    /* counts[i] is number of Huffman codes of length i bits, i=1..16 */
    huff_ptr->bits[i] = counts[i];
}
for (i = 0; i < 256; i++) {
    /* symbols[] is the list of Huffman symbols, in code-length order */
    huff_ptr->huffval[i] = symbols[i];
}
```

(Note that trying to set `cinfo.quant_tbl_ptrs[n]` to point directly at a constant `JQUANT_TBL` object is not safe. If the incoming file happened to contain a quantization table definition, your master table would get overwritten! Instead allocate a working table copy and copy the master table into it, as illustrated above. Ditto for Huffman tables, of course.)

You might want to read the tables from a tables-only file, rather than hard-wiring them into your application. The `jpeg_read_header()` call is sufficient to read a tables-only file. You must pass a second parameter of `FALSE` to indicate that you do not require an image to be present. Thus, the typical scenario is

```
create JPEG decompression object
set source to tables-only file
jpeg_read_header(&cinfo, FALSE);
set source to abbreviated image file
jpeg_read_header(&cinfo, TRUE);
set decompression parameters
jpeg_start_decompress(&cinfo);
read data...
jpeg_finish_decompress(&cinfo);
```

In some cases, you may want to read a file without knowing whether it contains an image

or just tables. In that case, pass `FALSE` and check the return value from `jpeg_read_header()`: it will be `JPEG_HEADER_OK` if an image was found, `JPEG_HEADER_TABLES_ONLY` if only tables were found. (A third return value, `JPEG_SUSPENDED`, is possible when using a suspending data source manager.) Note that `jpeg_read_header()` will not complain if you read an abbreviated image for which you haven't loaded the missing tables; the missing-table check occurs later, in `jpeg_start_decompress()`.

It is possible to read a series of images from a single source file by repeating the `jpeg_read_header() ... jpeg_finish_decompress()` sequence, without releasing/recreating the JPEG object or the data source module. (If you did reinitialize, any partial bufferload left in the data source buffer at the end of one image would be discarded, causing you to lose the start of the next image.) When you use this method, stored tables are automatically carried forward, so some of the images can be abbreviated images that depend on tables from earlier images.

If you intend to write a series of images into a single destination file, you might want to make a specialized data destination module that doesn't flush the output buffer at `term_destination()` time. This would speed things up by some trifling amount. Of course, you'd need to remember to flush the buffer after the last image. You can make the later images be abbreviated ones by passing `FALSE` to `jpeg_start_compress()`.

#### Special markers

-----

Some applications may need to insert or extract special data in the JPEG datastream. The JPEG standard provides marker types "COM" (comment) and "APP0" through "APP15" (application) to hold application-specific data. Unfortunately, the use of these markers is not specified by the standard. COM markers are fairly widely used to hold user-supplied text. The JFIF file

format spec uses APP0 markers with specified initial strings to hold certain data. Adobe applications use APP14 markers beginning with the string "Adobe" for miscellaneous data. Other APPn markers are rarely seen, but might contain almost anything.

If you wish to store user-supplied text, we recommend you use COM markers and place readable 7-bit ASCII text in them. Newline conventions are not standardized --- expect to find LF (Unix style), CR/LF (DOS style), or CR (Mac style). A robust COM reader should be able to cope with random binary garbage, including nulls, since some applications generate COM markers containing non-ASCII junk. (But yours should not be one of them.)

For program-supplied data, use an APPn marker, and be sure to begin it with an identifying string so that you can tell whether the marker is actually yours. It's probably best to avoid using APP0 or APP14 for any private markers. (NOTE: the upcoming SPIFF standard will use APP8 markers; we recommend you not use APP8 markers for any private purposes, either.)

Keep in mind that at most 65533 bytes can be put into one marker, but you can have as many markers as you like.

By default, the IJG compression library will write a JFIF APP0 marker if the selected JPEG colorspace is grayscale or YCbCr, or an Adobe APP14 marker if the selected colorspace is RGB, CMYK, or YCCK. You can disable this, but we don't recommend it. The decompression library will recognize JFIF and Adobe markers and will set the JPEG colorspace properly when one is found.

You can write special markers immediately following the datastream header by calling `jpeg_write_marker()` after `jpeg_start_compress()` and before the first call to `jpeg_write_scanlines()`. When you do this, the markers appear after the SOI and the JFIF APP0 and Adobe APP14 markers (if written), but before all else. Specify the marker type parameter as "JPEG\_COM" for COM or "JPEG\_APP0 + n" for APPn. (Actually, `jpeg_write_marker` will let you write any marker type, but we don't recommend writing any other kinds of marker.) For example, to write a user comment string pointed to `comment_text`:

```
jpeg_write_marker(cinfo, JPEG_COM, comment_text, strlen(comment_text));
```

If it's not convenient to store all the marker data in memory at once, you can instead call `jpeg_write_m_header()` followed by multiple calls to `jpeg_write_m_byte()`. If you do it this way, it's your responsibility to call `jpeg_write_m_byte()` exactly the number of times given in the length parameter to `jpeg_write_m_header()`. (This method lets you empty the output buffer partway through a marker, which might be important when using a suspending data destination module. In any case, if you are using

a suspending destination, you should flush its buffer after inserting any special markers. See "I/O suspension".)

Or, if you prefer to synthesize the marker byte sequence yourself, you can just cram it straight into the data destination module.

If you are writing JFIF 1.02 extension markers (thumbnail images), don't forget to set `cinfo.JFIF_minor_version = 2` so that the encoder will write the correct

JFIF version number in the JFIF header marker. The library's default is to write version 1.01, but that's wrong if you insert any 1.02 extension markers. (We could probably get away with just defaulting to 1.02, but there used to be broken decoders that would complain about unknown minor version numbers. To reduce compatibility risks it's safest not to write 1.02 unless you are actually using 1.02 extensions.)

When reading, two methods of handling special markers are available:

1. You can ask the library to save the contents of COM and/or APPn markers into memory, and then examine them at your leisure afterwards.
2. You can supply your own routine to process COM and/or APPn markers on-the-fly as they are read.

The first method is simpler to use, especially if you are using a suspending data source; writing a marker processor that copes with input suspension is not easy (consider what happens if the marker is longer than your available input buffer). However, the second method conserves memory since the marker data need not be kept around after it's been processed.

For either method, you'd normally set up marker handling after creating a decompression object and before calling `jpeg_read_header()`, because the markers of interest will typically be near the head of the file and so will be scanned by `jpeg_read_header`. Once you've established a marker handling method, it will be used for the life of that decompression object (potentially many datastreams), unless you change it. Marker handling is determined separately for COM markers and for each APPn marker code.

To save the contents of special markers in memory, call `jpeg_save_markers(cinfo, marker_code, length_limit)` where `marker_code` is the marker type to save, `JPEG_COM` or `JPEG_APP0+n`. (To arrange to save all the special marker types, you need to call this routine 17 times, for COM and APP0-APP15.) If the incoming marker is longer than `length_limit` data bytes, only `length_limit` bytes will be saved; this parameter

allows you to avoid chewing up memory when you only need to see the first few bytes of a potentially large marker. If you want to save all the data, set `length_limit` to `0xFFFF`; that is enough since marker lengths are only

16 bits. As a special case, setting `length_limit` to 0 prevents that marker type from being saved at all. (That is the default behavior, in fact.)

After `jpeg_read_header()` completes, you can examine the special markers by following the `cinfo->marker_list` pointer chain. All the special markers in the file appear in this list, in order of their occurrence in the file (but omitting any markers of types you didn't ask for). Both the original data length and the saved data length are recorded for each list entry; the latter will not exceed `length_limit` for the particular marker type. Note that these lengths exclude the marker length word, whereas the stored representation within the JPEG file includes it. (Hence the maximum data length is really only 65533.)

It is possible that additional special markers appear in the file beyond the SOS marker at which `jpeg_read_header` stops; if so, the marker list will be extended during reading of the rest of the file. This is not expected to be common, however. If you are short on memory you may want to reset the length limit to zero for all marker types after finishing `jpeg_read_header`, to ensure that the `max_memory_to_use` setting cannot be exceeded due to addition of later markers.

The marker list remains stored until you call `jpeg_finish_decompress` or `jpeg_abort`, at which point the memory is freed and the list is set to empty. (`jpeg_destroy` also releases the storage, of course.)

Note that the library is internally interested in APP0 and APP14 markers; if you try to set a small nonzero length limit on these types, the library will silently force the length up to the minimum it wants. (But you can set a zero length limit to prevent them from being saved at all.) Also, in a 16-bit environment, the maximum length limit may be constrained to less than 65533 by `malloc()` limitations. It is therefore best not to assume that the effective length limit is exactly what you set it to be.

If you want to supply your own marker-reading routine, you do it by calling `jpeg_set_marker_processor()`. A marker processor routine must have the signature

```
boolean jpeg_marker_parser_method (j_decompress_ptr cinfo)
```

Although the marker code is not explicitly passed, the routine can find it in `cinfo->unread_marker`. At the time of call, the marker proper has been read from the data source module. The processor routine is responsible for reading the marker length word and the remaining parameter bytes, if any. Return TRUE to indicate success. (FALSE should be returned only if you are using a suspending data source and it tells you to suspend. See the standard marker processors in `jdmarker.c` for appropriate coding methods if you need to use a suspending data source.)

If you override the default

APP0 or APP14 processors, it is up to you to recognize JFIF and Adobe markers if you want colorspace recognition to occur properly. We recommend copying and extending the default processors if you want to do that. (A better idea is to save these marker types for later examination by calling `jpeg_save_markers()`; that method doesn't interfere with the library's own processing of these markers.)

`jpeg_set_marker_processor()` and `jpeg_save_markers()` are mutually exclusive --- if you call one it overrides any previous call to the other, for the particular marker type specified.

A simple example of an external COM processor can be found in `djpeg.c`. Also, see `jpegtran.c` for an example of using `jpeg_save_markers`.

Raw (downsampled) image data

-----

Some applications need to supply already-downsampled image data to the JPEG compressor, or to receive raw downsampled data from the decompressor. The library supports this requirement by allowing the application to write or read raw data, bypassing the normal preprocessing or postprocessing steps. The interface is different from the standard one and is somewhat harder to use. If your interest is merely in bypassing color conversion, we recommend that you use the standard interface and simply set `jpeg_color_space = in_color_space` (or `jpeg_color_space = out_color_space` for decompression). The mechanism described in this section is necessary only to supply or receive downsampled image data, in which not all components have the same dimensions.

To compress raw data, you must supply the data in the colorspace to be used in the JPEG file (please read the earlier section on Special color spaces) and downsampled to the sampling factors specified in the JPEG parameters. You must supply the data in the format used internally by the JPEG library, namely a JSAMPIMAGE array. This is an array of pointers to two-dimensional arrays, each of type JSAMPARRAY. Each 2-D array holds the values for one color component.

This structure is necessary since the components are of different sizes. If the image dimensions are not a multiple of the MCU size, you must also pad the data correctly (usually, this is done by replicating the last column and/or row). The data must be padded to a multiple of a DCT block in each component: that is, each downsampled row must contain a multiple of `block_size` valid samples, and there must be a multiple of `block_size` sample rows for each component. (For applications such as



conversion of digital TV images, the standard image size is usually a multiple of the DCT block size, so that no padding need actually be done.)

The procedure for compression of raw data is basically the same as normal compression, except that you call `jpeg_write_raw_data()` in place of `jpeg_write_scanlines()`. Before calling `jpeg_start_compress()`, you must do the following:

- \* Set `cinfo->raw_data_in` to TRUE. (It is set FALSE by `jpeg_set_defaults()`.)

This notifies the library that you will be supplying raw data.

Furthermore, set `cinfo->do_fancy_downsampling` to FALSE if you want to use real downsampled data. (It is set TRUE by `jpeg_set_defaults()`.)

- \* Ensure `jpeg_color_space` is correct --- an explicit `jpeg_set_colorspace()` call is a good idea. Note that since color conversion is bypassed, `in_color_space` is ignored, except that `jpeg_set_defaults()` uses it to choose the default `jpeg_color_space` setting.

- \* Ensure the sampling factors, `cinfo->comp_info[i].h_samp_factor` and `cinfo->comp_info[i].v_samp_factor`, are correct. Since these indicate the dimensions of the data you are supplying, it's wise to set them explicitly, rather than assuming the library's defaults are what you want.

To pass raw data to the library, call `jpeg_write_raw_data()` in place of `jpeg_write_scanlines()`. The two routines work similarly except that `jpeg_write_raw_data` takes a JSAMPIMAGE data array rather than JSAMPARRAY. The scanlines count passed to and returned from `jpeg_write_raw_data` is measured in terms of the component with the largest `v_samp_factor`.

`jpeg_write_raw_data()` processes one MCU row per call, which is to say `v_samp_factor*block_size` sample rows of each component. The passed `num_lines` value must be at least `max_v_samp_factor*block_size`, and the return value will be exactly that amount (or possibly some multiple of that amount, in future library versions). This is true even on the last call at the bottom of the image; don't forget to pad your data as necessary.

The required dimensions of the supplied data can be computed for each component as

`cinfo->comp_info[i].width_in_blocks*block_size` samples per row

`cinfo->comp_info[i].height_in_blocks*block_size` rows in image

after `jpeg_start_compress()` has initialized those fields. If the valid data is smaller than this, it must be padded appropriately. For some sampling factors and image sizes, additional dummy DCT blocks are inserted to make the image a multiple of the MCU dimensions.

The library creates such dummy

blocks itself; it does not read them from your supplied data. Therefore you need never pad by more than `block_size` samples. An example may help here.

Assume 2h2v downsampling of YCbCr data, that is

`cinfo->comp_info[0].h_samp_factor = 2` for Y

```
cinfo->comp_info[0].v_samp_factor = 2
cinfo->comp_info[1].h_samp_factor = 1 for Cb
cinfo->comp_info[1].v_samp_factor = 1
cinfo->comp_info[2].h_samp_factor = 1 for Cr
cinfo->comp_info[2].v_samp_factor = 1
```

and suppose that the nominal image dimensions (`cinfo->image_width` and `cinfo->image_height`) are 101x101 pixels. Then `jpeg_start_compress()` will compute `downsampled_width = 101` and `width_in_blocks = 13` for Y, `downsampled_width = 51` and `width_in_blocks = 7` for Cb and Cr (and the same for the height fields). You must pad the Y data to at least  $13*8 = 104$  columns and rows, the Cb/Cr data to at least  $7*8 = 56$  columns and rows. The MCU height is `max_v_samp_factor = 2` DCT rows so you must pass at least 16 scanlines on each call to `jpeg_write_raw_data()`, which is to say 16 actual sample rows of Y and 8 each of Cb and Cr. A total of 7 MCU rows are needed, so you must pass a total of  $7*16 = 112$  "scanlines". The last DCT block row of Y data is dummy, so it doesn't matter what you pass for it in the data arrays, but the scanlines count must total up to 112 so that all of the Cb and Cr data gets passed.

Output suspension is supported with raw-data compression: if the data destination module suspends, `jpeg_write_raw_data()` will return 0. In this case the same data rows must be passed again on the next call.

Decompression with raw data output implies bypassing all postprocessing. You must deal with the color space and sampling factors present in the incoming file. If your application only handles, say, 2h1v YCbCr data, you must check for and fail on other color spaces or other sampling factors. The library will not convert to a different color space for you.

To obtain raw data output, set `cinfo->raw_data_out = TRUE` before `jpeg_start_decompress()` (it is set `FALSE` by `jpeg_read_header()`). Be sure to verify that the color space and sampling factors are ones you can handle. Furthermore, set `cinfo->do_fancy_upsampling = FALSE` if you want to get real downsampled data (it is set `TRUE` by `jpeg_read_header()`). Then call `jpeg_read_raw_data()` in place of `jpeg_read_scanlines()`. The decompression process is otherwise the same as usual.

`jpeg_read_raw_data()` returns one MCU row per call, and thus you must pass a buffer of at least `max_v_samp_factor*block_size` scanlines (scanline counting is the same as for raw-data compression). The buffer you pass must be large enough to hold the actual data plus padding to DCT-block boundaries. As with compression, any entirely dummy DCT blocks are not processed so you need not allocate space for them, but the total scanline count includes them. The above example of computing buffer dimensions for raw-data compression is equally valid for decompression.

## Input

suspension is supported with raw-data decompression: if the data source module suspends, `jpeg_read_raw_data()` will return 0. You can also use buffered-image mode to read raw data in multiple passes.

## Really raw data: DCT coefficients

-----

It is possible to read or write the contents of a JPEG file as raw DCT coefficients. This facility is mainly intended for use in lossless transcoding between different JPEG file formats. Other possible applications include lossless cropping of a JPEG image, lossless reassembly of a multi-strip or multi-tile TIFF/JPEG file into a single JPEG datastream, etc.

To read the contents of a JPEG file as DCT coefficients, open the file and do `jpeg_read_header()` as usual. But instead of calling `jpeg_start_decompress()` and `jpeg_read_scanlines()`, call `jpeg_read_coefficients()`. This will read the entire image into a set of virtual coefficient-block arrays, one array per component. The return value is a pointer to an array of virtual-array descriptors. Each virtual array can be accessed directly using the JPEG memory manager's `access_virt_barray` method (see Memory management, below, and also read `structure.txt`'s discussion of virtual array handling). Or, for simple transcoding to a different JPEG file format, the array list can just be handed directly to `jpeg_write_coefficients()`.

Each block in the block arrays contains quantized coefficient values in normal array order (not JPEG zigzag order). The block arrays contain only DCT blocks containing real data; any entirely-dummy blocks added to fill out interleaved MCUs at the right or bottom edges of the image are discarded during reading and are not stored in the block arrays. (The size of each block array can be determined from the `width_in_blocks` and `height_in_blocks` fields of the component's `comp_info` entry.) This is also the data format expected by `jpeg_write_coefficients()`.

When you are done using the virtual arrays, call `jpeg_finish_decompress()` to release the array storage and return the decompression object to an idle state; or just call `jpeg_destroy()` if you don't need to reuse the object.

If you use a suspending data source, `jpeg_read_coefficients()` will return NULL if it is forced to suspend; a non-NULL return value indicates successful completion. You need not test for a NULL return value when using a non-suspending data source.

It is also possible to call `jpeg_read_coefficients()` to obtain access to the

decoder's coefficient arrays during a normal decode cycle in buffered-image mode. This frammish might be useful for progressively displaying an incoming image and then re-encoding it without loss. To do this, decode in buffered-image mode as discussed previously, then call `jpeg_read_coefficients()` after the last `jpeg_finish_output()` call. The arrays will be available for your use until you call `jpeg_finish_decompress()`.

To write the contents of a JPEG file as DCT coefficients, you must provide the

DCT coefficients stored in virtual block arrays. You can either pass block arrays read from an input JPEG file by `jpeg_read_coefficients()`, or allocate virtual arrays from the JPEG compression object and fill them yourself. In either case, `jpeg_write_coefficients()` is substituted for `jpeg_start_compress()` and `jpeg_write_scanlines()`. Thus the sequence is

- \* Create compression object
- \* Set all compression parameters as necessary
- \* Request virtual arrays if needed
- \* `jpeg_write_coefficients()`
- \* `jpeg_finish_compress()`
- \* Destroy or re-use compression object

`jpeg_write_coefficients()` is passed a pointer to an array of virtual block array descriptors; the number of arrays is equal to `cinfo.num_components`.

The virtual arrays need only have been requested, not realized, before `jpeg_write_coefficients()` is called. A side-effect of `jpeg_write_coefficients()` is to realize any virtual arrays that have been requested from the compression object's memory manager. Thus, when obtaining the

virtual arrays from the compression object, you should fill the arrays after calling `jpeg_write_coefficients()`. The data is actually written out when you call `jpeg_finish_compress()`; `jpeg_write_coefficients()` only writes the file header.

When writing raw DCT coefficients, it is crucial that the JPEG quantization tables and sampling factors match the way the data was encoded, or the resulting file will be invalid. For transcoding from an existing JPEG file, we recommend using `jpeg_copy_critical_parameters()`. This routine initializes all the compression parameters to default values (like `jpeg_set_defaults()`), then copies the critical information from a source decompression object. The decompression object should have just been used to read the entire JPEG input file --- that is, it should be awaiting `jpeg_finish_decompress()`.

`jpeg_write_coefficients()` marks all tables stored in the compression object as needing to be written to the output file (thus, it acts like

`jpeg_start_compress(cinfo,`

`TRUE)`). This is for safety's sake, to avoid

emitting abbreviated JPEG files by accident. If you really want to emit an

abbreviated JPEG file, call `jpeg_suppress_tables()`, or set the tables' individual `sent_table` flags, between calling `jpeg_write_coefficients()` and `jpeg_finish_compress()`.

## Progress monitoring

-----

Some applications may need to regain control from the JPEG library every so often. The typical use of this feature is to produce a percent-done bar or other progress display. (For a simple example, see `cjpeg.c` or `djpeg.c`.) Although you do get control back frequently during the data-transferring pass (the `jpeg_read_scanlines` or `jpeg_write_scanlines` loop), any additional passes will occur inside `jpeg_finish_compress` or `jpeg_start_decompress`; those routines may take a long time to execute, and you don't get control back until they are done.

You can define a progress-monitor routine which will be called periodically by the library. No guarantees are made about how often this call will occur, so we don't recommend you use it for mouse tracking or anything like that. At present, a call will occur once per MCU row, scanline, or sample row group, whichever unit is convenient for the current processing mode; so the wider the image, the longer the time between calls. During the data transferring pass, only one call occurs per call of `jpeg_read_scanlines` or `jpeg_write_scanlines`, so don't pass a large number of scanlines at once if you want fine resolution in the progress count. (If you really need to use the callback mechanism for time-critical tasks like mouse tracking, you could insert additional calls inside some of the library's inner loops.)

To establish a progress-monitor callback, create a struct `jpeg_progress_mgr`, fill in its `progress_monitor` field with a pointer to your callback routine, and set `cinfo->progress` to point to the struct. The callback will be called whenever `cinfo->progress` is non-NULL. (This pointer is set to NULL by `jpeg_create_compress` or `jpeg_create_decompress`; the library will not change it thereafter. So if you allocate dynamic storage for the progress struct, make sure it will live as long as the JPEG object does. Allocating from the JPEG memory manager with lifetime `JPOOL_PERMANENT` will work nicely.) You can use the same callback routine for both compression and decompression.

The `jpeg_progress_mgr` struct contains four fields which are set by the library:

```
long pass_counter; /* work units completed in this pass */
long pass_limit; /* total number of work units in this pass */
int completed_passes; /* passes completed so far */
int total_passes; /* total number of passes expected */
```

During any one pass, `pass_counter` increases from 0 up to (not including) `pass_limit`; the step size is usually but not necessarily 1. The `pass_limit`

value may change from one pass to another. The expected total number of passes is in `total_passes`, and the number of passes already completed is in `completed_passes`. Thus the fraction of work completed may be estimated as

$$\frac{\text{completed\_passes} + (\text{pass\_counter}/\text{pass\_limit})}{\text{total\_passes}}$$

ignoring the fact that the passes may not be equal amounts of work.

When decompressing, `pass_limit` can even change within a pass, because it depends on the number of scans in the JPEG file, which isn't always known in advance. The computed fraction-of-work-done may jump suddenly (if the library discovers it has overestimated the number of scans) or even decrease (in the opposite case). It is not wise to put great faith in the work estimate.

When using the decompressor's buffered-image mode, the progress monitor work estimate is likely to be completely unhelpful, because the library has no way to know how many output passes will be demanded of it. Currently, the library sets `total_passes` based on the assumption that there will be one more output pass if the input file end hasn't yet been read (`jpeg_input_complete()` isn't TRUE), but no more output passes if the file end has been reached when the output pass is started. This means that `total_passes` will rise as additional output passes are requested. If you have a way of determining the input file size, estimating progress based on the fraction of the file that's been read will probably be more useful than using the library's value.

## Memory management

This section covers some key facts about the JPEG library's built-in memory manager. For more info, please read `structure.txt`'s section about the memory manager, and consult the source code if necessary.

All memory and temporary file allocation within the library is done via the memory manager. If necessary, you can replace the "back end" of the memory manager to control allocation yourself (for example, if you don't want the library to use `malloc()` and `free()` for some reason).

Some data is allocated "permanently" and will not be freed until the JPEG object

is destroyed. Most data is allocated "per image" and is freed by `jpeg_finish_compress`, `jpeg_finish_decompress`, or `jpeg_abort`. You can call the memory manager yourself to allocate structures that will automatically be freed at these times. Typical code for this is

```
ptr = (*cinfo->mem->alloc_small) ((j_common_ptr) cinfo, JPOOL_IMAGE, size);
```

Use `JPOOL_PERMANENT` to get storage that lasts as long as the JPEG object.

Use `alloc_large` instead of `alloc_small` for anything bigger than a few Kbytes. There are also `alloc_sarray` and `alloc_barray` routines that automatically build 2-D sample or block arrays.

The library's minimum space requirements to process an image depend on the image's width, but not on its height, because the library ordinarily works with "strip" buffers that are as wide as the image but just a few rows high. Some operating modes (eg, two-pass color quantization) require full-image buffers. Such buffers are treated as "virtual arrays": only the current strip need be in memory, and the rest can be swapped out to a temporary file.

If you use the simplest memory manager back end (`jmemnobs.c`), then no temporary files are used; virtual arrays are simply `malloc()`'d. Images bigger than memory can be processed only if your system supports virtual memory. The other memory manager back ends support temporary files of various flavors and thus work in machines without virtual memory. They may also be useful on Unix machines if you need to process images that exceed available swap space.

When using temporary files, the library will make the in-memory buffers for its virtual arrays just big enough to stay within a "maximum memory" setting. Your application can set this limit by setting `cinfo->mem->max_memory_to_use` after creating the JPEG object. (Of course, there is still a minimum size for the buffers, so the max-memory setting is effective only if it is bigger than the minimum space needed.) If you allocate any large structures yourself, you must allocate them before `jpeg_start_compress()` or `jpeg_start_decompress()` in order to have them counted against the max memory limit. Also keep in mind that space allocated with `alloc_small()` is ignored, on the assumption that it's too small to be worth worrying about; so a reasonable safety margin should be left when setting `max_memory_to_use`.

If you use the `jmemname.c` or `jmemdos.c` memory manager back end, it is important to clean up the JPEG object properly to ensure that the temporary files get deleted. (This is especially crucial with `jmemdos.c`, where the "temporary files" may be extended-memory segments; if they are not freed, DOS will require a reboot to recover the memory.) Thus, with these memory managers, it's a good idea to provide a signal handler that will trap any early exit from your program. The handler should call either `jpeg_abort()` or `jpeg_destroy()` for any active JPEG objects. A handler is not needed with `jmemnobs.c`, and shouldn't be necessary with `jmemansi.c` or `jmemmac.c` either, since the C library is supposed to take care of deleting files made with `tmpfile()`.

Memory usage

-----

Working memory requirements while performing compression or decompression depend on image dimensions, image characteristics (such as colorspace and JPEG process), and operating mode (application-selected options).

As of v6b, the decompressor requires:

1. About 24K in more-or-less-fixed-size data. This varies a bit depending on operating mode and image characteristics (particularly color vs. grayscale), but it doesn't depend on image dimensions.
  2. Strip buffers (of size proportional to the image width) for IDCT and upsampling results. The worst case for commonly used sampling factors is about 34 bytes \* width in pixels for a color image. A grayscale image only needs about 8 bytes per pixel column.
  3. A full-image DCT coefficient buffer is needed to decode a multi-scan JPEG file (including progressive JPEGs), or whenever you select buffered-image mode. This takes 2 bytes/coefficient. At typical 2x2 sampling, that's 3 bytes per pixel for a color image. Worst case (1x1 sampling) requires 6 bytes/pixel. For grayscale, figure 2 bytes/pixel.
  4. To perform 2-pass color quantization, the decompressor also needs a 128K color lookup table and a full-image pixel buffer (3 bytes/pixel).
- This does not count any memory allocated by the application, such as a buffer to hold the final output image.

The above figures are valid for 8-bit JPEG data precision and a machine with 32-bit ints. For 9-bit to 12-bit JPEG data, double the size of the strip buffers and quantization pixel buffer. The "fixed-size" data will be somewhat smaller with 16-bit ints, larger with 64-bit ints. Also, CMYK or other unusual color spaces will require different amounts of space.

The full-image coefficient and pixel buffers, if needed at all, do not have to be fully RAM resident; you can have the library use temporary files instead when the total memory usage would exceed a limit you set. (But if your OS supports virtual memory, it's probably better to just use `jmemnobs` and let the OS do the swapping.)

The compressor's memory requirements are similar, except that it has no need for color quantization. Also, it needs a full-image DCT coefficient buffer if Huffman-table optimization is asked for, even if progressive mode is not requested.

If you need more detailed information about memory usage in a particular situation, you can enable the `MEM_STATS` code in `jmemmgr.c`.

Library compile-time options

-----



A number of compile-time options are available by modifying `jmorcfig.h`.

The IJG code currently supports 8-bit to 12-bit sample data precision by defining `BITS_IN_JSAMPLE` as 8, 9, 10, 11, or 12.

Note that a value larger than 8 causes `JSAMPLE` to be larger than a char, so it affects the surrounding application's image data.

The sample applications `cjpeg` and `djpeg` can support deeper than 8-bit data

only for PPM and GIF file formats; you must disable the other file formats to compile a 9-bit to 12-bit `cjpeg` or `djpeg`. (`install.txt` has more information about that.)

Run-time selection and conversion of data precision are currently not supported and may be added later.

Exception: The transcoding part (`jpegtran`) supports all settings in a single instance, since it operates on the level of DCT coefficients and not sample values.

(If you need to include an 8-bit library and a 9-bit to 12-bit library for compression or decompression in a single application, you could probably do it by defining `NEED_SHORT_EXTERNAL_NAMES` for just one of the copies. You'd have to access the 8-bit and the 9-bit to 12-bit copies from separate application source files. This is untested ... if you try it, we'd like to hear whether it works!)

Note that the standard Huffman tables are only valid for 8-bit data precision. If you selected more than 8-bit data precision, `cjpeg` uses arithmetic coding by default.

The Huffman encoder normally uses entropy optimization to compute usable tables for higher precision. Otherwise, you'll have to supply different default Huffman tables. You may also want to supply your own DCT quantization tables; the existing quality-scaling code has been developed for 8-bit use, and probably doesn't generate especially good tables for 9-bit to 12-bit.

The maximum number of components (color channels) in the image is determined by `MAX_COMPONENTS`. The JPEG standard allows up to 255 components, but we expect that few applications will need more than four or so.

On machines with unusual data type sizes, you may be able to improve performance or reduce memory space by tweaking the various typedefs in `jmorcfig.h`. In particular, on some RISC CPUs, access to arrays of "short"s is quite slow; consider trading memory for speed by making `JCOEF`, `INT16`, and `UINT16` be "int" or "unsigned int". `UINT8` is also a candidate to become int. You probably don't want to make `JSAMPLE` be int unless you have lots of memory to burn.

You can reduce the size of the library by compiling out various optional functions. To do this, undefine `xxx_SUPPORTED` symbols as necessary.

You can also save a few K by not having text error messages in the library; the standard error message table occupies about 5Kb. This is particularly reasonable for embedded applications where there's no good way to display a message anyway. To do this, remove the creation of the message table (`jpeg_std_message_table[]`) from `jerror.c`, and alter `format_message` to do something reasonable without it. You could output the numeric value of the message code number, for example. If you do this, you can also save a couple more K by modifying the `TRACEMSn()` macros in `jerror.h` to expand to nothing; you don't need trace capability anyway, right?

#### Portability considerations

-----

The JPEG library has been written to be extremely portable; the sample applications `cjpeg` and `djpeg` are slightly less so. This section summarizes the design goals in this area. (If you encounter any bugs that cause the library to be less portable than is claimed here, we'd appreciate hearing about them.)

The code works fine on ANSI C, C++, and pre-ANSI C compilers, using any of the popular system include file setups, and some not-so-popular ones too. See `install.txt` for configuration procedures.

The code is not dependent on the exact sizes of the C data types. As distributed, we make the assumptions that

- char is at least 8 bits wide
- short is at least 16 bits wide
- int is at least 16 bits wide
- long is at least 32 bits wide

(These are the minimum requirements of the ANSI C standard.) Wider types will work fine, although memory may be used inefficiently if char is much larger than 8 bits or short is much bigger than 16 bits. The code should work equally well with 16- or 32-bit ints.

In a system where these assumptions are not met, you may be able to make the code work by

- modifying the typedefs in `jmorecfg.h`. However, you will probably have difficulty if int is less than 16 bits wide, since references to plain int abound in the code.

char can be either signed or unsigned, although the code runs faster if an unsigned char type is available. If char is wider than 8 bits, you will need to redefine `JOCTET` and/or provide custom data source/destination managers so that `JOCTET` represents exactly 8 bits of data on external storage.

The JPEG library proper does not assume ASCII representation of characters. But some of the image file I/O modules in cjpeg/djpeg do have ASCII dependencies in file-header manipulation; so does cjpeg's select\_file\_type() routine.

The JPEG library does not rely heavily on the C library. In particular, C stdio is used only by the data source/destination modules and the error handler, all of which are application-replaceable. (cjpeg/djpeg are more heavily dependent on stdio.) malloc and free are called only from the memory manager

"back end" module, so you can use a different memory allocator by replacing that one file.

The code generally assumes that C names must be unique in the first 15 characters. However, global function names can be made unique in the first 6 characters by defining NEED\_SHORT\_EXTERNAL\_NAMES.

More info about porting the code may be gleaned by reading jconfig.txt, jmorecfg.h, and jinclude.h.

Notes for MS-DOS implementors

-----

The IJG code is designed to work efficiently in 80x86 "small" or "medium" memory models (i.e., data pointers are 16 bits unless explicitly declared "far"; code pointers can be either size). You may be able to use small model to compile cjpeg or djpeg by itself, but you will probably have to use medium model for any larger application. This won't make much difference in performance. You *will* take a noticeable performance hit if you use a large-data memory model (perhaps 10%-25%), and you should avoid "huge" model if at all possible.

The

JPEG library typically needs 2Kb-3Kb of stack space. It will also malloc about 20K-30K of near heap space while executing (and lots of far heap, but that doesn't count in this calculation). This figure will vary depending on selected operating mode, and to a lesser extent on image size. There is also about 5Kb-6Kb of constant data which will be allocated in the near data segment (about 4Kb of this is the error message table).

Thus you have perhaps 20K available for other modules' static data and near heap space before you need to go to a larger memory model. The C library's static data will account for several K of this, but that still leaves a good deal for your needs. (If you are tight on space, you could reduce the sizes of the I/O buffers allocated by jdatasrc.c and jdatadst.c, say from 4K to 1K. Another possibility is to move the error message table to far memory; this should be doable with only localized hacking on jerror.c.)

About 2K of the near heap space is "permanent" memory that will not be released until you destroy the JPEG object. This is only an issue if you save a JPEG object between compression or decompression operations.

Far data space may also be a tight resource when you are dealing with large images. The most memory-intensive case is decompression with two-pass color quantization, or single-pass quantization to an externally supplied color map. This requires a 128Kb color lookup table plus strip buffers amounting to about 40 bytes per column for typical sampling ratios (eg, about 25600 bytes for a 640-pixel-wide image). You may not be able to process wide images if you have large data structures of your own.

Of course, all of these concerns vanish if you use a 32-bit flat-memory-model compiler, such as DJGPP or Watcom C. We highly recommend flat model if you can use it; the JPEG library is significantly faster in flat model.

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/libjpeg.txt

No license file was found, but licenses were detected in source scan.

/\*

\* jdarith.c

\*

\* Developed 1997-2015 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains portable arithmetic entropy decoding routines for JPEG

\* (implementing the ISO/IEC IS 10918-1 and CCITT Recommendation ITU-T T.81).

\*

\* Both sequential and progressive modes are supported in this single module.

\*

\* Suspension is not currently supported in this module.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jdarith.c

No license file was found, but licenses were detected in source scan.

/\*

\* transupp.c

\*

\* Copyright (C) 1997-2017, Thomas G. Lane, Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains image transformation routines and other utility code

\* used by the jpegtran sample application. These are NOT part of the core  
\* JPEG library. But we keep these routines separate from jpegtran.c to  
\* ease the task of maintaining jpegtran-like programs that have other user  
\* interfaces.  
\*/

Found in path(s):

\*/opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/transupp.c  
No license file was found, but licenses were detected in source scan.

/\*

\* rdswitch.c

\*

\* Copyright (C) 1991-1996, Thomas G. Lane.

\* Modified 2003-2015 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains routines to process some of cjpeg's more complicated

\* command-line switches. Switches processed here are:

\* -qtables file Read quantization tables from text file

\* -scans file Read scan script from text file

\* -quality N[,N,...] Set quality ratings

\* -qslots N[,N,...] Set component quantization table selectors

\* -sample HxV[,HxV,...] Set component sampling factors

\*/

Found in path(s):

\*/opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/rdswitch.c  
No license file was found, but licenses were detected in source scan.

/\*

\* jchuff.c

\*

\* Copyright (C) 1991-1997, Thomas G. Lane.

\* Modified 2006-2013 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains Huffman entropy encoding routines.

\* Both sequential and progressive modes are supported in this single module.

\*

\* Much of the complexity here has to do with supporting output suspension.

\* If the data destination module demands suspension, we want to be able to

\* back up to the start of the current MCU. To do this, we copy state

\* variables into local working storage, and update them back to the

\* permanent JPEG objects only upon successful completion of an MCU.

\*

\* We do not support output suspension for the progressive JPEG mode, since  
\* the library currently does not allow multiple-scan files to be written  
\* with output suspension.  
\*/

#### Found

in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jchuff.c  
No license file was found, but licenses were detected in source scan.

/\*

\* jmemname.c

\*

\* Copyright (C) 1992-1997, Thomas G. Lane.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file provides a generic implementation of the system-dependent

\* portion of the JPEG memory manager. This implementation assumes that

\* you must explicitly construct a name for each temp file.

\* Also, the problem of determining the amount of memory available

\* is shoved onto the user.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jmemname.c  
No license file was found, but licenses were detected in source scan.

/\*

\* jccoefct.c

\*

\* Copyright (C) 1994-1997, Thomas G. Lane.

\* Modified 2003-2011 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains the coefficient buffer controller for compression.

\* This controller is the top level of the JPEG compressor proper.

\* The coefficient buffer lies between forward-DCT and entropy encoding steps.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jccoefct.c  
No license file was found, but licenses were detected in source scan.

/\*

\* jdsample.c

\*

\* Copyright (C) 1991-1996, Thomas G. Lane.  
\* Modified 2002-2015 by Guido Vollbeding.  
\* This file is part of the Independent JPEG Group's software.  
\* For conditions of distribution and use, see the accompanying README file.  
\*  
\* This file contains upsampling routines.  
\*  
\* Upsampling input data is counted in "row groups". A row group  
\* is defined to be (v\_samp\_factor \* DCT\_v\_scaled\_size / min\_DCT\_v\_scaled\_size)  
\* sample rows of each component. Upsampling will normally produce  
\* max\_v\_samp\_factor pixel rows from each row group (but this could vary  
\* if the upsampler is applying a scale factor of its own).  
\*  
\* An excellent reference for image resampling is  
\* Digital Image Warping, George Wolberg, 1990.  
\* Pub. by IEEE Computer Society Press, Los Alamitos, CA. ISBN 0-8186-8944-7.  
\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jdsample.c  
No license file was found, but licenses were detected in source scan.

/\*

\* jdct.h

\*

\* Copyright (C) 1994-1996, Thomas G. Lane.  
\* Modified 2002-2017 by Guido Vollbeding.  
\* This file is part of the Independent JPEG Group's software.  
\* For conditions of distribution and use, see the accompanying README file.  
\*  
\* This include file contains common declarations for the forward and  
\* inverse DCT modules. These declarations are private to the DCT managers  
\* (jcdctmgr.c, jddctmgr.c) and the individual DCT algorithms.  
\* The individual DCT algorithms are kept in separate files to ease  
\* machine-dependent tuning (e.g., assembly coding).  
\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jdct.h  
No license file was found, but licenses were detected in source scan.

/\*

\* jdmainct.c

\*

\* Copyright (C) 1994-1996, Thomas G. Lane.  
\* Modified 2002-2016 by Guido Vollbeding.  
\* This file is part of the Independent JPEG Group's software.  
\* For conditions of distribution and use, see the accompanying README file.

\*  
\* This file contains the main buffer controller for decompression.  
\* The main buffer lies between the JPEG decompressor proper and the  
\* post-processor; it holds downsampled data in the JPEG colorspace.  
\*  
\* Note that this code is bypassed in raw-data mode, since the application  
\* supplies the equivalent of the main buffer in that case.  
\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jdmainct.c  
No license file was found, but licenses were detected in source scan.

/\*

\* jmemdos.c

\*

\* Copyright (C) 1992-1997, Thomas G. Lane.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file provides an MS-DOS-compatible implementation of the system-  
\* dependent portion of the JPEG memory manager. Temporary data can be  
\* stored in extended or expanded memory as well as in regular DOS files.

\*

\* If you use this file, you must be sure that NEED\_FAR\_POINTERS is defined

\* if you compile in a small-data memory model; it should NOT be defined if

\* you use a large-data memory model. This file is not recommended if you

\* are using a flat-memory-space 386 environment such as DJGCC or Watcom C.

\* Also, this code will NOT work if struct fields are aligned on greater than

\* 2-byte boundaries.

\*

\* Based on code contributed by Ge' Weijers.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jmemdos.c  
No license file was found, but licenses were detected in source scan.

/\*

\* jidctint.c

\*

\* Copyright (C) 1991-1998, Thomas G. Lane.

\* Modification developed 2002-2016 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains a slow-but-accurate integer implementation of the

\* inverse DCT (Discrete Cosine Transform). In the IJG code, this routine



- \* must also perform dequantization of the input coefficients.
- \*
- \* A 2-D IDCT can be done by 1-D IDCT on each column followed by 1-D IDCT
- \* on each row (or vice versa, but it's more convenient to emit a row at
- \* a time). Direct algorithms are also available, but they are much more
- \* complex and seem not to be any faster when reduced to code.
- \*
- \* This implementation is based on an algorithm described in
- \* C. Loeffler, A. Ligtenberg and G. Moschytz, "Practical Fast 1-D DCT
- \* Algorithms with 11 Multiplications",
- Proc. Int'l. Conf. on Acoustics,
- \* Speech, and Signal Processing 1989 (ICASSP '89), pp. 988-991.
- \* The primary algorithm described there uses 11 multiplies and 29 adds.
- \* We use their alternate method with 12 multiplies and 32 adds.
- \* The advantage of this method is that no data path contains more than one
- \* multiplication; this allows a very simple and accurate implementation in
- \* scaled fixed-point arithmetic, with a minimal number of shifts.
- \*
- \* We also provide IDCT routines with various output sample block sizes for
- \* direct resolution reduction or enlargement and for direct resolving the
- \* common 2x1 and 1x2 subsampling cases without additional resampling: NxN
- \* (N=1...16), 2NxN, and Nx2N (N=1...8) pixels for one 8x8 input DCT block.
- \*
- \* For N<8 we simply take the corresponding low-frequency coefficients of
- \* the 8x8 input DCT block and apply an NxN point IDCT on the sub-block
- \* to yield the downsampled outputs.
- \* This can be seen as direct low-pass downsampling
- from the DCT domain
- \* point of view rather than the usual spatial domain point of view,
- \* yielding significant computational savings and results at least
- \* as good as common bilinear (averaging) spatial downsampling.
- \*
- \* For N>8 we apply a partial NxN IDCT on the 8 input coefficients as
- \* lower frequencies and higher frequencies assumed to be zero.
- \* It turns out that the computational effort is similar to the 8x8 IDCT
- \* regarding the output size.
- \* Furthermore, the scaling and descaling is the same for all IDCT sizes.
- \*
- \* CAUTION: We rely on the FIX() macro except for the N=1,2,4,8 cases
- \* since there would be too many additional constants to pre-calculate.
- \*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jidctint.c

No license file was found, but licenses were detected in source scan.

INSTALLATION INSTRUCTIONS for the Independent JPEG Group's JPEG software

Copyright (C) 1991-2017, Thomas G. Lane, Guido Vollbeding.  
This file is part of the Independent JPEG Group's software.  
For conditions of distribution and use, see the accompanying README file.

This file explains how to configure and install the IJG software. We have tried to make this software extremely portable and flexible, so that it can be adapted to almost any environment. The downside of this decision is that the installation process is complicated. We have provided shortcuts to simplify the task on common systems. But in any case, you will need at least a little familiarity with C programming and program build procedures for your system.

If you are only using this software as part of a larger program, the larger program's installation procedure may take care of configuring the IJG code. For example, Ghostscript's installation script will configure the IJG code. You don't need to read this file if you just want to compile Ghostscript.

If you are on a Unix machine, you may not need to read this file at all.

Try doing

```
./configure
```

```
make
```

```
make test
```

If that doesn't complain, do

```
make install
```

(better do "make -n install" first to see if the makefile will put the files where you want them). Read further if you run into snags or want to customize the code for your system.

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-----

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## BEFORE YOU START

=====

Before installing the software you must unpack the distributed source code. Since you are reading this file, you have probably already succeeded in this task. However, there is a potential for error if you needed to convert the files to the local standard text file format (for example, if you are on MS-DOS you may have converted LF end-of-line to CR/LF). You must apply such conversion to all the files EXCEPT those whose names begin with "test". The test files contain binary data; if you change them in any way then the self-test will give bad results.

Please check the last section of this file to see if there are hints for the specific machine or compiler you are using.

## CONFIGURING THE SOFTWARE

=====

To configure the IJG code for your system, you need to create two files:

- \* jconfig.h: contains values for system-dependent #define symbols.
- \* Makefile: controls the compilation process.

(On a non-Unix machine, you may create "project files" or some other substitute for a Makefile. jconfig.h is needed in any environment.)

We provide three different ways to generate these files:

- \* On a Unix system, you can just run the "configure" script.
- \* We provide sample jconfig files and makefiles for popular machines; if your machine matches one of the samples, just copy the right sample files to jconfig.h and Makefile.
- \* If all else fails, read the instructions below and make your own files.

Configuring the software using the automatic "configure" script

-----

If you are on a Unix machine, you can just type

```
./configure
```

and let the configure script construct appropriate configuration files.

If you're using "csh" on an old version of System V, you might need to type

```
sh configure
```

instead to prevent csh from trying to execute configure itself.

Expect configure to run for a few minutes, particularly on slower machines; it works by compiling a series of test programs.

Configure was created with GNU Autoconf and it follows the usual conventions for GNU configure scripts. It makes a few assumptions that you may want to override. You can do this by providing optional switches to configure:

\*

Configure will build both static and shared libraries, if possible.

If you want to build libjpeg only as a static library, say

```
./configure --disable-shared
```

If you want to build libjpeg only as a shared library, say

```
./configure --disable-static
```

Configure uses GNU libtool to take care of system-dependent shared library building methods.

\* Configure will use gcc (GNU C compiler) if it's available, otherwise cc.

To force a particular compiler to be selected, use the CC option, for example

```
./configure CC='cc'
```

The same method can be used to include any unusual compiler switches.

For example, on HP-UX you probably want to say

```
./configure CC='cc -Aa'
```

to get HP's compiler to run in ANSI mode.

\* The default CFLAGS setting is "-g" for non-gcc compilers, "-g -O2" for gcc.

You can override this by saying, for example,

```
./configure CFLAGS='-O2'
```

if you want to compile without debugging support.

\* Configure will set up the makefile so that "make install" will install files into /usr/local/bin,

/usr/local/man, etc. You can specify an installation

prefix other than "/usr/local" by giving configure the option "--prefix=PATH".

\* If you don't have a lot of swap space, you may need to enable the IJG

software's internal virtual memory mechanism. To do this, give the option

"--enable-maxmem=N" where N is the default maxmemory limit in megabytes.

This is discussed in more detail under "Selecting a memory manager", below.

You probably don't need to worry about this on reasonably-sized Unix machines, unless you plan to process very large images.

Configure has some other features that are useful if you are cross-compiling or working in a network of multiple machine types; but if you need those features, you probably already know how to use them.

Configuring the software using one of the supplied jconfig and makefile files

-----

If you have one of these systems, you can just use the provided configuration files:

Makefile jconfig

file System and/or compiler

makefile.manx jconfig.manx Amiga, Manx Aztec C  
makefile.sas jconfig.sas Amiga, SAS C  
makeproj.mac jconfig.mac Apple Macintosh, Metrowerks CodeWarrior  
mak\*jpeg.st jconfig.st Atari ST/STE/TT, Pure C or Turbo C  
makefile.bcc jconfig.bcc MS-DOS or OS/2, Borland C  
makefile.dj jconfig.dj MS-DOS, DJGPP (Delorie's port of GNU C)  
makefile.mc6 jconfig.mc6 MS-DOS, Microsoft C (16-bit only)  
makefile.wat jconfig.wat MS-DOS, OS/2, or Windows NT, Watcom C  
makefile.vc jconfig.vc Windows, MS Visual C++  
makefile.vs jconfig.vc Windows, MS Visual C++ 6 Developer Studio  
make\*.vc6  
makefile.vs jconfig.vc Windows, Visual Studio 2017 (v15)  
make\*.v15  
makefile.b32 jconfig.vc Windows, Borland C++ 32-bit (bcc32)  
makefile.mms jconfig.vms Digital VMS, with MMS software  
makefile.vms jconfig.vms Digital VMS, without MMS software

Copy the proper jconfig file to jconfig.h and the makefile to Makefile (or whatever your system uses as the standard makefile name). For more info see the appropriate system-specific hints section near the end of this file.

#### Configuring the software by hand

-----

First, generate a jconfig.h file. If you are moderately familiar with C, the comments in jconfig.txt should be enough information to do this; just copy jconfig.txt to jconfig.h and edit it appropriately. Otherwise, you may prefer to use the ckconfig.c program. You will need to compile and execute ckconfig.c by hand --- we hope you know at least enough to do that. ckconfig.c may not compile the first try (in fact, the whole idea is for it to fail if anything is going to). If you get compile errors, fix them by editing ckconfig.c according to the directions given in ckconfig.c. Once you get it to run, it will write a suitable jconfig.h file, and will also print out some advice about which makefile to use.

You may also want to look at the canned jconfig files, if there is one for a system similar to yours.

Second, select a makefile

and copy it to Makefile (or whatever your system uses as the standard makefile name). The most generic makefiles we provide are

makefile.ansi: if your C compiler supports function prototypes  
makefile.unix: if not.

(You have function prototypes if ckconfig.c put "#define HAVE\_PROTOTYPES" in jconfig.h.) You may want to start from one of the other makefiles if there is one for a system similar to yours.

Look over the selected Makefile and adjust options as needed. In particular you may want to change the CC and CFLAGS definitions. For instance, if you are using GCC, set CC=gcc. If you had to use any compiler switches to get ckconfig.c to work, make sure the same switches are in CFLAGS.

If you are on a system that doesn't use makefiles, you'll need to set up project files (or whatever you do use) to compile all the source files and link them into executable files cjpeg, djpeg, jpegtran, rdjpgcom, and wrjpgcom. See the file lists in any of the makefiles to find out which files go into each program. Note that the provided makefiles all make a "library" file libjpeg first, but you don't have to do that if you don't want to; the file lists identify which source files are actually needed for compression, decompression, or both. As a last resort, you can make a batch script that just compiles everything and links it all together; makefile.vms is an example of this (it's for VMS systems that have no make-like utility).

Here are comments about some specific configuration decisions you'll need to make:

#### Command line style

-----

These programs can use a Unix-like command line style which supports redirection and piping, like this:

```
cjpeg inputfile >outputfile
```

```
cjpeg <inputfile >outputfile
```

```
source program | cjpeg >outputfile
```

The simpler "two file" command line style is just

```
cjpeg inputfile outputfile
```

You may prefer the two-file style, particularly if you don't have pipes.

You **MUST** use two-file style on any system that doesn't cope well with binary data

fed through stdin/stdout; this is true for some MS-DOS compilers, for example. If you're not on a Unix system, it's safest to assume you need two-file style. (But if your compiler provides either the Posix-standard fdopen() library routine or a Microsoft-compatible setmode() routine, you can safely use the Unix command line style, by defining USE\_FDOPEN or USE\_SETMODE respectively.)

To use the two-file style, make jconfig.h say "#define TWO\_FILE\_COMMANDLINE".

Selecting a memory manager

-----

The IJG code is capable of working on images that are too big to fit in main memory; data is swapped out to temporary files as necessary. However, the code to do this is rather system-dependent. We provide five different memory managers:

\* `jmemansi.c` This version uses the ANSI-standard library routine `tmpfile()`, which not all non-ANSI systems have. On some systems `tmpfile()` may put the temporary file in a non-optimal location; if you don't like what it does, use `jmemname.c`.

\* `jmemname.c` This version creates named temporary files. For anything except a Unix machine, you'll need to configure the `select_file_name()` routine appropriately; see the comments near the head of `jmemname.c`. If you use this version, define `NEED_SIGNAL_CATCHER` in `jconfig.h` to make sure the temp files are removed if the program is aborted.

\* `jmemnobs.c` (That stands for No Backing Store :-).) This will compile on almost any system, but it assumes you have enough main memory or virtual memory to hold the biggest images you work with.

\* `jmemdos.c` This should be used with most 16-bit MS-DOS compilers. See the system-specific notes about MS-DOS for more info. IMPORTANT: if you use this, define `USE_MSDDOS_MEMMGR` in `jconfig.h`, and include the assembly file `jmemdosa.asm` in the programs. The supplied makefiles and `jconfig` files for 16-bit MS-DOS compilers already do both.

\* `jmemmac.c` Custom version for Apple Macintosh; see the system-specific notes for Macintosh for more info.

To use a particular memory manager, change the `SYSDEPMEM` variable in your makefile to equal the corresponding object file name (for example, `jmemansi.o` or `jmemansi.obj` for `jmemansi.c`).

If you have plenty of (real or virtual) main memory, just use `jmemnobs.c`.

"Plenty" means about ten bytes for every pixel in the largest images you plan to process, so a lot of systems don't meet this criterion.

If yours doesn't, try `jmemansi.c` first. If that doesn't compile, you'll have to use `jmemname.c`; be sure to adjust `select_file_name()` for local conditions. You may also need to change `unlink()` to `remove()` in `close_backing_store()`.

Except with `jmemnobs.c` or `jmemmac.c`, you need to adjust the `DEFAULT_MAX_MEM` setting to a reasonable value for your system (either by adding a `#define` for

DEFAULT\_MAX\_MEM to jconfig.h, or by adding a -D switch to the Makefile). This value limits the amount of data space the program will attempt to allocate. Code and static data space isn't counted, so the actual memory needs for cjpeg or djpeg are typically 100 to 150Kb more than the max-memory setting. Larger max-memory settings reduce the amount of I/O needed to process a large image, but too large a value can result in "insufficient memory" failures. On most Unix machines (and other systems with virtual memory), just set DEFAULT\_MAX\_MEM to several million and forget it. At the other end of the spectrum, for MS-DOS machines you probably can't go much above 300K to 400K. (On MS-DOS the value refers to conventional memory only. Extended/expanded memory is handled separately by jmemdos.c.)

## BUILDING THE SOFTWARE

=====

Now you should be able to compile the software. Just say "make" (or whatever's necessary to start the compilation). Have a cup of coffee.

Here are some things that could go wrong:

If your compiler complains about undefined structures, you should be able to shut it up by putting "#define INCOMPLETE\_TYPES\_BROKEN" in jconfig.h.

If you have trouble with missing system include files or inclusion of the wrong ones, read jinclude.h. This shouldn't happen if you used configure or ckconfig.c to set up jconfig.h.

There are a fair number of routines that do not use all of their parameters; some compilers will issue warnings about this, which you can ignore. There are also a few configuration checks that may give "unreachable code" warnings. Any other warning deserves investigation.

If you don't have a getenv() library routine, define NO\_GETENV.

Also see the system-specific hints, below.

## TESTING THE SOFTWARE

=====

As a quick test of functionality we've included a small sample image in several forms:

- testorig.jpg Starting point for the djpeg tests.
- testimg.ppm The output of djpeg testorig.jpg
- testimg.bmp The output of djpeg -bmp -colors 256 testorig.jpg



testimg.jpg The output of cjpeg testimg.ppm  
testprog.jpg Progressive-mode equivalent of testorig.jpg.  
testimgp.jpg The output of cjpeg -progressive  
-optimize testimg.ppm

(The first- and second-generation .jpg files aren't identical since the default compression parameters are lossy.) If you can generate duplicates of the testimg\* files then you probably have working programs.

With most of the makefiles, "make test" will perform the necessary comparisons.

If you're using a makefile that doesn't provide the test option, run djpeg and cjpeg by hand and compare the output files to testimg\* with whatever binary file comparison tool you have. The files should be bit-for-bit identical.

If the programs complain "MAX\_ALLOC\_CHUNK is wrong, please fix", then you need to reduce MAX\_ALLOC\_CHUNK to a value that fits in type size\_t. Try adding "#define MAX\_ALLOC\_CHUNK 65520L" to jconfig.h. A less likely configuration error is "ALIGN\_TYPE is wrong, please fix": defining ALIGN\_TYPE as long should take care of that one.

If the cjpeg test run fails with "Missing Huffman code table entry", it's a good bet that you needed to define RIGHT\_SHIFT\_IS\_UNSIGNED.

Go back to the configuration step and run ckconfig.c. (This is a good plan for any other test failure, too.)

If you are using Unix (one-file) command line style on a non-Unix system, it's a good idea to check that binary I/O through stdin/stdout actually works. You should get the same results from "djpeg <testorig.jpg >out.ppm" as from "djpeg -outfile out.ppm testorig.jpg". Note that the makefiles all use the latter style and therefore do not exercise stdin/stdout! If this check fails, try recompiling with USE\_SETMODE or USE\_FDOPEN defined. If it still doesn't work, better use two-file style.

If you chose a memory manager other than jmemnobs.c, you should test that temporary-file usage works. Try "djpeg -bmp -colors 256 -max 0 testorig.jpg" and make sure its output matches testimg.bmp. If you have any really large images handy, try compressing them with -optimize and/or decompressing with -colors 256 to make sure your DEFAULT\_MAX\_MEM setting is not too large.

NOTE:

this is far from an exhaustive test of the JPEG software; some modules, such as 1-pass color quantization, are not exercised at all. It's just a quick test to give you some confidence that you haven't missed something major.

## INSTALLING THE SOFTWARE

=====

Once you're done with the above steps, you can install the software by copying the executable files (cjpeg, djpeg, jpegtran, rdjpgcom, and wrjpgcom) to wherever you normally install programs. On Unix systems, you'll also want to put the man pages (cjpeg.1, djpeg.1, jpegtran.1, rdjpgcom.1, wrjpgcom.1) in the man-page directory. The pre-fab makefiles don't support this step since there's such a wide variety of installation procedures on different systems.

If you generated a Makefile with the "configure" script, you can just say  
make install  
to install the programs and their man pages into the standard places. (You'll probably need to be root to do this.) We recommend first saying  
make -n install  
to see  
where configure thought the files should go. You may need to edit the Makefile, particularly if your system's conventions for man page filenames don't match what configure expects.

If you want to install the IJG library itself, for use in compiling other programs besides ours, then you need to put the four include files  
jpeglib.h jerror.h jconfig.h jmorecfg.h  
into your include-file directory, and put the library file libjpeg.a (extension may vary depending on system) wherever library files go. If you generated a Makefile with "configure", it will do what it thinks is the right thing if you say  
make install-lib

## OPTIONAL STUFF

=====

Progress monitor:

If you like, you can #define PROGRESS\_REPORT (in jconfig.h) to enable display of percent-done progress reports. The routine provided in cdjpeg.c merely prints percentages to stderr, but you can customize it to do something fancier.

Utah RLE file format support:

We distribute the software with support for RLE image files (Utah Raster Toolkit format) disabled, because the RLE support won't compile without the Utah library. If you have URT version 3.1 or later, you can enable RLE

support as follows:

1. #define RLE\_SUPPORTED in jconfig.h.
2. Add a -I option to CFLAGS in the Makefile for the directory containing the URT .h files (typically the "include" subdirectory of the URT distribution).
3. Add -L... -lrle to LDLIBS in the Makefile, where ... specifies the directory containing the URT "librle.a" file (typically the "lib" subdirectory of the URT distribution).

Support for 9-bit to 12-bit deep pixel data:

The IJG code currently allows 8, 9, 10, 11, or 12 bits sample data precision. (For color, this means 8 to 12 bits per channel, of course.) If you need to work with deeper than 8-bit data, you can compile the IJG code for 9-bit to 12-bit operation.

To do so:

1. In jmorecfg.h, define BITS\_IN\_JSAMPLE as 9, 10, 11, or 12 rather than 8.
2. In jconfig.h, undefine BMP\_SUPPORTED, RLE\_SUPPORTED, and TARGA\_SUPPORTED, because the code for those formats doesn't handle deeper than 8-bit data and won't even compile. (The PPM code does work, as explained below. The GIF code works too; it scales 8-bit GIF data to and from 12-bit depth automatically.)
3. Compile. Don't expect "make test" to pass, since the supplied test files are for 8-bit data.

Currently, 9-bit to 12-bit support does not work on 16-bit-int machines.

Run-time selection and conversion of data precision are currently not supported and may be added later.

Exception: The transcoding part (jpegtran) supports all settings in a single instance, since it operates on the level of DCT coefficients and not sample values.

The PPM reader (rdppm.c) can read deeper than 8-bit data from either text-format or binary-format PPM and PGM files. Binary-format PPM/PGM files which have a maxval greater than 255 are assumed to use 2 bytes per sample, MSB first (big-endian order). As of early 1995, 2-byte binary format is not officially supported by the PBMPLUS library, but it is expected that a future release of PBMPLUS will support it. Note that the PPM reader will read files of any maxval regardless of the BITS\_IN\_JSAMPLE setting; incoming data is automatically rescaled to maxval=MAXJSAMPLE as appropriate for the cjpeg bit depth.

The PPM writer (wrppm.c) will normally write 2-byte binary PPM or PGM format, maxval=MAXJSAMPLE, when compiled with BITS\_IN\_JSAMPLE>8. Since this format is not yet widely supported, you can disable it by compiling wrppm.c

with PPM\_NORAWWORD defined; then the data is scaled down to 8 bits to make a standard 1-byte/sample PPM or PGM file. (Yes, this means still another copy of djpeg to keep around. But hopefully you won't need it for very long. Poskanzer's supposed to get that new PBMPLUS release out Real Soon Now.)

Of course, if you are working with 9-bit to 12-bit data, you probably have it stored in some other, nonstandard format. In that case you'll probably want to write your own I/O modules to read and write your format.

Note:

The standard Huffman tables are only valid for 8-bit data precision. If you selected more than 8-bit data precision, cjpeg uses arithmetic coding by default. The Huffman encoder normally uses entropy optimization to compute usable tables for higher precision. Otherwise, you'll have to supply different default Huffman tables.

Removing code:

If you need to make a smaller version of the JPEG software, some optional functions can be removed at compile time. See the xxx\_SUPPORTED #defines in jconfig.h and jmorecfg.h. If at all possible, we recommend that you leave in decoder support for all valid JPEG files, to ensure that you can read anyone's output. Taking out support for image file formats that you don't use is the most painless way to make the programs smaller. Another possibility is to remove some of the DCT methods: in particular, the "IFAST" method may not be enough faster than the others to be worth keeping on your machine. (If you do remove ISLOW or IFAST, be sure to redefine JDCT\_DEFAULT or JDCT\_FASTEST to a supported method, by adding a #define in jconfig.h.)

## OPTIMIZATION

=====

Unless you own a Cray, you'll probably be interested in making the JPEG software go as fast as possible. This section covers some machine-dependent optimizations you may want to try. We suggest that before trying any of this, you first get the basic installation to pass the self-test step. Repeat the self-test after any optimization to make sure that you haven't broken anything.

The integer DCT routines perform a lot of multiplications. These multiplications must yield 32-bit results, but none of their input values are more than 16 bits wide. On many machines, notably the 680x0 and 80x86 CPUs, a 16x16=>32 bit multiply instruction is faster than a full 32x32=>32 bit multiply. Unfortunately there is no portable way to specify such a multiplication in C, but some

compilers can generate one when you use the right combination of casts. See the MULTIPLYxxx macro definitions in jdct.h. If your compiler makes "int" be 32 bits and "short" be 16 bits, defining SHORTxSHORT\_32 is fairly likely to work. When experimenting with alternate definitions, be sure to test not only whether the code still works (use the self-test), but also whether it is actually faster --- on some compilers, alternate definitions may compute the right answer, yet be slower than the default. Timing cjpeg on a large PGM (grayscale) input file is the best way to check this, as the DCT will be the largest fraction of the runtime in that mode. (Note: some of the distributed compiler-specific jconfig files already contain #define switches to select appropriate MULTIPLYxxx definitions.)

If your machine has sufficiently fast floating point hardware, you may find that the float DCT method is faster than the integer DCT methods, even after tweaking the integer multiply macros. In that case you may want to make the float DCT be the default method. (The only objection to this is that float DCT results may vary slightly across machines.) To do that, add "#define JDCT\_DEFAULT JDCT\_FLOAT" to jconfig.h. Even if you don't change the default, you should redefine JDCT\_FASTEST, which is the method selected by djpeg's -fast switch. Don't forget to update the documentation files (usage.txt and/or cjpeg.1, djpeg.1) to agree with what you've done.

If access to "short" arrays is slow on your machine, it may be a win to define type JCOEF as int rather than short. This will cost a good deal of memory though, particularly in some multi-pass modes, so don't do it unless you have memory to burn and short is REALLY slow.

If your compiler can compile function calls in-line, make sure the INLINE macro in jmorecfg.h is defined as the keyword that marks a function inline-able. Some compilers have a switch that tells the compiler to inline any function it thinks is profitable (e.g., -finline-functions for gcc). Enabling such a switch is likely to make the compiled code bigger but faster.

In general, it's worth trying the maximum optimization level of your compiler, and experimenting with any optional optimizations such as loop unrolling. (Unfortunately, far too many compilers have optimizer bugs ... be prepared to back off if the code fails self-test.) If you do any experimentation along these lines, please report the optimal settings to jpeg-info@jpegclub.org so we can mention them in future releases. Be sure to specify your machine and compiler version.

#### HINTS FOR SPECIFIC SYSTEMS

=====

We welcome reports on changes needed for systems not mentioned here. Submit 'em to jpeg-info@jpegclub.org. Also, if configure or ckconfig.c is wrong about how to configure the JPEG software for your system, please let us know.

Acorn RISC OS:

(Thanks to Simon Middleton for these hints on compiling with Desktop C.)

After renaming the files according to Acorn conventions, take a copy of makefile.ansi, change all occurrences of 'libjpeg.a' to 'libjpeg.o' and change these definitions as indicated:

```
CFLAGS= -throwback -IC: -Wn
LDLIBS=C:o.Stubs
SYSDEPMEM=jmemansi.o
LN=Link
AR=LibFile -c -o
```

Also add a new line '.c.o: \$(cc) \$< \$(cflags) -c -o \$@'. Remove the lines '\$(RM) libjpeg.o' and '\$(AR2) libjpeg.o' and the 'jconfig.h' dependency section.

Copy jconfig.txt to jconfig.h. Edit jconfig.h to define TWO\_FILE\_COMMANDLINE and CHAR\_IS\_UNSIGNED.

Run the makefile using !AMU not !Make. If you want to use the 'clean' and 'test' makefile entries then you will have to fiddle with the syntax a bit and rename the test files.

Amiga:

SAS C 6.50 reportedly is too buggy to compile the IJG code properly. A patch to update to 6.51 is available from SAS or AmiNet FTP sites.

The supplied config files are set up to use jmemname.c as the memory manager, with temporary files being created on the device named by "JPEGTMP:".

Atari ST/STE/TT:

Copy

the project files makcjpeg.st, makdjpeg.st, maktjpeg.st, and makljpeg.st to cjpeg.prj, djpeg.prj, jpegtran.prj, and libjpeg.prj respectively. The project files should work as-is with Pure C. For Turbo C, change library filenames "pc..." to "tc..." in each project file. Note that libjpeg.prj

selects `jmemansi.c` as the recommended memory manager. You'll probably want to adjust the `DEFAULT_MAX_MEM` setting --- you want it to be a couple hundred K less than your normal free memory. Put `"#define DEFAULT_MAX_MEM nnnn"` into `jconfig.h` to do this.

To use the 68881/68882 coprocessor for the floating point DCT, add the compiler option `"-8"` to the project files and replace `pcfltlb.lib` with `pc881lib.lib` in `cjpeg.prj` and `djpeg.prj`. Or if you don't have a coprocessor, you may prefer to remove the float DCT code by undefining `DCT_FLOAT_SUPPORTED` in `jmorecfg.h` (since without a coprocessor, the float code will be too slow to be useful). In that case, you can delete `pcfltlb.lib` from the project files.

Note that you must make `libjpeg.lib` before making `cjpeg.ttp`, `djpeg.ttp`, or `jpegtran.ttp`. You'll have to perform the self-test by hand.

We haven't bothered to include project files for `rdjpgcom` and `wrjpgcom`. Those source files should just be compiled by themselves; they don't depend on the JPEG library. You can use the `default.prj` project file of the Pure C distribution to make the programs.

There is a bug in some older versions of the Turbo C library which causes the space used by temporary files created with `"tmpfile()"` not to be freed after an abnormal program exit. If you check your disk afterwards, you will find cluster chains that are allocated but not used by a file. This should not happen in `cjpeg/djpeg/jpegtran`, since we enable a signal catcher to explicitly close temp files before exiting. But if you use the JPEG library with your own code, be sure to supply a signal catcher, or else use a different system-dependent memory manager.

Cray:

Should you be so fortunate as to be running JPEG on a Cray YMP, there is a compiler bug in old versions of Cray's Standard C (prior to 3.1). If you still have an old compiler, you'll need to insert a line reading `"#pragma novector"` just before the loop

```
for (i = 1; i <= (int) htbl->bits[i]; i++)
    huffsize[p++] = (char) i;
```

in `fix_huff_tbl` (in `V5beta1`, line 204 of `jchuff.c` and line 176 of `jdchuff.c`). [This bug may or may not still occur with the current IJG code, but it's probably a dead issue anyway...]

HP-UX:

If you have HP-UX 7.05 or later with the "software development" C compiler, you should run the compiler in ANSI mode. If using the configure script, say

```
./configure CC='cc -Aa'
```

(or `-Ae` if you prefer). If configuring by hand, use `makefile.ansi` and add `"-Aa"` to the `CFLAGS` line in the makefile.

If you have a pre-7.05 system, or if you are using the non-ANSI C compiler delivered with a minimum HP-UX system, then you must use `makefile.unix` (and do NOT add `-Aa`); or just run `configure` without the `CC` option.

On HP 9000 series 800 machines, the HP C compiler is buggy in revisions prior to A.08.07. If you get complaints about "not a typedef name", you'll have to use `makefile.unix`, or run `configure` without the `CC` option.

Macintosh, generic comments:

The supplied user-interface files (`cjpeg.c`, `djpeg.c`, etc) are set up to provide a Unix-style command line interface. You can use this interface on the Mac by means of the `ccommand()` library routine provided by Metrowerks CodeWarrior or Think C. This is only appropriate for testing the library, however; to make a user-friendly equivalent of `cjpeg/djpeg` you'd really want to develop a Mac-style user interface. There isn't a complete example available at the moment, but there are some helpful starting points:

1. Sam Bushell's free "To JPEG" applet provides drag-and-drop conversion to JPEG under System 7 and later. This only illustrates how to use the compression half of the library, but it does a very nice job of that part.

The

CodeWarrior source code is available from <http://www.pobox.com/~jsam>.

2. Jim Brunner prepared a Mac-style user interface for both compression and decompression. Unfortunately, it hasn't been updated since IJG v4, and the library's API has changed considerably since then. Still it may be of some help, particularly as a guide to compiling the IJG code under Think C. Jim's code is available from the Info-Mac archives, at [sumex-aim.stanford.edu](http://sumex-aim.stanford.edu) or mirrors thereof; see file `/info-mac/dev/src/jpeg-convert-c.hqx`.

`jmemmac.c` is the recommended memory manager back end for Macintosh. It uses `NewPtr/DisposePtr` instead of `malloc/free`, and has a Mac-specific implementation of `jpeg_mem_available()`. It also creates temporary files that follow Mac conventions. (That part of the code relies on System-7-or-later OS functions. See the comments in `jmemmac.c` if you need to run it on System 6.) NOTE that `USE_MAC_MEMMGR` must be defined in `jconfig.h` to use `jmemmac.c`.

You can also use `jmemnobs.c`, if you don't care about handling images larger than available memory. If you use any memory manager back end other than



jmemmac.c, we recommend replacing "malloc" and "free" by "NewPtr" and "DisposePtr", because Mac C libraries often have peculiar implementations of malloc/free. (For instance, free() may not return the freed space to the Mac Memory Manager. This is undesirable for the IJG code because jmemmgr.c already clumps space requests.)

Macintosh, Metrowerks CodeWarrior:

The Unix-command-line-style interface can be used by defining USE\_CCOMMAND. You'll also need to define TWO\_FILE\_COMMANDLINE to avoid stdin/stdout. This means that when using the cjpeg/djpeg programs, you'll have to type the input and output file names in the "Arguments" text-edit box, rather than using the file radio buttons. (Perhaps USE\_FDOPEN or USE\_SETMODE would eliminate the problem, but I haven't heard from anyone who's tried it.)

On 680x0 Macs, Metrowerks defines type "double" as a 10-byte IEEE extended float.

jmemmgr.c won't like this: it wants sizeof(ALIGN\_TYPE) to be a power of 2. Add "#define ALIGN\_TYPE long" to jconfig.h to eliminate the complaint.

The supplied configuration file jconfig.mac can be used for your jconfig.h; it includes all the recommended symbol definitions. If you have AppleScript installed, you can run the supplied script makeproj.mac to create CodeWarrior project files for the library and the testbed applications, then build the library and applications. (Thanks to Dan Sears and Don Agro for this nifty hack, which saves us from trying to maintain CodeWarrior project files as part of the IJG distribution...)

Macintosh, Think C:

The documentation in Jim Brunner's "JPEG Convert" source code (see above) includes detailed build instructions for Think C; it's probably somewhat out of date for the current release, but may be helpful.

If you want to build the minimal command line version, proceed as follows. You'll have to prepare project files for the programs; we don't include any in the distribution since they are not text files. Use the file lists in any of the supplied makefiles as a guide. Also add the ANSI and Unix C libraries in a separate segment. You may need to divide the JPEG files into more than one segment; we recommend dividing compression and decompression modules. Define USE\_CCOMMAND in jconfig.h so that the ccommand() routine is called. You must also define TWO\_FILE\_COMMANDLINE because stdin/stdout don't handle binary data correctly.

On 680x0 Macs, Think C defines type "double" as a 12-byte IEEE extended float.

jmemmgr.c won't like this: it wants sizeof(ALIGN\_TYPE) to be a power of 2.  
Add "#define ALIGN\_TYPE long" to jconfig.h to eliminate the complaint.

jconfig.mac should work as a jconfig.h configuration file for Think C,  
but the makeproj.mac AppleScript script is specific to CodeWarrior. Sorry.

MIPS R3000:

MIPS's cc version 1.31 has a rather nasty optimization bug. Don't use -O  
if you have that compiler version.

(Use "cc -V" to check the version.)

Note that the R3000 chip is found in workstations from DEC and others.

MS-DOS, generic comments for 16-bit compilers:

The IJG code is designed to work well in 80x86 "small" or "medium" memory  
models (i.e., data pointers are 16 bits unless explicitly declared "far";  
code pointers can be either size). You may be able to use small model to  
compile cjpeg or djpeg by itself, but you will probably have to use medium  
model for any larger application. This won't make much difference in  
performance. You *will* take a noticeable performance hit if you use a  
large-data memory model, and you should avoid "huge" model if at all  
possible. Be sure that NEED\_FAR\_POINTERS is defined in jconfig.h if you use  
a small-data memory model; be sure it is NOT defined if you use a large-data  
model. (The supplied makefiles and jconfig files for Borland and Microsoft C  
compile in medium model and define NEED\_FAR\_POINTERS.)

The DOS-specific memory manager, jmemdos.c,  
should be used if possible.

It needs some assembly-code routines which are in jmemdosa.asm; make sure  
your makefile assembles that file and includes it in the library. If you  
don't have a suitable assembler, you can get pre-assembled object files for  
jmemdosa by FTP from ftp.uu.net:/graphics/jpeg/jdosaobj.zip. (DOS-oriented  
distributions of the IJG source code often include these object files.)

When using jmemdos.c, jconfig.h must define USE\_MSDOS\_MEMMGR and must set  
MAX\_ALLOC\_CHUNK to less than 64K (65520L is a typical value). If your  
C library's far-heap malloc() can't allocate blocks that large, reduce  
MAX\_ALLOC\_CHUNK to whatever it can handle.

If you can't use jmemdos.c for some reason --- for example, because you  
don't have an assembler to assemble jmemdosa.asm --- you'll have to fall  
back to jmemansi.c or jmemname.c. You'll probably still need to set  
MAX\_ALLOC\_CHUNK in jconfig.h, because most DOS C libraries won't malloc()  
more than 64K at a time. IMPORTANT: if you use

jmemansi.c or jmemname.c,  
you will have to compile in a large-data memory model in order to get the  
right stdio library. Too bad.

wrjpgcom needs to be compiled in large model, because it malloc()s a 64KB  
work area to hold the comment text. If your C library's malloc can't  
handle that, reduce MAX\_COM\_LENGTH as necessary in wrjpgcom.c.

Most MS-DOS compilers treat stdin/stdout as text files, so you must use  
two-file command line style. But if your compiler has either fdopen() or  
setmode(), you can use one-file style if you like. To do this, define  
USE\_SETMODE or USE\_FDOPEN so that stdin/stdout will be set to binary mode.  
(USE\_SETMODE seems to work with more DOS compilers than USE\_FDOPEN.) You  
should test that I/O through stdin/stdout produces the same results as I/O  
to explicitly named files... the "make test" procedures in the supplied  
makefiles do NOT use stdin/stdout.

MS-DOS, generic comments for 32-bit compilers:

None of the above comments about memory models apply if you  
are using a  
32-bit flat-memory-space environment, such as DJGPP or Watcom C. (And you  
should use one if you have it, as performance will be much better than  
8086-compatible code!) For flat-memory-space compilers, do NOT define  
NEED\_FAR\_POINTERS, and do NOT use jmemdos.c. Use jmemnobs.c if the  
environment supplies adequate virtual memory, otherwise use jmemansi.c or  
jmemname.c.

You'll still need to be careful about binary I/O through stdin/stdout.  
See the last paragraph of the previous section.

MS-DOS, Borland C:

Be sure to convert all the source files to DOS text format (CR/LF newlines).  
Although Borland C will often work OK with unmodified Unix (LF newlines)  
source files, sometimes it will give bogus compile errors.  
"Illegal character '#'" is the most common such error. (This is true with  
Borland C 3.1, but perhaps is fixed in newer releases.)

If you want one-file command line style, just undefine TWO\_FILE\_COMMANDLINE.  
jconfig.bcc already includes #define USE\_SETMODE to make  
this work.  
(fdopen does not work correctly.)

MS-DOS, Microsoft C:

makefile.mc6 works with Microsoft C, DOS Visual C++, etc. It should only be used if you want to build a 16-bit (small or medium memory model) program.

If you want one-file command line style, just undefine TWO\_FILE\_COMMANDLINE. jconfig.mc6 already includes #define USE\_SETMODE to make this work. (fdopen does not work correctly.)

Note that this makefile assumes that the working copy of itself is called "makefile". If you want to call it something else, say "makefile.mak", be sure to adjust the dependency line that reads "\$(RFILE) : makefile". Otherwise the make will fail because it doesn't know how to create "makefile". Worse, some releases of Microsoft's make utilities give an incorrect error message in this situation.

Old versions of MS C fail with an "out of macro expansion space" error because they can't cope with the macro TRACEMS8 (defined in jerror.h). If this happens to you, the easiest solution is to change TRACEMS8 to expand to nothing. You'll lose the ability to dump out JPEG coefficient tables with djpeg -debug -debug, but at least you can compile.

Original MS C 6.0 is very buggy; it compiles incorrect code unless you turn off optimization entirely (remove -O from CFLAGS). 6.00A is better, but it still generates bad code if you enable loop optimizations (-Ol or -Ox).

MS C 8.0 crashes when compiling jquant1.c with optimization switch /Oo ... which is on by default. To work around this bug, compile that one file with /Oo-.

Microsoft Windows (all versions), generic comments:

Some Windows system include files define typedef boolean as "unsigned char". The IJG code also defines typedef boolean, but we make it an "enum" by default. This doesn't affect the IJG programs because we don't import those Windows include files. But if you use the JPEG library in your own program, and some of your program's files import one definition of boolean while some import the other, you can get all

sorts of mysterious problems. A good preventive step is to make the IJG library use "unsigned char" for boolean. To do that, add something like this to your jconfig.h file:

```
/* Define "boolean" as unsigned char, not enum, per Windows custom */
#ifndef __RPCNDR_H__ /* don't conflict if rpcndr.h already read */
typedef unsigned char boolean;
#endif
#ifndef FALSE /* in case these macros already exist */
#define FALSE 0 /* values of boolean */
```

```
#endif
#ifndef TRUE
#define TRUE 1
#endif
#define HAVE_BOOLEAN /* prevent jmorecfg.h from redefining it */
(This is already in jconfig.vc, by the way.)
```

windef.h contains the declarations

```
#define far
#define FAR far
```

Since jmorecfg.h tries to define FAR as empty, you may get a compiler warning if you include both jpeglib.h and windef.h (which windows.h includes). To suppress the warning, you can put "#ifndef FAR"/"#endif" around the line "#define FAR" in jmorecfg.h.

(Something like this is already in jmorecfg.h, by the way.)

When using

the library in a Windows application, you will almost certainly want to modify or replace the error handler module jerror.c, since our default error handler does a couple of inappropriate things:

1. it tries to write error and warning messages on stderr;
2. in event of a fatal error, it exits by calling exit().

A simple stopgap solution for problem 1 is to replace the line

```
fprintf(stderr, "%s\n", buffer);
```

(in output\_message in jerror.c) with

```
MessageBox(GetActiveWindow(),buffer,"JPEG Error",MB_OK|MB_ICONERROR);
```

It's highly recommended that you at least do that much, since otherwise error messages will disappear into nowhere. (Beginning with IJG v6b, this code is already present in jerror.c; just define USE\_WINDOWS\_MESSAGEBOX in jconfig.h to enable it.)

The proper solution for problem 2 is to return control to your calling application after a library error. This can be done with the setjmp/longjmp technique discussed in libjpeg.txt and illustrated in example.c. (NOTE: some

older Windows C compilers provide versions of setjmp/longjmp that don't actually work under Windows. You may need to use the Windows system functions Catch and Throw instead.)

The recommended memory manager under Windows is jmemnobs.c; in other words, let Windows do any virtual memory management needed. You should NOT use jmemdos.c nor jmemdosa.asm under Windows.

For Windows 3.1, we recommend compiling in medium or large memory model; for newer Windows versions, use a 32-bit flat memory model. (See the MS-DOS sections above for more info about memory models.) In the 16-bit memory models only, you'll need to put

`#define MAX_ALLOC_CHUNK 65520L /* Maximum request to malloc() */`  
into `jconfig.h` to limit allocation chunks to 64Kb. (Without that, you'd have to use huge memory model, which slows things down unnecessarily.) `jmemo.c` works without modification in large or flat memory models, but to use medium model, you need to modify its `jpeg_get_large` and `jpeg_free_large` routines to allocate far memory. In any case, you might like to replace its calls to `malloc` and `free` with direct calls on Windows memory allocation functions.

You may also want to modify `jdatasrc.c` and `jdatadst.c` to use Windows file operations rather than `fread/fwrite`. This is only necessary if your C compiler doesn't provide a competent implementation of C `stdio` functions.

You might want to tweak the `RGB_xxx` macros in `jmreconf.h` so that the library will accept or deliver color pixels in BGR sample order, not RGB; BGR order is usually more convenient under Windows. Note that this change will break the sample applications `cjpeg/djpeg`, but the library itself works fine.

Many people want to convert the IJG library into a DLL. This is reasonably straightforward, but watch out for the following:

1. Don't try to compile as a DLL in small or medium memory model; use large model, or even better, 32-bit flat model. Many places in the IJG code assume the address of a local variable is an ordinary (not FAR) pointer; that isn't true in a medium-model DLL.

2. Microsoft C cannot pass file pointers between applications and DLLs. (See Microsoft Knowledge Base, PSS ID Number Q50336.) So `jdatasrc.c` and `jdatadst.c` don't work if you open a file in your application and then pass the pointer to the DLL. One workaround is to make `jdatasrc.c/jdatadst.c` part of your main application rather than part of the DLL.

3. You'll probably need to modify the macros `GLOBAL()` and `EXTERN()` to attach suitable linkage keywords to the exported routine names. Similarly, you'll want to modify `METHODDEF()` and `JMETHOD()` to ensure function pointers are declared in a way that lets application routines be called back through the function pointers. These macros are in `jmreconf.h`. Typical definitions for a 16-bit DLL are:

```
#define GLOBAL(type) type _far _pascal _loadds _export
#define EXTERN(type) extern type _far _pascal _loadds
#define METHODDEF(type) static type _far _pascal
#define JMETHOD(type,methodname,arglist)
\
type (_far _pascal *methodname) arglist
```

For a 32-bit DLL you may want something like

```
#define GLOBAL(type) __declspec(dllexport) type
#define EXTERN(type) extern __declspec(dllexport) type
```

Although not all the GLOBAL routines are actually intended to be called by the application, the performance cost of making them all DLL entry points is negligible.

The unmodified IJG library presents a very C-specific application interface, so the resulting DLL is only usable from C or C++ applications. There has been some talk of writing wrapper code that would present a simpler interface usable from other languages, such as Visual Basic. This is on our to-do list but hasn't been very high priority --- any volunteers out there?

Microsoft Windows, Borland C:

The provided jconfig.bcc should work OK in a 32-bit Windows environment, but you'll need to tweak it in a 16-bit environment (you'd need to define NEED\_FAR\_POINTERS and MAX\_ALLOC\_CHUNK). Beware that makefile.bcc will need alteration if you want to use it for Windows --- in particular, you should use jmemnobs.c not jmemdos.c under Windows.

Borland C++ 4.5 fails with an internal compiler error when trying to compile jdmerge.c in 32-bit mode. If enough people complain, perhaps Borland will fix it. In the meantime, the simplest known workaround is to add a redundant definition of the variable range\_limit in h2v1\_merged\_upsample(), at the head of the block that handles odd image width (about line 268 in v6 jdmerge.c):

```
/* If image width is odd, do the last output column separately */
if (cinfo->output_width & 1) {
    register JSAMPLE * range_limit = cinfo->sample_range_limit; /* ADD THIS */
    cb = GETJSAMPLE(*inptr1);
```

Pretty bizarre, especially since the very similar routine h2v2\_merged\_upsample doesn't trigger the bug.

Recent reports suggest that this bug does not occur with "bcc32a" (the Pentium-optimized version of the compiler).

Another report from a user of Borland C 4.5 was that incorrect code (leading to a color shift in processed images) was produced if any of the following optimization switch combinations were used:

```
-Ot -Og
-Ot -Op
-Ot -Om
```

So try backing off on optimization if you see such a problem. (Are there several different releases all numbered "4.5"??)

Microsoft Windows, Microsoft Visual C++:

jconfig.vc should work OK with any Microsoft compiler for a 32-bit memory model. makefile.vc is intended for command-line use. (If you are using the Developer Studio environment, you may prefer the DevStudio project files; see below.)

IJG JPEG 7 adds extern "C" to jpeglib.h. This avoids the need to put extern "C" { ... } around #include "jpeglib.h" in your C++ application. You can also force VC++ to treat the library as C++ code by renaming all the \*.c files to \*.cpp (and adjusting the makefile to match). In this case you also need to define the symbol DONT\_USE\_EXTERN\_C in the configuration to prevent jpeglib.h from using extern "C".

Microsoft Windows,  
Microsoft Visual C++ 6 Developer Studio:

We include makefiles that should work as project files in Developer Studio 6.0 or later. There is a library makefile that builds the IJG library as a static Win32 library, and application makefiles that build the sample applications as Win32 console applications. (Even if you only want the library, we recommend building the applications so that you can run the self-test.)

To use:

1. Open the command prompt, change to the main directory and execute the command line  
NMAKE /f makefile.vs setup-vc6  
This will move jconfig.vc to jconfig.h and makefiles to project files.  
(Note that the renaming is critical!)
2. Open the workspace file jpeg.dsw, build the library project.  
(If you are using Developer Studio more recent than 6.0, you'll probably get a message saying that the project files are being updated.)
3. Open the workspace file apps.dsw, build the application projects.
4. To perform the self-test, execute the command line  
NMAKE  
/f makefile.vs test-build
5. Move the application .exe files from `app`\Release to an appropriate location on your path.

Microsoft Windows, Visual Studio 2017 (v15):

We include makefiles that should work as project files in Visual Studio 2017 (v15) or later. There is a library makefile that builds the IJG library as a static Win32 library, and application makefiles that build the sample applications as Win32 console applications. (Even if you only want the library, we recommend building the applications so that you can



run the self-test.)

To use:

1. Open the Developer Command Prompt, change to the main directory and execute the command line  
NMAKE /f makefile.vs setup-v15  
This will move jconfig.vc to jconfig.h and makefiles to project files.  
(Note that the renaming is critical!)
2. Open the solution file jpeg.sln, build the library project.
  - a) If you are using Visual Studio more recent than 2017 (v15), you'll probably get a message saying that the project files are being updated.
  - b) If necessary, open the project properties and adapt the Windows Target Platform Version in the Configuration Properties, General section; we support the latest version at the time of release.
3. Open the solution file apps.sln, build the application projects.
4. To perform the self-test, execute the command line  
NMAKE /f makefile.vs test-build
5. Move the application .exe files from `app`\Release to an appropriate location on your path.

OS/2, Borland C++:

Watch out for optimization bugs in older Borland compilers; you may need to back off the optimization switch settings. See the comments in makefile.bcc.

SGI:

On some SGI systems, you may need to set "AR2= ar -ts" in the Makefile.

If you are using configure, you can do this by saying

```
./configure RANLIB='ar -ts'
```

This change is not needed on all SGIs. Use it only if the make fails at the stage of linking the completed programs.

On the MIPS R4000 architecture (Indy, etc.), the compiler

option "-mips2"

reportedly speeds up the float DCT method substantially, enough to make it faster than the default int method (but still slower than the fast int

method). If you use -mips2, you may want to alter the default DCT method to be float. To do this, put "#define JDCT\_DEFAULT JDCT\_FLOAT" in jconfig.h.

VMS:

On an Alpha/VMS system with MMS, be sure to use the "/Marco=Alpha=1" qualifier with MMS when building the JPEG package.

VAX/VMS v5.5-1 may have problems with the test step of the build procedure reporting differences when it compares the original and test images. If the error points to the last block of the files, it is most likely bogus and may be safely ignored. It seems to be because the files are Stream\_LF and Backup/Compare has difficulty with the (presumably) null padded files. This problem was not observed on VAX/VMS v6.1 or AXP/VMS v6.1.

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/install.txt  
No license file was found, but licenses were detected in source scan.

/\*

\* jcmaster.c

\*

\* Copyright (C) 1991-1997, Thomas G. Lane.

\* Modified 2003-2017 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains master control logic for the JPEG compressor.

\* These routines are concerned with parameter validation, initial setup,

\* and inter-pass control (determining the number of passes and the work

\* to be done in each pass).

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jcmaster.c  
No license file was found, but licenses were detected in source scan.

/\*

\* jctrans.c

\*

\* Copyright (C) 1995-1998, Thomas G. Lane.

\* Modified 2000-2017 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains library routines for transcoding compression,

\* that is, writing raw DCT coefficient arrays to an output JPEG file.

\* The routines in jcapimin.c will also be needed by a transcoder.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jctrans.c

No license file was found, but licenses were detected in source scan.

```
/*
 * jdinput.c
 *
 * Copyright (C) 1991-1997, Thomas G. Lane.
 * Modified 2002-2013 by Guido Vollbeding.
 * This file is part of the Independent JPEG Group's software.
 * For conditions of distribution and use, see the accompanying README file.
 *
 * This file contains input control logic for the JPEG decompressor.
 * These routines are concerned with controlling the decompressor's input
 * processing (marker reading and coefficient decoding). The actual input
 * reading is done in jdmarker.c, jdhuft.c, and jdarith.c.
 */
```

Found in path(s):

```
* /opt/cola/permits/1104792432_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jdinput.c
```

No license file was found, but licenses were detected in source scan.

```
/*
 * jdcoefct.c
 *
 * Copyright (C) 1994-1997, Thomas G. Lane.
 * Modified 2002-2011 by Guido Vollbeding.
 * This file is part of the Independent JPEG Group's software.
 * For conditions of distribution and use, see the accompanying README file.
 *
 * This file contains the coefficient buffer controller for decompression.
 * This controller is the top level of the JPEG decompressor proper.
 * The coefficient buffer lies between entropy decoding and inverse-DCT steps.
 *
 * In buffered-image mode, this controller is the interface between
 * input-oriented processing and output-oriented processing.
 * Also, the input side (only) is used when reading a file for transcoding.
 */
```

Found in path(s):

```
* /opt/cola/permits/1104792432_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jdcoefct.c
```

No license file was found, but licenses were detected in source scan.

```
/*
 * jcparam.c
 *
 * Copyright (C) 1991-1998, Thomas G. Lane.
 * Modified 2003-2013 by Guido Vollbeding.
 * This file is part of the Independent JPEG Group's software.
 * For conditions of distribution and use, see the accompanying README file.
```

```
*
* This file contains optional default-setting code for the JPEG compressor.
* Applications do not have to use this file, but those that don't use it
* must know a lot more about the innards of the JPEG code.
*/
```

Found in path(s):

```
*/opt/cola/permits/1104792432_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jcparam.c
```

No license file was found, but licenses were detected in source scan.

```
/*
```

```
*/ jconfig.txt
```

```
/*
```

```
*/ Copyright (C) 1991-1994, Thomas G. Lane.
```

```
*/ Modified 2009-2013 by Guido Vollbeding.
```

```
*/ This file is part of the Independent JPEG Group's software.
```

```
*/ For conditions of distribution and use, see the accompanying README file.
```

```
/*
```

```
*/ This file documents the configuration options that are required to
```

```
*/ customize the JPEG software for a particular system.
```

```
/*
```

```
*/ The actual configuration options for a particular installation are stored
```

```
*/ in jconfig.h. On many machines, jconfig.h can be generated automatically
```

```
*/ or copied from one of the "canned" jconfig files that we supply. But if
```

```
*/ you need to generate a jconfig.h file by hand, this file tells you how.
```

```
/*
```

```
*/ DO NOT EDIT THIS FILE --- IT WON'T ACCOMPLISH ANYTHING.
```

```
*/ EDIT A COPY NAMED JCONFIG.H.
```

```
*/
```

```
/*
```

```
*/ These symbols indicate the properties of your machine or compiler.
```

```
*/ #define the symbol if yes, #undef it if no.
```

```
*/
```

```
/* Does your compiler
```

```
support function prototypes?
```

```
*/ (If not, you also need to use ansi2knr, see install.txt)
```

```
*/
```

```
#define HAVE_PROTOTYPES
```

```
/* Does your compiler support the declaration "unsigned char" ?
```

```
*/ How about "unsigned short" ?
```

```
*/
```

```
#define HAVE_UNSIGNED_CHAR
```

```
#define HAVE_UNSIGNED_SHORT
```

```

/* Define "void" as "char" if your compiler doesn't know about type void.
* NOTE: be sure to define void such that "void *" represents the most general
* pointer type, e.g., that returned by malloc().
*/
/* #define void char */

/* Define "const" as empty if your compiler doesn't know the "const" keyword.
*/
/* #define const */

/* Define this if an ordinary "char" type is unsigned.
* If you're not sure, leaving it undefined will work at some cost in speed.
* If you defined HAVE_UNSIGNED_CHAR then the speed difference is minimal.
*/
#undef CHAR_IS_UNSIGNED

/* Define this if your system has an ANSI-conforming <stddef.h> file.
*/
#define HAVE_STDDEF_H

/* Define this if your system has an ANSI-conforming <stdlib.h>
file.
*/
#define HAVE_STDLIB_H

/* Define this if your system does not have an ANSI/SysV <string.h>,
* but does have a BSD-style <strings.h>.
*/
#undef NEED_BSD_STRINGS

/* Define this if your system does not provide typedef size_t in any of the
* ANSI-standard places (stddef.h, stdlib.h, or stdio.h), but places it in
* <sys/types.h> instead.
*/
#undef NEED_SYS_TYPES_H

/* For 80x86 machines, you need to define NEED_FAR_POINTERS,
* unless you are using a large-data memory model or 80386 flat-memory mode.
* On less brain-damaged CPUs this symbol must not be defined.
* (Defining this symbol causes large data structures to be referenced through
* "far" pointers and to be allocated with a special version of malloc.)
*/
#undef NEED_FAR_POINTERS

/* Define this if your linker needs global names to be unique in less
* than the first 15 characters.
*/
#undef NEED_SHORT_EXTERNAL_NAMES

```

```

/* Although a real ANSI C compiler can deal perfectly well with pointers to
* unspecified
structures (see "incomplete types" in the spec), a few pre-ANSI
* and pseudo-ANSI compilers get confused. To keep one of these bozos happy,
* define INCOMPLETE_TYPES_BROKEN. This is not recommended unless you
* actually get "missing structure definition" warnings or errors while
* compiling the JPEG code.
*/
#undef INCOMPLETE_TYPES_BROKEN

/* Define "boolean" as unsigned char, not enum, on Windows systems.
*/
#ifdef _WIN32
#ifdef __RPCNDR_H__ /* don't conflict if rpcnldr.h already read */
typedef unsigned char boolean;
#endif
#ifdef FALSE /* in case these macros already exist */
#define FALSE 0 /* values of boolean */
#endif
#ifdef TRUE
#define TRUE 1
#endif
#define HAVE_BOOLEAN /* prevent jmorecfg.h from redefining it */
#endif

/*
* The following options affect code selection within the JPEG library,
* but they don't need to be visible to applications using the library.
* To minimize application namespace pollution, the symbols won't be
* defined unless JPEG_INTERNALS
has been defined.
*/

#ifdef JPEG_INTERNALS

/* Define this if your compiler implements ">>" on signed values as a logical
* (unsigned) shift; leave it undefined if ">>" is a signed (arithmetic) shift,
* which is the normal and rational definition.
*/
#undef RIGHT_SHIFT_IS_UNSIGNED

#endif /* JPEG_INTERNALS */

/*

```

\* The remaining options do not affect the JPEG library proper,  
\* but only the sample applications cjpeg/djpeg (see cjpeg.c, djpeg.c).  
\* Other applications can ignore these.  
\*/

```
#ifdef JPEG_CJPEG_DJPEG
```

```
/* These defines indicate which image (non-JPEG) file formats are allowed. */
```

```
#define BMP_SUPPORTED /* BMP image file format */  
#define GIF_SUPPORTED /* GIF image file format */  
#define PPM_SUPPORTED /* PBMPLUS PPM/PGM image file format */  
#undef RLE_SUPPORTED /* Utah RLE image file format */  
#define TARGA_SUPPORTED /* Targa image file format */
```

```
/* Define this if you want to name both input and output files on the command  
* line, rather than using stdout  
and optionally stdin. You MUST do this if  
* your system can't cope with binary I/O to stdin/stdout. See comments at  
* head of cjpeg.c or djpeg.c.  
*/
```

```
#undef TWO_FILE_COMMANDLINE
```

```
/* Define this if your system needs explicit cleanup of temporary files.  
* This is crucial under MS-DOS, where the temporary "files" may be areas  
* of extended memory; on most other systems it's not as important.  
*/
```

```
#undef NEED_SIGNAL_CATCHER
```

```
/* By default, we open image files with fopen(...,"rb") or fopen(...,"wb").  
* This is necessary on systems that distinguish text files from binary files,  
* and is harmless on most systems that don't. If you have one of the rare  
* systems that complains about the "b" spec, define this symbol.  
*/
```

```
#undef DONT_USE_B_MODE
```

```
/* Define this if you want percent-done progress reports from cjpeg/djpeg.  
*/
```

```
#undef PROGRESS_REPORT
```

```
#endif /* JPEG_CJPEG_DJPEG */
```

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jconfig.txt

No license file was found, but licenses were detected in source scan.

```
/*
```

```

* jidctfst.c
*
* Copyright (C) 1994-1998, Thomas G. Lane.
* Modified 2015-2017 by Guido Vollbeding.
* This file is part of the Independent JPEG Group's software.
* For conditions of distribution and use, see the accompanying README file.
*
* This file contains a fast, not so accurate integer implementation of the
* inverse DCT (Discrete Cosine Transform). In the IJG code, this routine
* must also perform dequantization of the input coefficients.
*
* A 2-D IDCT can be done by 1-D IDCT on each column followed by 1-D IDCT
* on each row (or vice versa, but it's more convenient to emit a row at
* a time). Direct algorithms are also available, but they are much more
* complex and seem not to be any faster when reduced to code.
*
* This implementation is based on Arai, Agui, and Nakajima's algorithm for
* scaled DCT. Their original paper (Trans. IEICE E-71(11):1095) is in
* Japanese, but the algorithm
* is described in the Pennebaker & Mitchell
* JPEG textbook (see REFERENCES section in file README). The following code
* is based directly on figure 4-8 in P&M.
* While an 8-point DCT cannot be done in less than 11 multiplies, it is
* possible to arrange the computation so that many of the multiplies are
* simple scalings of the final outputs. These multiplies can then be
* folded into the multiplications or divisions by the JPEG quantization
* table entries. The AA&N method leaves only 5 multiplies and 29 adds
* to be done in the DCT itself.
* The primary disadvantage of this method is that with fixed-point math,
* accuracy is lost due to imprecise representation of the scaled
* quantization values. The smaller the quantization table entry, the less
* precise the scaled value, so this implementation does worse with high-
* quality-setting files than with low-quality ones.
*/

```

Found in path(s):

```

* /opt/cola/permits/1104792432_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jidctfst.c

```

No license file was found, but licenses were detected in source scan.

```

/*

```

```

* jdmaster.c

```

```

*

```

```

* Copyright (C) 1991-1997, Thomas G. Lane.

```

```

* Modified 2002-2017 by Guido Vollbeding.

```

```

* This file is part of the Independent JPEG Group's software.

```

```

* For conditions of distribution and use, see the accompanying README file.

```

```

*

```

```

* This file contains master control logic for the JPEG decompressor.

```



\* These routines are concerned with selecting the modules to be executed  
\* and with determining the number of passes and the work to be done in each  
\* pass.  
\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jdmaster.c  
No license file was found, but licenses were detected in source scan.

/\*

\* rdbmp.c

\*

\* Copyright (C) 1994-1996, Thomas G. Lane.

\* Modified 2009-2017 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains routines to read input images in Microsoft "BMP"

\* format (MS Windows 3.x, OS/2 1.x, and OS/2 2.x flavors).

\* Currently, only 8-, 24-, and 32-bit images are supported, not 1-bit or

\* 4-bit (feeding such low-depth images into JPEG would be silly anyway).

\* Also, we don't support RLE-compressed files.

\*

\* These routines may need modification for non-Unix environments or

\* specialized applications. As they stand, they assume input from

\* an ordinary stdio stream. They further assume that reading begins

\* at the start of the file; start\_input may need work if the

\* user interface has already read some data (e.g., to determine that

\* the file is

indeed BMP format).

\*

\* This code contributed by James Arthur Boucher.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/rdbmp.c  
No license file was found, but licenses were detected in source scan.

/\*

\* wrppm.c

\*

\* Copyright (C) 1991-1996, Thomas G. Lane.

\* Modified 2009-2017 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains routines to write output images in PPM/PGM format.

\* The extended 2-byte-per-sample raw PPM/PGM formats are supported.

\* The PBMPLUS library is NOT required to compile this software  
\* (but it is highly useful as a set of PPM image manipulation programs).  
\*  
\* These routines may need modification for non-Unix environments or  
\* specialized applications. As they stand, they assume output to  
\* an ordinary stdio stream.  
\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/wrppm.c

No license file was found, but licenses were detected in source scan.

/\*

\* jpeglib.h

\*

\* Copyright (C) 1991-1998, Thomas G. Lane.

\* Modified 2002-2017 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file defines the application interface for the JPEG library.

\* Most applications using the library need only include this file,

\* and perhaps jerror.h if they want to know the exact error codes.

\*/

Found in path(s):

\* /opt/cola/permits/1104792432\_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/jpeglib.h

No license file was found, but licenses were detected in source scan.

/\*

\* wrgif.c

\*

\* Copyright (C) 1991-1997, Thomas G. Lane.

\* Modified 2015-2017 by Guido Vollbeding.

\* This file is part of the Independent JPEG Group's software.

\* For conditions of distribution and use, see the accompanying README file.

\*

\* This file contains routines to write output images in GIF format.

\*

\*\*\*\*\*

\* NOTE: to avoid entanglements with Unisys' patent on LZW compression, \*

\* this code has been modified to output "uncompressed GIF" files. \*

\* There is no trace of the LZW algorithm in this file. \*

\*\*\*\*\*

\*

\* These routines may need modification for non-Unix environments or

\* specialized applications. As they stand, they assume output to

\* an ordinary stdio stream.

```
*/
/*
* This code is loosely based on ppmtogif from the PBMPLUS
distribution
* of Feb. 1991. That file contains the following copyright notice:
* Based on GIFENCODE by David Rowley <mgardi@watdscu.waterloo.edu>.
* Lempel-Ziv compression based on "compress" by Spencer W. Thomas et al.
* Copyright (C) 1989 by Jef Poskanzer.
* Permission to use, copy, modify, and distribute this software and its
* documentation for any purpose and without fee is hereby granted, provided
* that the above copyright notice appear in all copies and that both that
* copyright notice and this permission notice appear in supporting
* documentation. This software is provided "as is" without express or
* implied warranty.
*
* We are also required to state that
* "The Graphics Interchange Format(c) is the Copyright property of
* CompuServe Incorporated. GIF(sm) is a Service Mark property of
* CompuServe Incorporated."
*/
```

Found in path(s):

```
*/opt/cola/permits/1104792432_1607505170.95/0/jpeg-9c-tar-gz/jpeg-9c/wrgif.c
```

## 1.36 conntrack-tools 1.0.1

### 1.36.1 Available under license :

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Version 2, June 1991

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675 Mass Ave, Cambridge, MA 02139, USA

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```
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```

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```
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```

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```

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The of the start-stop-daemon

- \* A rewrite  
of the original Debian's start-stop-daemon Perl script
- \* in C (faster - it is executed many times during system startup).
- \*
- \* Written by Marek Michalkiewicz <[marekm@i17linuxb.ists.pwr.wroc.pl](mailto:marekm@i17linuxb.ists.pwr.wroc.pl)>,  
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## 1.44 sysv-init 2.88

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The of the start-stop-daemon

- \* A rewrite
- of the original Debian's start-stop-daemon Perl script
- \* in C (faster - it is executed many times during system startup).
- \*
- \* Written by Marek Michalkiewicz <[marekm@i17linuxb.ists.pwr.wroc.pl](mailto:marekm@i17linuxb.ists.pwr.wroc.pl)>,
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/\* nicstar.c v0.22 Jawaid Bazyar (bazyar@hypermall.com)

\* nicstar.c, M. Welsh (matt.welsh@cl.cam.ac.uk)

\*

\* Hacked October, 1997 by Jawaid Bazyar, Interlink Advertising Services Inc.



- \* <http://www.hypermall.com/>
- \* 10/1/97 - commented out CFG\_PHYIE bit - we don't care when the PHY
- \* interrupts us (except possibly for removal/insertion of the cable?)
- \* 10/4/97 - began heavy inline documentation of the code. Corrected typos
- \* and spelling mistakes.
- \* 10/5/97 - added code to handle PHY interrupts, disable PHY on
- \* loss of link, and correctly re-enable PHY when link is
- \* re-established. (put back CFG\_PHYIE)
- \*
- \* Modified to work with the IDT7721 nicstar -- AAL5 (tested) only.
- \*
- \* R. D. Rechenmacher <ron@fnal.gov>, Aug. 6, 1997
- \*
- \* Linux driver for the IDT77201 NICStAR PCI ATM controller.
- \* PHY component is expected to be 155 Mbps S/UNI-Lite or IDT 77155;
- \* see init\_nicstar() for PHY initialization to change this. This driver
- \* expects the Linux ATM stack to support scatter-gather
- lists
- \* (skb->atm.iovcnt != 0) for Rx skb's passed to vcc->push.
- \*
- \* Implementing minimal-copy of received data:
- \* IDT always receives data into a small buffer, then large buffers
- \* as needed. This means that data must always be copied to create
- \* the linear buffer needed by most non-ATM protocol stacks (e.g. IP)
- \* Fix is simple: make large buffers large enough to hold entire
- \* SDU, and leave <small\_buffer\_data> bytes empty at the start. Then
- \* copy small buffer contents to head of large buffer.
- \* Trick is to avoid fragmenting Linux, due to need for a lot of large
- \* buffers. This is done by 2 things:
- \* 1) skb->destructor / skb->atm.recycle\_buffer
- \* combined, allow nicstar\_free\_rx\_skb to be called to
- \* recycle large data buffers
- \* 2) skb\_clone of received buffers
- \* See nicstar\_free\_rx\_skb and linearize\_buffer for implementation
- \* details.
- \*
- \*
- \*
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\* along with this program; if not, write to the Free Software  
\* Foundation, Inc., 675 Mass Ave, Cambridge, MA 02139, USA.  
\*  
\* M. Welsh, 6 July 1996  
\*  
\*  
\*/

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(in case you are wondering where CyberLogin is, EON changed its login procedure and CyberLogin is no longer used.)

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Kirk Lapray <kirk.lapray@gmail.com>  
for the or51211 and or51132 frontend drivers, and  
for merging the nxt2002 and nxt2004 modules into a  
single nxt200x frontend driver.

(If you think you should be in this list, but you are not, drop  
a  
line to the DVB mailing list)  
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# 1.46 libnsl 2.18

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bzip2/libbzip2 version 1.0.4 of 20 December 2006

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Written by: Philip Hazel

Email local part: ph10

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## 1.53 iputils 20101006

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```
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 * rarpd.c RARP daemon.
 *
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 *
 * Authors: Alexey Kuznetsov, <kuznet@ms2.inr.ac.ru>
 */
```

Found in path(s):

```
*/opt/cola/permits/1826454257_1697752738.11816/0/iputils-s20101006-tar-gz/iputils-s20101006/rarpd.c
```

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 *
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- \*/

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\*

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 \*  
 \* @(#)tftp.h 8.1 (Berkeley) 6/2/93  
 \*/

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\* /opt/cola/permits/1826454257\_1697752738.11816/0/iputils-s20101006-tar-gz/iputils-s20101006/doc/clockdiff.shtml

\* /opt/cola/permits/1826454257\_1697752738.11816/0/iputils-s20101006-tar-gz/iputils-s20101006/doc/tracepath.shtml

\* /opt/cola/permits/1826454257\_1697752738.11816/0/iputils-s20101006-tar-gz/iputils-s20101006/doc/arping.shtml

\* /opt/cola/permits/1826454257\_1697752738.11816/0/iputils-s20101006-tar-gz/iputils-s20101006/doc/rarpd.shtml

\* /opt/cola/permits/1826454257\_1697752738.11816/0/iputils-s20101006-tar-gz/iputils-s20101006/doc/traceroute6.shtml

\* /opt/cola/permits/1826454257\_1697752738.11816/0/iputils-s20101006-tar-gz/iputils-s20101006/doc/pg3.shtml

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=head1 NAME

docbook2man-spec - convert DocBook RefEntries to Unix manpages

=head1 SYNOPSIS

The SGMLSpM package from CPAN. This contains the sgmlspl script which is used to grok this file. Use it like this:

```
nsgmls some-docbook-document.sgml | sgmlspl docbook2man-spec.pl
```

=head1 DESCRIPTION

This is a sgmlspl spec file that produces Unix-style manpages from RefEntry markup.

See the accompanying RefEntry man page for 'plain new' documentation. :)

=head1 LIMITATIONS

Trying docbook2man on non-DocBook or non-conformant SGML results in undefined behavior. :-)

This program is a slow, dodgy Perl script.

This program does not come close to supporting all the possible markup in DocBook, and will produce wrong output in some cases with supported markup.

=head1 TODO

Add new element handling and fix existing handling. Be robust.

Produce cleanest, readable man output as possible (unlike some other converters). Follow

Linux man(7) convention.

If this results in added logic in this script, that's okay. The code should still be reasonably organized.

Make it faster. If Perl sucks port it to another language.

=head1 COPYRIGHT

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=cut

# \$Id: docbook2man-spec.pl,v 1.1 2000/07/21 20:22:30 rosalia Exp \$

use SGMLS; # Use the SGMLS package.  
use SGMLS::Output; # Use stack-based output.  
use SGMLS::Refs;

#####

# SGMLSPL script produced automatically by  
the script sgmlspl.pl

#

# Document Type: any, but processes only RefEntries

# Edited by: me :)

#####

\$write\_manpages = 0;

\$blank\_xrefs = 0;

sgml('start', sub {  
push\_output('nul');  
\$raw\_cdata = 1; # Makes it a bit faster.

# Links file  
open(LINKSFILE, ">manpage.links");

\$Refs = new SGMLS::Refs("manpage.refs");  
});  
sgml('end', sub {  
close(LINKSFILE);  
if(\$blank\_xrefs) {  
print STDERR "Warning: output contains unresolved XRefs\n";  
}  
});

#####

#

# Output helpers

#

#####

```
# Our own version of sgml() and output() to allow simple string output
# to play well with roff's stupid whitespace rules.
```

```
sub man_sgml
```

```
{
  if(ref($_[1]) eq 'CODE') {
    return &sgml;
  }
}
```

```
my $s = $_[1];
```

```
$s =~ s/\\|\\\|/g;
```

```
$s =~ s/^\|'/g;
```

```
# \n at the beginning means start at beginning of line
```

```
if($s
  =~ s/^\n/) {
  $sub = 'sub { output "\n" unless $newline_last++; }';
  if($s eq "") {
    sgml($_[0], eval('sub { output "\n" unless $newline_last++; }'));
  } elsif($s =~ ^\n$/) {
    sgml($_[0], eval("sub { output '\\\n' unless \$newline_last++; output '$s'; }"));
  } else {
    sgml($_[0], eval("sub { output '\\\n' unless \$newline_last; output '$s'; \$newline_last = 0; }"));
  }
} else {
  if($s =~ ^\n$/) {
    sgml($_[0], eval("sub { output '$s'; \$newline_last = 1; }"));
  } else {
    sgml($_[0], eval("sub { output '$s'; \$newline_last = 0; }"));
  }
}
}
```

```
sub man_output
```

```
{
  $_ = shift;
  if(s/^\n/) {
    output "\n" unless $newline_last++;
  }
  return if $_ eq "";
}
```

```
output $_;
```

```
if(@_) {
  output @_;
  $newline_last = (pop(@_) =~ ^\n/);
}
```

```

} else {
    $newline_last = ($_ =~ /\n$/)
}
}

# Fold lines into one, quote some characters
sub fold_string
{
    $_ = shift;

    s/\|\\\|/g;
    s/"^\\&"/g;

    # Change tabs to spaces
    tr/\t\n/ /;

    # Trim whitespace from beginning and end.
    s/^ +//;
    s/
    +$///;

    return $_;
}

sub save_cdata()
{
    $raw_cdata++;
    push_output('string');
}

sub bold_on()
{
    # If the last font is also bold, don't change anything.
    # Basically this is to just get more readable man output.
    if($fontstack[$#fontstack] ne 'bold') {
        if(!$raw_cdata) {
            output '\fB';
            $newline_last = 0;
        }
    }
    push(@fontstack, 'bold');
}

sub italic_on()
{
    # If the last font is also italic, don't change anything.
    if($fontstack[$#fontstack] ne 'italic') {
        if(!$raw_cdata) {

```

```

output '\fI';
$newline_last = 0;
}
}
push(@fontstack, 'italic');
}

sub font_off()
{
my $thisfont = pop(@fontstack);
my $lastfont = $fontstack[$#fontstack];

# Only output font change if it is different
if($thisfont ne $lastfont) {
if($raw_cdata) { return; }
elsif($lastfont eq 'bold') { output '\fB'; }
elsif($lastfont eq 'italic') { output '\fI'; }
else { output '\fR'; }

$newline_last = 0;
}
}

```

```

#####
#
#

```

Manpage management

```

#
#####

```

```

sgml('<REFENTRY>', sub {
# This will be overwritten at end of REFMETA, when we know the name of the page.
pop_output();

```

\$write\_manpages = 1; # Currently writing manpage.

\$nocollapse\_whitespace = 0; # Current whitespace collapse counter.

\$newline\_last = 1; # At beginning of line?

# Just a bit of warning, you will see this variable manipulated

# manually a lot. It makes the code harder to follow but it

# saves you from having to worry about collapsing at the end of

# parse, stopping at verbatims, etc.

\$raw\_cdata = 0; # Instructs certain output functions to

```

# leave CDATA alone, so we can assign
# it to a string and process it, etc.
@fontstack = (); # Fonts being activated.

$manpage_title = ""; # Needed for indexing.
$manpage_sect = "";
@manpage_names = ();

$manpage_misc = "";

$list_nestlevel = 0; # Indent certain nested
content.
});
sgml('</REFENTRY>', sub {
if(!$newline_last) {
output "\n";
}

$write_manpages = 0;
$raw_cdata = 1;
push_output('nul');
});

sgml('</REFMETA>', sub {
push_output('file', "$manpage_title.$manpage_sect");

output <<_END_BANNER;
.\|" This manpage has been automatically generated by docbook2man
.\|" from a DocBook document. This tool can be found at:
.\|" <http://shell.ipoline.com/~elmert/comp/docbook2X/>
.\|" Please send any bug reports, improvements, comments, patches,
.\|" etc. to Steve Cheng <steve\@ggi-project.org>.
_END_BANNER

my $manpage_date = `date "+%d %B %Y"`;

output '.TH "'";

# If the title is not mixed-case, convention says to
# uppercase the whole title. (The canonical title is
# lowercase.)
if($manpage_title =~ /[A-Z]/) {
output fold_string($manpage_title);
} else {
output uc(fold_string($manpage_title));
}

output "' '", fold_string($manpage_sect),

```

```

""", fold_string(`date "+%d %B %Y"^),
""", $manpage_misc,
""",
$manpage_manual,
"\n";

$newline_last = 1;

# References to this RefEntry.
my $id = $_[0]->parent->attribute('ID')->value;
if($id ne "") {
    # The 'package name' part of the section should
    # not be used when citing it.
    my ($sectnum) = ($manpage_sect =~ /[0-9]*/);

    if($_[0]->parent->attribute('XREFLABEL')->value eq "") {
        $Refs->put("refentry:$id", "$manpage_title($sectnum)");
    } else {
        $Refs->put("refentry:$id",
            $_[0]->parent->attribute('XREFLABEL')->value .
            "($sectnum)");
    }
}
});

sgml('<REFENTRYTITLE>', sub {
    if($_[0]->in('REFMETA')) {
        save_cdata();
    } else {
        # Manpage citations are in bold.
        bold_on();
    }
});

sgml('</REFENTRYTITLE>', sub {
    if($_[0]->in('REFMETA')) {
        $raw_cdata--;
        $manpage_title = pop_output();
    }
    else { font_off(); }
});

sgml('<MANVOLNUM>', sub {
    if($_[0]->in('REFMETA')) {
        save_cdata();
    } else {
        # Manpage citations use ().
        output '(';
    }
}

```

```

});
sgml('</MANVOLNUM>', sub {
  if($_[0]->in('REFMETA')) {
    $raw_cdata--;
    $manpage_sect
    = pop_output();
  }
  else { output ' ' }
});

sgml('<REFMISCINFO>', \&save_cdata);
sgml('</REFMISCINFO>', sub {
  $raw_cdata--;
  $manpage_misc = fold_string(pop_output());
});

# NAME section
man_sgml('<REFNAMEDIV>', "\n.SH NAME\n");

sgml('<REFNAME>', \&save_cdata);
sgml('</REFNAME>', sub {
  $raw_cdata--;
  push(@manpage_names, pop_output());
});

sgml('<REFPURPOSE>', \&save_cdata);
sgml('</REFPURPOSE>', sub {
  $raw_cdata--;
  my $manpage_purpose = fold_string(pop_output());

  for(my $i = 0; $i < $#manpage_names; $i++) {
    output fold_string($manpage_names[$i], ' ');
  }

  output fold_string($manpage_names[$#manpage_names]);
  output " \|- $manpage_purpose\n";

  $newline_last = 1;

  foreach(@manpage_names) {
    # Don't link to itself
    if($_ ne $manpage_title) {
      print LINKSFILE "$manpage_title.$manpage_sect $_.$manpage_sect\n";
    }
  }
});

```



```
man_sgml('<REFCLASS>', "\n.sp\n");
```

```
#RefDescriptor
```

```
#####  
#  
#  
SYNOPSIS section and synopses  
#  
#####
```

```
man_sgml('<REFSYNOPSISDIV>', "\n.SH SYNOPSIS\n");  
man_sgml('</REFSYNOPSISDIV>', "\n");
```

```
## FIXME! Must be made into block elements!!
```

```
#sgml('<FUNCSYNOPSIS>', \&bold_on);  
#sgml('</FUNCSYNOPSIS>', \&font_off);  
#sgml('<CMDSYNOPSIS>', \&bold_on);  
#sgml('</CMDSYNOPSIS>', \&font_off);
```

```
man_sgml('<FUNCSYNOPSIS>', sub {  
  man_output("\n.sp\n");  
  bold_on();  
});  
man_sgml('</FUNCSYNOPSIS>', sub {  
  font_off();  
  man_output("\n");  
});
```

```
man_sgml('<CMDSYNOPSIS>', "\n\n");  
man_sgml('</CMDSYNOPSIS>', "\n\n");
```

```
man_sgml('<FUNCPROTOTYPE>', "\n.sp\n");
```

```
# Arguments to functions. This is C convention.
```

```
man_sgml('<PARAMDEF>', '(');  
man_sgml('</PARAMDEF>', '); \n");  
man_sgml('<VOID>', "(void); \n");
```

```
sub arg_start  
{  
  # my $choice = $_[0]->attribute('CHOICE')->value;
```

```

# The content model for CmdSynopsis doesn't include #PCDATA,
# so we won't see any of the whitespace in the source file,
#
so we have to add it after each component.
output ' ';

if($_[0]->attribute('CHOICE')->value =~ /opt/i) {
    output '[';
    }
bold_on();
}
sub arg_end
{
font_off();
if($_[0]->attribute('REP')->value =~ /^Repeat/i) {
    italic_on();
    output ' ...';
    font_off();
    }
if($_[0]->attribute('CHOICE')->value =~ /opt/i) {
    output ']';
    }
}

sgml('<ARG>', \&arg_start);
sgml('</ARG>', \&arg_end);
sgml('<GROUP>', \&arg_start);
sgml('</GROUP>', \&arg_end);

sgml('<OPTION>', \&bold_on);
sgml('</OPTION>', \&font_off);

# FIXME: This is one _blank_ line.
man_sgml('<SBR>', "\n\n");

#####
#
# General sections
#
#####

# The name of the section is handled by TITLE. This just sets
# up the roff markup.
man_sgml('<REFSECT1>', "\n.SH ");
man_sgml('<REFSECT2>', "\n.SS ");
man_sgml('<REFSECT3>', "\n.SS ");

```

```
#####
#
#
Titles, metadata.
#
#####

sgml('<TITLE>', sub {
if($_->in('REFERENCE') or $_->in('BOOK')) {
    $write_manpages = 1;
    }
save_cdata();
});
sgml('</TITLE>', sub {
my $title = fold_string(pop_output());
$raw_cdata--;

if($_->in('REFERENCE') or $_->in('BOOK')) {
    # We use TITLE of enclosing Reference or Book as manual name
    $manpage_manual = $title;
    $write_manpages = 0;
    }
elseif(exists $_->parent->ext->{'title'}) {
    # By far the easiest case. Just fold the string as
    # above, and then set the parent element's variable.
    $_->parent->ext->{'title'} = $title;
    }
else {
    # If the parent element's handlers are lazy,
    # output the folded string for them :)
    # We assume they want uppercase and a newline.
    output "", uc($title), "\\n";
    $newline_last = 1;
    }
});

sgml('<ATTRIBUTION>', sub { push_output('string') });
sgml('</ATTRIBUTION>', sub { $_->parent->ext->{'attribution'}
= pop_output(); });

# IGNORE.
sgml('<DOCINFO>', sub { push_output('nul'); });
sgml('</DOCINFO>', sub { pop_output(); });
sgml('<REFSECT1INFO>', sub { push_output('nul'); });
sgml('</REFSECT1INFO>', sub { pop_output(); });
```

```
sgml('<REFSECT2INFO>', sub { push_output('nul'); });
sgml('</REFSECT2INFO>', sub { pop_output(); });
sgml('<REFSECT3INFO>', sub { push_output('nul'); });
sgml('</REFSECT3INFO>', sub { pop_output(); });
```

```
sgml('<INDEXTERM>', sub { push_output('nul'); });
sgml('</INDEXTERM>', sub { pop_output(); });
```

```
#####
#
# Set bold on enclosed content
#
#####
```

```
sgml('<APPLICATION>', \&bold_on); sgml('</APPLICATION>', \&font_off);
```

```
sgml('<CLASSNAME>', \&bold_on); sgml('</CLASSNAME>', \&font_off);
sgml('<STRUCTNAME>', \&bold_on); sgml('</STRUCTNAME>', \&font_off);
sgml('<STRUCTFIELD>', \&bold_on); sgml('</STRUCTFIELD>', \&font_off);
sgml('<SYMBOL>',
\&bold_on); sgml('</SYMBOL>', \&font_off);
sgml('<TYPE>', \&bold_on); sgml('</TYPE>', \&font_off);
```

```
sgml('<ENVAR>', \&bold_on); sgml('</ENVAR>', \&font_off);
```

```
sgml('<FUNCTION>', \&bold_on); sgml('</FUNCTION>', \&font_off);
```

```
sgml('<EMPHASIS>', \&bold_on); sgml('</EMPHASIS>', \&font_off);
```

```
sgml('<ERRORNAME>', \&bold_on); sgml('</ERRORNAME>', \&font_off);
# ERRORTYPE
```

```
sgml('<COMMAND>', \&bold_on); sgml('</COMMAND>', \&font_off);
```

```
sgml('<GUIBUTTON>', \&bold_on); sgml('</GUIBUTTON>', \&font_off);
sgml('<GUIICON>', \&bold_on); sgml('</GUIICON>', \&font_off);
# GUILABEL
# GUIMENU
# GUIMENUITEM
# GUISUBMENU
# MENUCHOICE
# MOUSEBUTTON
```

```
sgml('<ACCEL>', \&bold_on); sgml('</ACCEL>', \&font_off);
sgml('<KEYCAP>', \&bold_on); sgml('</KEYCAP>', \&font_off);
sgml('<KEYSYM>', \&bold_on); sgml('</KEYSYM>', \&font_off);
# KEYCODE
```

# KEYCOMBO

# SHORTCUT

sgml('<USERINPUT>', \&bold\_on); sgml('</USERINPUT>', \&font\_off);

sgml('<INTERFACEDEFINITION>', \&bold\_on);

sgml('</INTERFACEDEFINITION>', \&font\_off);

#

May need to look at the CLASS

sgml('<SYSTEMITEM>', \&bold\_on);

sgml('</SYSTEMITEM>', \&font\_off);

#####

#

# Set italic on enclosed content

#

#####

sgml('<FIRSTTERM>', \&italic\_on); sgml('</FIRSTTERM>', \&font\_off);

sgml('<FILENAME>', \&italic\_on); sgml('</FILENAME>', \&font\_off);

sgml('<PARAMETER>', \&italic\_on); sgml('</PARAMETER>', \&font\_off);

sgml('<PROPERTY>', \&italic\_on); sgml('</PROPERTY>', \&font\_off);

sgml('<REPLACEABLE>', sub {

italic\_on();

if(\$\_[0]->in('TOKEN')) {

# When tokenizing, follow more 'intuitive' convention

output "<";

}

});

sgml('</REPLACEABLE>', sub {

if(\$\_[0]->in('TOKEN')) {

output ">";

}

font\_off();

});

sgml('<CITETITLE>', \&italic\_on); sgml('</CITETITLE>', \&font\_off);

sgml('<FOREIGNPHRASE>', \&italic\_on); sgml('</FOREIGNPHRASE>', \&font\_off);

sgml('<LINEANNOTATION>', \&italic\_on); sgml('</LINEANNOTATION>',

\&font\_off);

```
#####  
#  
# Other 'inline' elements  
#  
#####
```

```
man_sgml('<EMAIL>', '<');  
man_sgml('</EMAIL>', '>');  
man_sgml('<OPTIONAL>', '[');  
man_sgml('</OPTIONAL>', ']');
```

```
man_sgml('</TRADEMARK>', "\\u\\s-2TM\\s+2\\d");
```

```
man_sgml('<COMMENT>', "[Comment: ");  
man_sgml('</COMMENT>', "];
```

```
man_sgml('<QUOTE>', "`");  
man_sgml('</QUOTE>', "`");
```

```
#man_sgml('<LITERAL>', '"');  
#man_sgml('</LITERAL>', '"');
```

```
# No special presentation:
```

```
# AUTHOR  
# AUTHORINITIALS
```

```
# ABBREV  
# ACTION  
# ACRONYM  
# ALT  
# CITATION  
# PHRASE  
# QUOTE  
# WORDASWORD
```

```
# COMPUTEROUTPUT  
# MARKUP  
# PROMPT  
# RETURNVALUE  
# SGMLTAG
```

# TOKEN

# DATABASE

# HARDWARE

# INTERFACE

# MEDIALABEL

# There doesn't seem to be a good way to represent LITERAL in -man

#####

#

# Paragraph and paragraph-like elements

#

#####

sub

para\_start {

output "\n" unless \$newline\_last++;

# In lists, etc., don't start paragraph with .PP since

# the indentation will be gone.

if(\$\_[0]->parent->ext->{'nobreak'}==1) {

# Usually this is the FIRST element of

# a hanging tag, so we MUST not do a full

# paragraph break.

\$\_[0]->parent->ext->{'nobreak'} = 2;

} elsif(\$\_[0]->parent->ext->{'nobreak'}==2) {

# Usually these are the NEXT elements of

# a hanging tag. If we break using a blank

# line, we're okay.

output "\n";

} else {

# Normal case. (For indented blocks too, at least

# -man isn't so braindead in this area.)

output ".PP\n";

}

}

# Actually applies to a few other block elements as well

sub para\_end {

output "\n" unless \$newline\_last++;

}

sgml('<PARA>', \&para\_start);

sgml('</PARA>', \&para\_end);

sgml('<SIMPARA>', \&para\_start);

```
sgml('</SIMPARA>', \&para_end);
```

```
# Nothing special, except maybe FIXME set nobreak.
```

```
sgml('<INFORMALEXAMPLE>',  
 \&para_start);  
sgml('</INFORMALEXAMPLE>', \&para_end);
```

```
#####
```

```
#
```

```
# Blocks using SS sections
```

```
#
```

```
#####
```

```
# FIXME: We need to consider the effects of SS  
# in a hanging tag :(
```

```
# Complete with the optional-title dilemma (again).
```

```
sgml('<ABSTRACT>', sub {  
  $_[0]->ext->{'title'} = 'ABSTRACT';  
  output "\n" unless $newline_last++;  
  push_output('string');  
});  
sgml('</ABSTRACT>', sub {  
  my $content = pop_output();
```

```
# As ABSTRACT is never on the same level as RefSect1,  
# this leaves us with only .SS in terms of -man macros.  
output ".SS \"", uc($_[0]->ext->{'title'}), "\"\n";
```

```
output $content;  
output "\n" unless $newline_last++;  
});
```

```
# Ah, I needed a break. Example always has a title.
```

```
man_sgml('<EXAMPLE>', "\n.SS ");  
sgml('</EXAMPLE>', \&para_end);
```

```
# Same with sidebar.
```

```
man_sgml('<SIDEBAR>', "\n.SS ");  
sgml('</SIDEBAR>', \&para_end);
```

```
# NO title.
```

```
man_sgml('<HIGHLIGHTS>',
```



```
"\n.SS HIGHLIGHTS\n");
sgml('</HIGHLIGHTS>', \&para_end);
```

```
#####
#
# Indented 'Block' elements
#
#####
```

```
sub indent_block_start
{
  output "\n" unless $newline_last++;
  output ".sp\n.RS\n";
}
sub indent_block_end
{
  output "\n" unless $newline_last++;
  output ".RE\n";
}
```

```
# This element is almost like an admonition (below),
# only the default title is blank :)
```

```
sgml('<BLOCKQUOTE>', sub {
  $_[0]->ext->{'title'} = "";
  output "\n" unless $newline_last++;
  push_output('string');
});
sgml('</BLOCKQUOTE>', sub {
  my $content = pop_output();

  indent_block_start();

  if($_[0]->ext->{'title'}) {
    output ".B \'", $_[0]->ext->{'title'}, ":\n";
  }
}
```

```
output $content;
```

```
if($_[0]->ext->{'attribution'}) {
  output "\n" unless $newline_last++;
  # One place where roff's space-sensitivity makes sense :)
  output "\n      -- ";
  output
```

```

$_[0]->ext->{'attribution'} . "\n";
}

indent_block_end();
});

# Set off admonitions from the rest of the text by indenting.
# FIXME: Need to check if this works inside paragraphs, not enclosing them.
sub admonition_end {
    my $content = pop_output();

    indent_block_start();

    # When the admonition is only one paragraph,
    # it looks nicer if the title was inline.
    my $num_para;
    while ($content =~ /\^.PP/gm) { $num_para++ }
    if($num_para==1) {
        $content =~ s/^\.PP\n//;
    }

    output ".B \"\" . $_[0]->ext->{'title'} . ":\n";
    output $content;

    indent_block_end();
}

sgml('<NOTE>', sub {
    # We can't see right now whether or not there is a TITLE
    # element, so we have to save the output now and add it back
    # at the end of this admonition.
    $_[0]->ext->{'title'} = 'Note';

    # Although admonition_end's indent_block_start will do this,
    # we need to synchronize the output _now_
    output "\n" unless $newline_last++;

    push_output('string');
});
sgml('</NOTE>', \&admonition_end);

#
# Same as above.
sgml('<WARNING>', sub {
    $_[0]->ext->{'title'} = 'Warning';
    output "\n" unless $newline_last++;
    push_output('string');
});

```

```
sgml('</WARNING>', \&admonition_end);
```

```
sgml('<TIP>', sub {  
  $_[0]->ext->{'title'} = 'Tip';  
  output "\n" unless $newline_last++;  
  push_output('string');  
});
```

```
sgml('</TIP>', \&admonition_end);
```

```
sgml('<CAUTION>', sub {  
  $_[0]->ext->{'title'} = 'Caution';  
  output "\n" unless $newline_last++;  
  push_output('string');  
});
```

```
sgml('</CAUTION>', \&admonition_end);
```

```
sgml('<IMPORTANT>', sub {  
  $_[0]->ext->{'title'} = 'Important';  
  output "\n" unless $newline_last++;  
  push_output('string');  
});
```

```
sgml('</IMPORTANT>', \&admonition_end);
```

```
#####
```

```
#
```

```
# Verbatim displays.
```

```
#
```

```
#####
```

```
sub verbatim_start {  
  output "\n" unless $newline_last++;
```

```
if($_[0]->parent->ext->{'nobreak'}==1) {
```

```
  # Usually this is the FIRST element of
```

```
  #
```

```
  a hanging tag, so we MUST not do a full
```

```
  # paragraph break.
```

```
  $_[0]->parent->ext->{'nobreak'} = 2;
```

```

} else {
  output "\n";
}

output(".nf\n") unless $nocollapse_whitespace++;
}

sub verbatim_end {
  output "\n" unless $newline_last++;
  output(".fi\n") unless --$nocollapse_whitespace;
}

sgml('<PROGRAMLISTING>', \&verbatim_start);
sgml('</PROGRAMLISTING>', \&verbatim_end);

sgml('<SCREEN>', \&verbatim_start);
sgml('</SCREEN>', \&verbatim_end);

sgml('<LITERALLAYOUT>', \&verbatim_start);
sgml('</LITERALLAYOUT>', \&verbatim_end);

#sgml('<SYNOPSIS>', sub {
# if($_[0]->attribute('FORMAT')->value =~ /linespecific/i) {
# &verbatim_start;
# } else {
# roffcmd("");
# }
#});
#
#sgml('</SYNOPSIS>', sub {
# if($_[0]->attribute('FORMAT')->value =~ /linespecific/i) {
# &verbatim_end;
# }
# else {
# roffcmd("");# not sure about this.
# }
#});
sgml('<SYNOPSIS>', \&verbatim_start);
sgml('</SYNOPSIS>', \&verbatim_end);

```

```
#####
#
#
Lists
#
#####

# Indent nested lists.
sub indent_list_start {
  if($list_nestlevel++) {
    output "\n" unless $newline_last++;
    output ".RS\n";
  }
}
sub indent_list_end {
  if(--$list_nestlevel) {
    output "\n" unless $newline_last++;
    output ".RE\n";
  }
}

sgml('<VARIABLELIST>', \&indent_list_start);
sgml('</VARIABLELIST>', \&indent_list_end);
sgml('<ITEMIZEDLIST>', \&indent_list_start);
sgml('</ITEMIZEDLIST>', \&indent_list_end);
sgml('<ORDEREDLIST>', sub {
  indent_list_start();
  $_[0]->ext->{'count'} = 1;
});
sgml('</ORDEREDLIST>', \&indent_list_end);

# Output content on one line, bolded.
sgml('<TERM>', sub {
  output "\n" unless $newline_last++;
  output ".TP\n";
  bold_on();
  push_output('string');
});
sgml('</TERM>', sub {
  my $term = pop_output();
  $term =~ tr/\n/ /;
  output $term;
  font_off();
  output "\n";
  $newline_last = 1;
});

sgml('<LISTITEM>', sub {
```

```

# A bulleted list.
if($_[0]->in('ITEMIZEDLIST'))
{
    output "\n" unless $newline_last++;
    output ".TP 0.2i\n\\(bu\n";
}

# Need numbers.
# Assume Arabic numeration for now.
elsif($_[0]->in('ORDEREDLIST')) {
    output "\n" unless $newline_last++;
    output ".TP ", $_[0]->parent->ext->{'count'}++, ". \n";
}

$_[0]->ext->{'nobreak'} = 1;
});

sgml('<SIMPLELIST>', sub {
    $_[0]->ext->{'first_member'} = 1;
});

sgml('<MEMBER>', sub {
    my $parent = $_[0]->parent;

    if($parent->attribute('TYPE')->value =~ /Inline/i) {
        if($parent->ext->{'first_member'}) {
            # If this is the first member don't put any commas
            $parent->ext->{'first_member'} = 0;
        } else {
            output ", ";
        }
    } elsif($parent->attribute('TYPE')->value =~ /Vert/i) {
        output "\n" unless $newline_last++;
        output "\n";
    }
});

#####
#
# Stuff we don't know how to handle (yet)
#
#####

# Address blocks:

```

```
# Credit stuff:
#
ACKNO
# ADDRESS
# AFFILIATION
# ARTPAGENUMS
# CONTRIBUTION
# AUTHORBLURB
# AUTHORGROUP
# OTHERCREDIT
# HONORIFIC
```

```
# Areas:
# AREA
# AREASET
# AREASPEC
```

```
#####
#
# Linkage, cross references
#
#####
```

```
# Print the URL
sgml('</ULINK>', sub {
# output ' <URL:', $_[0]->attribute('URL')->value, '>';
$newline_last = 0;
});
```

```
# If cross reference target is a RefEntry,
# output CiteRefEntry-style references.
sgml('<XREF>', sub {
my $id = $_[0]->attribute('LINKEND')->value;
my $manref = $Refs->get("refentry:$id");
```

```
if($manref) {
my ($title, $sect) = ($manref =~ /(.*)(\(.*\))/);
bold_on();
output $title;
font_off();
output $sect;
} else {
$blank_xrefs++ if $write_manpages;
```

```

output "[XRef to $id]";
}

$newline_last = 0;
});

# Anchor

#####
#
# Other handlers
#
#####

man_sgml('[lt
    ]', '<');
man_sgml('[gt  ]', '>');
man_sgml('[amp ]', '&');

#
# Default handlers (uncomment these if needed). Right now, these are set
# up to gag on any unrecognised elements, sdata, processing-instructions,
# or entities.
#
# sgml('start_element',sub { die "Unknown element: " . $_[0]->name; });
# sgml('end_element',"");

# This is for weeding out and escaping certain characters.
# This looks like it's inefficient since it's done on every line, but
# in reality, SGMLspm and sgmlspl parsing ESIS takes _much_ longer.

sgml('cdata', sub
{
if(!$write_manpages) { return; }
elsif($raw_cdata) { output $_[0]; return; }

# Escape backslashes
$_[0] =~ s/\\|\\\|\\g;

# In non-'pre'-type elements:
if(!$nocollapse_whitespace) {
# Change tabs to spaces
$_[0] =~ tr/\t/ /;

# Do not allow indents at beginning of line

```



```

# groff chokes on that.
if($newline_last) {
  $_[0] =~ s/^ +//;

  # If the
line is all blank, don't do anything.
  if($_[0] eq "") { return; }

  $_[0] =~ s/^\.\.\&\./;

  # Argh... roff doesn't like ' either...
  $_[0] =~ s/^\.\.\&\/';
}
}

$newline_last = 0;

output $_[0];
});

# When in whitespace-collapsing mode, we disallow consecutive newlines.

sgml('re', sub
{
  if($nocollapse_whitespace || !$newline_last) {
    output "\n";
  }

  $newline_last = 1;
});

sgml('sdata',sub { die "Unknown SDATA: " . $_[0]; });
sgml('pi',sub { die "Unknown processing instruction: " . $_[0]; });
sgml('entity',sub { die "Unknown external entity: " . $_[0]->name; });
sgml('start_subdoc',sub { die "Unknown subdoc entity: " . $_[0]->name; });
sgml('end_subdoc',"");
sgml('conforming',"");

1;

Found in path(s):
* /opt/cola/permits/1826454257_1697752738.11816/0/iputils-s20101006-tar-gz/iputils-
s20101006/doc/docbook2man-spec.pl
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\*/  
/\*  
\* P I N G . C  
\*  
\* Using the InterNet Control Message Protocol (ICMP) "ECHO" facility,  
\* measure round-trip-delays and packet loss across network paths.  
\*  
\* Author -  
\* Mike Muuss  
\* U. S. Army Ballistic Research Laboratory  
\* December, 1983  
\*  
\* Status -  
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\* Bugs -

- \* More statistics could always be gathered.
- \* This program has to run SUID to ROOT to access the ICMP socket.
- \*/

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- \* /opt/cola/permits/1826454257\_1697752738.11816/0/iputils-s20101006-tar-gz/iputils-s20101006/ping.c
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/\* pg3.c: Packet Generator for packet performance testing.

\*

\* Copyright 2001 by Robert Olsson <robert.olsson@its.uu.se>

\*

Uppsala University, Sweden

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- \* Authors: Alexey Kuznetsov, <kuznet@ms2.inr.ac.ru>
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## 1.54 tinypoxy 1.8.3

## 1.54.1 Available under license :

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## 1.55 wpa-supPLICant 2.5-devel

### 1.55.1 Available under license :

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Found in path(s):

- \* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/doc/docbook/wpa\_priv.shtml
- \* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/doc/docbook/wpa\_gui.shtml
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- \* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/doc/docbook/wpa\_background.shtml

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```
/*
 * wpa_supplicant - Temporary BSSID blacklist
 * Copyright (c) 2003-2007, Jouni Malinen <j@w1.fi>
 *
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 * See README for more details.
 */
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/blacklist.c
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/blacklist.h
```

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ChangeLog for wpa\_supplicant

2016-10-02 - v2.6

- \* fixed WNM Sleep Mode processing when PMF is not enabled  
[<http://w1.fi/security/2015-6/>] (CVE-2015-5310)
- \* fixed EAP-pwd last fragment validation  
[<http://w1.fi/security/2015-7/>] (CVE-2015-5315)
- \* fixed EAP-pwd unexpected Confirm message processing  
[<http://w1.fi/security/2015-8/>] (CVE-2015-5316)
- \* fixed WPS configuration update vulnerability with malformed passphrase  
[<http://w1.fi/security/2016-1/>] (CVE-2016-4476)
- \* fixed configuration update vulnerability with malformed parameters set over the local control interface  
[<http://w1.fi/security/2016-1/>] (CVE-2016-4477)
- \* fixed TK configuration to the driver in EAPOL-Key 3/4 retry case
- \* extended channel switch support for P2P GO
- \* started to throttle control interface event message bursts to avoid issues with monitor sockets running out of buffer space
- \* mesh mode fixes/improvements
  - generate proper AID for peer
  - enable WMM by default
  - add VHT support
  - fix PMKID derivation
  - improve robustness on various exchanges
  - fix peer link counting in reconnect case
  - improve mesh joining behavior
  - allow DTIM period to be configured
  - allow HT to be disabled (disable\_ht=1)
  - add MESH\_PEER\_ADD and MESH\_PEER\_REMOVE commands
  - add support for PMKSA caching
  - add minimal support for SAE group negotiation
  - allow pairwise/group cipher to be configured in the network profile
  - use ieee80211w profile parameter to enable/disable PMF and derive a separate TX IGTK if PMF is enabled instead of using MGTK

- incorrectly
- fix AEK and MTK derivation
- remove GTKdata and IGTKdata from Mesh Peering Confirm/Close
- note: these changes are not fully backwards compatible for secure (RSN) mesh network
- \* fixed PMKID derivation with SAE
- \* added support for requesting and fetching arbitrary ANQP-elements without internal support in wpa\_supplicant for the specific element (anqp[265]=<hexdump> in "BSS <BSSID>" command output)
- \* P2P
  - filter control characters in group client device names to be consistent with other P2P peer cases
  - support VHT 80+80 MHz and 160 MHz
  - indicate group completion in P2P Client role after data association instead of already after the WPS provisioning step
  - improve group-join operation to use SSID, if known, to filter BSS entries
  - added optional ssid=<hexdump> argument to P2P\_CONNECT for join case
  - added P2P\_GROUP\_MEMBER command to fetch client interface address
- \* P2PS
  - fix follow-on PD Response behavior
  - fix PD Response generation for unknown peer
  - fix persistent group reporting
  - add channel policy to PD Request
  - add group SSID to the P2PS-PROV-DONE event
  - allow "P2P\_CONNECT <addr> p2ps" to be used without specifying the default PIN
- \* BoringSSL
  - support for OCSP stapling
  - support building of h20-osu-client
- \* D-Bus
  - add ExpectDisconnect()
  - add global config parameters as properties
  - add SaveConfig()
  - add VendorElemAdd(), VendorElemGet(), VendorElemRem()
- \* fixed Suite B 192-bit AKM to use proper PMK length (note: this makes old releases incompatible with the fixed behavior)
- \* improved PMF behavior for cases where the AP and STA has different configuration by not trying to connect in some corner cases where the connection cannot succeed
- \* added option to reopen debug log (e.g., to rotate the file) upon receipt of SIGHUP signal
- \* EAP-pwd: added support for Brainpool Elliptic Curves (with OpenSSL 1.0.2 and newer)
- \* fixed EAPOL reauthentication after FT protocol run
- \* fixed FTIE generation for 4-way handshake after FT protocol run

- \* extended INTERFACE\_ADD command to allow certain type (sta/ap) interface to be created
- \* fixed and improved various FST operations
- \* added 80+80 MHz and 160 MHz VHT support for IBSS/mesh
- \* fixed SIGNAL\_POLL in IBSS and mesh cases
- \*
- added an option to abort an ongoing scan (used to speed up connection and can also be done with the new ABORT\_SCAN command)
- \* TLS client
  - do not verify CA certificates when ca\_cert is not specified
  - support validating server certificate hash
  - support SHA384 and SHA512 hashes
  - add signature\_algorithms extension into ClientHello
  - support TLS v1.2 signature algorithm with SHA384 and SHA512
  - support server certificate probing
  - allow specific TLS versions to be disabled with phase2 parameter
  - support extKeyUsage
  - support PKCS #5 v2.0 PBES2
  - support PKCS #5 with PKCS #12 style key decryption
  - minimal support for PKCS #12
  - support OCSP stapling (including ocspl\_multi)
- \* OpenSSL
  - support OpenSSL 1.1 API changes
  - drop support for OpenSSL 0.9.8
  - drop support for OpenSSL 1.0.0
- \* added support for multiple schedule scan plans (sched\_scan\_plans)
- \* added support for external server certificate chain validation (tls\_ext\_cert\_check=1 in the network profile phase1 parameter)
- \* made phase2 parser more strict about correct use of auth=<val> and authheap=<val> values
- \* improved GAS offchannel operations with comeback request
- \* added SIGNAL\_MONITOR command to request signal strength monitoring events
- \* added command for retrieving HS 2.0 icons with in-memory storage (REQ\_HS20\_ICON, GET\_HS20\_ICON, DEL\_HS20\_ICON commands and RX-HS20-ICON event)
- \* enabled ACS support for AP mode operations with wpa\_supplicant
- \* EAP-PEAP: fixed interoperability issue with Windows 2012r2 server ("Invalid Compound\_MAC in cryptobinding TLV")
- \* EAP-TTLS: fixed success after fragmented final Phase 2 message
- \* VHT: added interoperability workaround for 80+80 and 160 MHz channels
- \* WNM: workaround for broken AP operating class behavior
- \* added kqueue(2) support for eloop (CONFIG\_ELOOP\_KQUEUE)
- \* nl80211:
  - add support for full station state operations
  - do not add NL80211\_ATTR\_SMPS\_MODE attribute if HT is disabled



- add NL80211\_ATTR\_PREV\_BSSID with Connect command
- fix IEEE 802.1X/WEP EAP reauthentication and rekeying to use unencrypted EAPOL frames
- \* added initial MBO support; number of extensions to WNM BSS Transition Management
- \* added support for PBSS/PCP and P2P on 60 GHz
- \* Interworking: add credential realm to EAP-TLS identity
- \* fixed EAPOL-Key Request Secure bit to be 1 if PTK is set
- \* HS 2.0: add support for configuring frame filters
- \* added POLL\_STA command to check connectivity in AP mode
- \* added initial functionality for location related operations
- \* started to ignore pmf=1/2 parameter for non-RSN networks
- \* added wps\_disabled=1 network profile parameter to allow AP mode to be started without enabling WPS
- \* wpa\_cli: added action script support for AP-ENABLED and AP-DISABLED events
- \* improved Public Action frame addressing
  - add gas\_address3 configuration parameter to control Address 3 behavior
- \* number of small fixes

2015-09-27 - v2.5

- \*
  - fixed P2P validation of SSID element length before copying it
    - [<http://w1.fi/security/2015-1/>] (CVE-2015-1863)
  - \* fixed WPS UPnP vulnerability with HTTP chunked transfer encoding
    - [<http://w1.fi/security/2015-2/>] (CVE-2015-4141)
  - \* fixed WMM Action frame parser (AP mode)
    - [<http://w1.fi/security/2015-3/>] (CVE-2015-4142)
  - \* fixed EAP-pwd peer missing payload length validation
    - [<http://w1.fi/security/2015-4/>] (CVE-2015-4143, CVE-2015-4144, CVE-2015-4145, CVE-2015-4146)
  - \* fixed validation of WPS and P2P NFC NDEF record payload length
    - [<http://w1.fi/security/2015-5/>]
- \* nl80211:
  - added VHT configuration for IBSS
  - fixed vendor command handling to check OUI properly
  - allow driver-based roaming to change ESS
- \* added AVG\_BEACON\_RSSI to SIGNAL\_POLL output
- \* wpa\_cli: added tab completion for number of commands
- \* removed unmaintained and not yet completed SChannel/CryptoAPI support
- \* modified Extended Capabilities element use in Probe Request frames to include all cases if any of the values are non-zero
- \* added support for dynamically creating/removing a virtual interface with interface\_add/interface\_remove
- \* added support for hashed password (NtHash) in EAP-pwd peer
- \* added support for memory-only PSK/passphrase (mem\_only\_psk=1 and

CTRL-REQ/RSP-PSK\_PASSPHRASE)

\* P2P

- optimize scan frequencies list when re-joining a persistent group
- fixed number of sequences with nl80211 P2P Device interface
- added operating class 125 for P2P use cases (this allows 5 GHz channels 161 and 169 to be used if they are enabled in the current regulatory domain)
- number of fixes to P2PS functionality
- do not allow 40 MHz co-ex PRI/SEC switch to force MCC
- extended support for preferred channel listing

\* D-Bus:

- fixed WPS property of fi.w1.wpa\_supplicant1.BSS interface
- fixed PresenceRequest to use group interface
- added new signals: FindStopped, WPS pbc-overlap, GroupFormationFailure, WPS timeout, InvitationReceived
  
- added new methods: WPS Cancel, P2P Cancel, Reconnect, RemoveClient
- added manufacturer info

\* added EAP-EKE peer support for deriving Session-Id

\* added wps\_priority configuration parameter to set the default priority for all network profiles added by WPS

\* added support to request a scan with specific SSIDs with the SCAN command (optional "ssid <hexdump>" arguments)

\* removed support for WEP40/WEP104 as a group cipher with WPA/WPA2

\* fixed SAE group selection in an error case

\* modified SAE routines to be more robust and PWE generation to be stronger against timing attacks

\* added support for Brainpool Elliptic Curves with SAE

\* added support for CCMP-256 and GCMP-256 as group ciphers with FT

\* fixed BSS selection based on estimated throughput

\* added option to disable TLSv1.0 with OpenSSL (phase1="tls\_disable\_tlsv1\_0=1")

\* added Fast Session Transfer (FST) module

\* fixed OpenSSL PKCS#12 extra certificate handling

\* fixed key derivation for

Suite B 192-bit AKM (this breaks compatibility with the earlier version)

\* added RSN IE to Mesh Peering Open/Confirm frames

\* number of small fixes

2015-03-15 - v2.4

\* allow OpenSSL cipher configuration to be set for internal EAP server (openssl\_ciphers parameter)

\* fixed number of small issues based on hwsim test case failures and static analyzer reports

\* P2P:

- add new=<0/1> flag to P2P-DEVICE-FOUND events
- add passive channels in invitation response from P2P Client

- enable nl80211 P2P\_DEVICE support by default
- fix regression in disallow\_freq preventing search on social channels
- fix regressions in P2P SD query processing
- try to re-invite with social operating channel if no common channels in invitation
- allow cross connection on parent interface (this fixes number of use cases with nl80211)
- add support for P2P services (P2PS)
- add p2p\_go\_ctwindow configuration parameter to allow GO CTWindow to be configured

\*

increase postponing of EAPOL-Start by one second with AP/GO that supports WPS 2.0 (this makes it less likely to trigger extra roundtrip of identity frames)

- \* add support for PMKSA caching with SAE
- \* add support for control mesh BSS (IEEE 802.11s) operations
- \* fixed number of issues with D-Bus P2P commands
- \* fixed regression in ap\_scan=2 special case for WPS
- \* fixed macsec\_validate configuration
- \* add a workaround for incorrectly behaving APs that try to use EAPOL-Key descriptor version 3 when the station supports PMF even if PMF is not enabled on the AP
- \* allow TLS v1.1 and v1.2 to be negotiated by default; previous behavior of disabling these can be configured to work around issues with broken servers with phase1="tls\_disable\_tlsv1\_1=1 tls\_disable\_tlsv1\_2=1"
- \* add support for Suite B (128-bit and 192-bit level) key management and cipher suites
- \* add WMM-AC support (WMM\_AC\_ADDTS/WMM\_AC\_DELTS)
- \* improved BSS Transition Management processing
- \* add support for neighbor report
- \* add support for link measurement
- \* fixed expiration of BSS entry with all-zeros BSSID
- \* add optional LAST\_ID=x argument to LIST\_NETWORK to allow all configured networks to be listed even with huge number of network profiles
- \* add support for EAP Re-Authentication Protocol (ERP)
- \* fixed EAP-IKEv2 fragmentation reassembly
- \* improved PKCS#11 configuration for OpenSSL
- \* set stdout to be line-buffered
- \* add TDLS channel switch configuration
- \* add support for MAC address randomization in scans with nl80211
- \* enable HT for IBSS if supported by the driver
- \* add BSSID black and white lists (bssid\_blacklist, bssid\_whitelist)
- \* add support for domain\_suffix\_match with GnuTLS
- \* add OCSP stapling client support with GnuTLS
- \* include peer certificate in EAP events even without a separate probe

- operation; old behavior can be restored with cert\_in\_cb=0
- \* add peer certificate alt subject name to EAP events  
(CTRL-EVENT-EAP-PEER-ALT)
- \* add domain\_match  
network profile parameter (similar to  
domain\_suffix\_match, but full match is required)
- \* enable AP/GO mode HT Tx STBC automatically based on driver support
- \* add ANQP-QUERY-DONE event to provide information on ANQP parsing  
status
- \* allow passive scanning to be forced with passive\_scan=1
- \* add a workaround for Linux packet socket behavior when interface is in  
bridge
- \* increase 5 GHz band preference in BSS selection (estimate SNR, if info  
not available from driver; estimate maximum throughput based on common  
HT/VHT/specific TX rate support)
- \* add INTERWORKING\_ADD\_NETWORK ctrl\_iface command; this can be used to  
implement Interworking network selection behavior in upper layers  
software components
- \* add optional reassoc\_same\_bss\_optim=1 (disabled by default)  
optimization to avoid unnecessary Authentication frame exchange
- \* extend TDLS frame padding workaround to cover all packets
- \* allow wpa\_supplicant to recover nl80211 functionality if the cfg80211  
module  
gets removed and reloaded without restarting wpa\_supplicant
- \* allow hostapd DFS implementation to be used in wpa\_supplicant AP mode

2014-10-09 - v2.3

- \* fixed number of minor issues identified in static analyzer warnings
- \* fixed wfd\_dev\_info to be more careful and not read beyond the buffer  
when parsing invalid information for P2P-DEVICE-FOUND
- \* extended P2P and GAS query operations to support drivers that have  
maximum remain-on-channel time below 1000 ms (500 ms is the current  
minimum supported value)
- \* added p2p\_search\_delay parameter to make the default p2p\_find delay  
configurable
- \* improved P2P operating channel selection for various multi-channel  
concurrency cases
- \* fixed some TDLS failure cases to clean up driver state
- \* fixed dynamic interface addition cases with nl80211 to avoid adding  
ifindex values to incorrect interface to skip foreign interface events  
properly
- \* added TDLS workaround for some APs that may add extra data to the  
end of a short  
frame
- \* fixed EAP-AKA' message parser with multiple AT\_KDF attributes
- \* added configuration option (p2p\_passphrase\_len) to allow longer  
passphrases to be generated for P2P groups
- \* fixed IBSS channel configuration in some corner cases

- \* improved HT/VHT/QoS parameter setup for TDLS
- \* modified D-Bus interface for P2P peers/groups
- \* started to use constant time comparison for various password and hash values to reduce possibility of any externally measurable timing differences
- \* extended explicit clearing of freed memory and expired keys to avoid keeping private data in memory longer than necessary
- \* added optional scan\_id parameter to the SCAN command to allow manual scan requests for active scans for specific configured SSIDs
- \* fixed CTRL-EVENT-REGDOM-CHANGE event init parameter value
- \* added option to set Hotspot 2.0 Rel 2 update\_identifier in network configuration to support external configuration
- \* modified Android PNO functionality to send Probe Request frames only
  - for hidden SSIDs (based on scan\_ssid=1)
- \* added generic mechanism for adding vendor elements into frames at runtime (VENDOR\_ELEM\_ADD, VENDOR\_ELEM\_GET, VENDOR\_ELEM\_REMOVE)
- \* added fields to show unrecognized vendor elements in P2P\_PEER
- \* removed EAP-TTLS/MSCHAPv2 interoperability workaround so that MS-CHAP2-Success is required to be present regardless of eap\_workaround configuration
- \* modified EAP fast session resumption to allow results to be used only with the same network block that generated them
- \* extended freq\_list configuration to apply for sched\_scan as well as normal scan
- \* modified WPS to merge mixed-WPA/WPA2 credentials from a single session
- \* fixed nl80211/RTM\_DELLINK processing when a P2P GO interface is removed from a bridge
- \* fixed number of small P2P issues to make negotiations more robust in corner cases
- \* added experimental support for using temporary, random local MAC address (mac\_addr and preassoc\_mac\_addr parameters);
  - this is disabled
  - by default (i.e., previous behavior of using permanent address is maintained if configuration is not changed)
- \* added D-Bus interface for setting/clearing WFD IEs
- \* fixed TDLS AID configuration for VHT
- \* modified -m<conf> configuration file to be used only for the P2P non-netdev management device and do not load this for the default station interface or load the station interface configuration for the P2P management interface
- \* fixed external MAC address changes while wpa\_supplicant is running
- \* started to enable HT (if supported by the driver) for IBSS
- \* fixed wpa\_cli action script execution to use more robust mechanism (CVE-2014-3686)

2014-06-04 - v2.2

- \* added DFS indicator to get\_capability freq

- \* added/fixes nl80211 functionality
  - BSSID/frequency hint for driver-based BSS selection
  - fix tearing down WDS STA interfaces
  - support vendor specific driver command  
(VENDOR <vendor id> <sub command id> [<hex formatted data>])
- GO interface teardown optimization
  - allow beacon interval to be configured for IBSS
  - add SHA256-based AKM suites to CONNECT/ASSOCIATE commands
- \* removed unused NFC\_RX\_HANDOVER\_REQ and NFC\_RX\_HANDOVER\_SEL control interface commands (the more generic NFC\_REPORT\_HANDOVER is now used)
- \* fixed MSCHAP UTF-8 to UCS-2 conversion for three-byte encoding; this fixes password with include UTF-8 characters that use three-byte encoding EAP methods that use NtPasswordHash
- \* fixed couple of sequences where radio work items could get stuck, e.g., when rkill blocking happens during scanning or when scan-for-auth workaround is used
- \* P2P enhancements/fixes
  - enable enable U-APSD on GO automatically if the driver indicates support for this
  - fixed some service discovery cases with broadcast queries not being sent to all stations
  - fixed Probe Request frame triggering invitation to trigger only a single invitation instance even if multiple Probe Request frames are received
  - fixed a potential NULL pointer dereference crash when processing an invalid Invitation Request frame
  - add optional configuration file for the P2P\_DEVICE parameters
  - optimize scan for GO during persistent group invocation
  - fix possible segmentation fault when PBC overlap is detected while using a separate P2P group interface
  - improve GO Negotiation robustness by allowing GO Negotiation Confirmation to be retransmitted
  - do use freed memory on device found event when P2P NFC
- \* added phase1 network parameter options for disabling TLS v1.1 and v1.2 to allow workarounds with misbehaving AAA servers (tls\_disable\_tlsv1\_1=1 and tls\_disable\_tlsv1\_2=1)
- \* added support for OCSP stapling to validate AAA server certificate during TLS exchange
- \* Interworking/Hotspot 2.0 enhancements
  - prefer the last added network in Interworking connection to make the behavior more consistent with likely user expectation
  -
- roaming partner configuration (roaming\_partner within a cred block)
  - support Hotspot 2.0 Release 2
    - \* "hs20\_anqp\_get <BSSID> 8" to request OSU Providers list
    - \* "hs20\_icon\_request <BSSID> <icon filename>" to request icon files

- \* "fetch\_osu" and "cancel\_osu\_fetch" to start/stop full OSU provider search (all suitable APs in scan results)
- \* OSEN network for online signup connection
- \* min\_{dl,ul}\_bandwidth\_{home,roaming} cred parameters
- \* max\_bss\_load cred parameter
- \* req\_conn\_capab cred parameter
- \* sp\_priority cred parameter
- \* oosp cred parameter
- \* slow down automatic connection attempts on EAP failure to meet required behavior (no more than 10 retries within a 10-minute interval)
- \* sample implementation of online signup client (both SPP and OMA-DM protocols) (hs20/client/\*)
- fixed GAS indication for additional comeback delay with status code 95
- extend ANQP\_GET to accept Hotspot 2.0 subtypes

ANQP\_GET <addr> <info id>[,<info id>]...

[,hs20:<subtype>][...,hs20:<subtype>]

- add control interface events CRED-ADDED <id>, CRED-MODIFIED <id> <field>, CRED-REMOVED <id>
- add "GET\_CRED <id> <field>" command
- enable FT for the connection automatically if the AP advertises support for this
- fix a case where auto\_interworking=1 could end up stopping scanning
- \* fixed TDLS interoperability issues with supported operating class in some deployed stations
- \* internal TLS implementation enhancements/fixes
  - add SHA256-based cipher suites
  - add DHE-RSA cipher suites
  - fix X.509 validation of PKCS#1 signature to check for extra data
- \* fixed PTK derivation for CCMP-256 and GCMP-256
- \* added "reattach" command for fast reassociate-back-to-same-BSS
- \* allow PMF to be enabled for AP mode operation with the ieee80211w parameter
- \* added "get\_capability tdls" command
- \* added option to set config blobs through control interface with "SET blob <name> <hexdump>"
- \* D-Bus interface extensions/fixes
  - make p2p\_no\_group\_iface configurable
  - declare ServiceDiscoveryRequest method properly
  - export peer's device address as a property
  - make reassociate command behave like the control interface one, i.e., to allow connection from disconnected state
- \* added optional "freq=<channel ranges>" parameter to SET pno
- \* added optional "freq=<channel ranges>" parameter to SELECT\_NETWORK
- \* fixed OBSS scan result processing for 20/40 MHz co-ex report

- \* remove WPS 1.0 only support, i.e., WSC 2.0 support is now enabled whenever CONFIG\_WPS=y is set
  - \* fixed regression in parsing of WNM Sleep Mode exit key data
  - \* fixed potential segmentation fault and memory leaks in WNM neighbor report processing
  - \* EAP-pwd fixes
    - fragmentation of PWD-Confirm-Resp
    - fix memory leak when fragmentation is used
    - fix possible segmentation fault on EAP method deinit if an invalid group is negotiated
  - \* added MACsec/IEEE Std 802.1X-2010
- PAE implementation (currently available only with the macsec\_qca driver wrapper)
- \* fixed EAP-SIM counter-too-small message
  - \* added 'dup\_network <id\_s> <id\_d> <name>' command; this can be used to clone the psk field without having to extract it from wpa\_supplicant
  - \* fixed GSM authentication on USIM
  - \* added support for usin epoll in eloop (CONFIG\_ELOOP\_EPOLL=y)
  - \* fixed some concurrent virtual interface cases with dedicated P2P management interface to not catch events from removed interface (this could result in the management interface getting disabled)
  - \* fixed a memory leak in SAE random number generation
  - \* fixed off-by-one bounds checking in printf\_encode()
    - this could result in some control interface ATTACH command cases terminating wpa\_supplicant
  - \* fixed EAPOL-Key exchange when GCMP is used with SHA256-based AKM
  - \* various bug fixes

2014-02-04 - v2.1

- \* added support for simultaneous authentication of equals (SAE) for stronger password-based authentication with WPA2-Personal
- \* improved P2P negotiation and group formation robustness
  - avoid unnecessary Dialog Token value changes during retries
  - avoid more concurrent scanning cases during full group formation sequence
  - do not use potentially obsolete scan result data from driver cache for peer discovery/updates
  - avoid undesired re-starting of GO negotiation based on Probe Request frames
  - increase GO Negotiation and Invitation timeouts to address busy environments and peers that take long time to react to messages, e.g., due to power saving
  - P2P Device interface type
- \* improved P2P channel selection (use more peer information and allow more local options)
- \* added support for optional per-device PSK assignment by P2P GO (wpa\_cli p2p\_set per\_sta\_psk <0/1>)



\* added P2P\_REMOVE\_CLIENT for removing a client from P2P groups (including persistent groups); this can be used to securely remove a client from a group if per-device

PSKs are used

\* added more configuration flexibility for allowed P2P GO/client channels (p2p\_no\_go\_freq list and p2p\_add\_cli\_chan=0/1)

\* added nl80211 functionality

- VHT configuration for nl80211
- MFP (IEEE 802.11w) information for nl80211 command API
- support split wiphy dump
- FT (IEEE 802.11r) with driver-based SME
- use advertised number of supported concurrent channels
- QoS Mapping configuration

\* improved TDLS negotiation robustness

\* added more TDLS peer parameters to be configured to the driver

\* optimized connection time by allowing recently received scan results to be used instead of having to run through a new scan

\* fixed ctrl\_iface BSS command iteration with RANGE argument and no exact matches; also fixed argument parsing for some cases with multiple arguments

\* added 'SCAN TYPE=ONLY' ctrl\_iface command to request manual scan without executing roaming/network re-selection on scan results

\* added Session-Id derivation for

EAP peer methods

\* added fully automated regression testing with mac80211\_hwsim

\* changed configuration parser to reject invalid integer values

\* allow AP/Enrollee to be specified with BSSID instead of UUID for WPS ER operations

\* disable network block temporarily on repeated connection failures

\* changed the default driver interface from wext to nl80211 if both are included in the build

\* remove duplicate networks if WPS provisioning is run multiple times

\* remove duplicate networks when Interworking network selection uses the same network

\* added global freq\_list configuration to allow scan frequencies to be limited for all cases instead of just for a specific network block

\* added support for BSS Transition Management

\* added option to use "IFNAME=<ifname> " prefix to use the global control interface connection to perform per-interface commands; similarly, allow global control interface to be used as a monitor interface to receive events from all interfaces

\*

fixed OKC-based PMKSA cache entry clearing

\* fixed TKIP group key configuration with FT

\* added support for using OCSP stapling to validate server certificate (ocsp=1 as optional and ocsp=2 as mandatory)

\* added EAP-EKE peer

\* added peer restart detection for IBSS RSN

- \* added domain\_suffix\_match (and domain\_suffix\_match2 for Phase 2 EAP-TLS) to specify additional constraint for the server certificate domain name
- \* added support for external SIM/USIM processing in EAP-SIM, EAP-AKA, and EAP-AKA' (CTRL-REQ-SIM and CTRL-RSP-SIM commands over control interface)
- \* added global bgscan configuration option as a default for all network blocks that do not specify their own bgscan parameters
- \* added D-Bus methods for TDLS
- \* added more control to scan requests
  - "SCAN freq=<freq list>" can be used to specify which channels are scanned (comma-separated frequency ranges in MHz)
  - "SCAN passive=1" can be used to request a passive scan (no Probe Request frames are sent)
  - "SCAN use\_id" can be used to request a scan id to be returned and included in event messages related to this specific scan operation
  - "SCAN only\_new=1" can be used to request the driver/cfg80211 to report only BSS entries that have been updated during this scan round
  - these optional arguments to the SCAN command can be combined with each other
- \* modified behavior on externally triggered scans
  - avoid concurrent operations requiring full control of the radio when an externally triggered scan is detected
  - do not use results for internal roaming decision
- \* added a new cred block parameter 'temporary' to allow credential blocks to be stored separately even if wpa\_supplicant configuration file is used to maintain other network information
- \* added "radio work" framework to schedule exclusive radio operations for off-channel functionality
  - reduce issues with concurrent operations that try to control which channel is used
  - allow external programs to request exclusive radio control in a way that avoids conflicts with wpa\_supplicant
- \* added support for using Protected Dual of Public Action frames for GAS/ANQP exchanges when associated with PMF
- \* added support for WPS+NFC updates and P2P+NFC
  - improved protocol for WPS
  - P2P group formation/join based on NFC connection handover
  - new IPv4 address assignment for P2P groups (ip\_addr\_\* configuration parameters on the GO) to replace DHCP
  - option to fetch and report alternative carrier records for external NFC operations
- \* various bug fixes

2013-01-12 - v2.0

- \* removed Qt3-based wpa\_gui (obsoleted by wpa\_QUI-qt4)
- \* removed unmaintained driver wrappers broadcom, iphone, osx, ralink, hostap, madwifi (hostap and madwifi remain available for hostapd; their wpa\_supplicant functionality is obsoleted by wext)
- \* improved debug logging (human readable event names, interface name included in more entries)
- \*
- changed AP mode behavior to enable WPS only for open and WPA/WPA2-Personal configuration
- \* improved P2P concurrency operations
  - better coordination of concurrent scan and P2P search operations
  - avoid concurrent remain-on-channel operation requests by canceling previous operations prior to starting a new one
  - reject operations that would require multi-channel concurrency if the driver does not support it
  - add parameter to select whether STA or P2P connection is preferred if the driver cannot support both at the same time
  - allow driver to indicate channel changes
  - added optional delay=<search delay in milliseconds> parameter for p2p\_find to avoid taking all radio resources
  - use 500 ms p2p\_find search delay by default during concurrent operations
  - allow all channels in GO Negotiation if the driver supports multi-channel concurrency
- \* added number of small changes to make it easier for static analyzers to understand the implementation
- \* fixed number of small bugs (see git logs for more details)
- \* nl80211: number of updates to use new cfg80211/nl80211 functionality
  - replace monitor interface with nl80211 commands for AP mode
  - additional information for driver-based AP SME
  - STA entry authorization in RSN IBSS
- \* EAP-pwd:
  - fixed KDF for group 21 and zero-padding
  - added support for fragmentation
  - increased maximum number of hunting-and-pecking iterations
- \* avoid excessive Probe Response retries for broadcast Probe Request frames (only with drivers using wpa\_supplicant AP mode SME/MLME)
- \* added "GET country" ctrl\_iface command
- \* do not save an invalid network block in wpa\_supplicant.conf to avoid problems reading the file on next start
- \* send STA connected/disconnected ctrl\_iface events to both the P2P group and parent interfaces
- \* added preliminary support for using TLS v1.2 (CONFIG\_TLsv12=y)
- \* added "SET pno <1/0>" ctrl\_iface command to start/stop preferred network
- offload with sched\_scan driver command
- \* merged in number of changes from Android repository for P2P, nl80211,

- and build parameters
- \* changed P2P GO mode configuration to use driver capabilities to automatically enable HT operations when supported
- \* added "wpa\_cli status wps" command to fetch WPA2-Personal passphrase for WPS use cases in AP mode
- \* EAP-AKA: keep pseudonym identity across EAP exchanges to match EAP-SIM behavior
- \* improved reassociation behavior in cases where association is rejected or when an AP disconnects us to handle common load balancing mechanisms
  - try to avoid extra scans when the needed information is available
- \* added optional "join" argument for p2p\_prov\_disc ctrl\_iface command
- \* added group ifname to P2P-PROV-DISC-\* events
- \* added P2P Device Address to AP-STA-DISCONNECTED event and use p2p\_dev\_addr parameter name with AP-STA-CONNECTED
- \* added workarounds for WPS PBC overlap detection for some P2P use cases where deployed stations work incorrectly
- \* optimize WPS connection speed by disconnecting prior to WPS scan and by using single channel scans when AP channel is known
- \* PCSC and SIM/USIM improvements:
  - accept 0x67 (Wrong length) as a response to READ RECORD to fix issues with some USIM cards
  - try to read MNC length from SIM/USIM
  - build realm according to 3GPP TS 23.003 with identity from the SIM
  - allow T1 protocol to be enabled
- \* added more WPS and P2P information available through D-Bus
- \* improve P2P negotiation robustness
  - extra waits to get ACK frames through
  - longer timeouts for cases where deployed devices have been identified have issues meeting the specification requirements
  - more retries for some P2P frames
  - handle race conditions in GO Negotiation start by both devices
  - ignore unexpected GO Negotiation Response frame
- \* added support for libnl 3.2 and newer
- \* added P2P persistent group info to P2P\_PEER data
- \* maintain a list of P2P Clients for persistent group on GO
- \* AP: increased initial group key handshake retransmit timeout to 500 ms
- \* added optional dev\_id parameter for p2p\_find
- \* added P2P-FIND-STOPPED ctrl\_iface event
- \* fixed issues in WPA/RSN element validation when roaming with ap\_scan=1 and driver-based BSS selection
- \* do not expire P2P peer entries while connected with the peer in a group
- \* fixed WSC element inclusion in cases where P2P is disabled
- \* AP: added a WPS workaround for mixed mode AP Settings with Windows 7
- \* EAP-SIM: fixed AT\_COUNTER\_TOO\_SMALL use

- \* EAP-SIM/AKA: append realm to pseudonym identity
- \* EAP-SIM/AKA: store pseudonym identity in network configuration to allow it to persist over multiple EAP sessions and wpa\_supplicant restarts
- \* EAP-AKA': updated to RFC 5448 (username prefixes changed); note: this breaks interoperability with older versions
- \* added support for WFA Hotspot 2.0
  - GAS/ANQP to fetch network information
  - credential configuration and automatic network selections based on credential match with ANQP information
- \* limited PMKSA cache entries to be used only with the network context that was used to create them
- \* improved PMKSA cache expiration to avoid unnecessary disconnections
- \* adjusted bgscan\_simple fast-scan backoff to avoid too frequent background scans
- \* removed ctrl\_iface event on P2P PD Response in join-group case
- \* added option to fetch BSS table entry based on P2P Device Address ("BSS p2p\_dev\_addr=<P2P Device Address>")
- \* added BSS entry age to ctrl\_iface BSS command output
- \* added optional MASK=0xH option for ctrl\_iface BSS command to select which fields are included in the response
- \* added optional RANGE=ALL|N1-N2 option for ctrl\_iface BSS command to fetch information about several BSSes in one call
- \* simplified licensing terms by selecting the BSD license as the only alternative
- \* added "P2P\_SET disallow\_freq <freq list>" ctrl\_iface command to disable channels from P2P use
- \*
- added p2p\_pref\_chan configuration parameter to allow preferred P2P channels to be specified
- \* added support for advertising immediate availability of a WPS credential for P2P use cases
- \* optimized scan operations for P2P use cases (use single channel scan for a specific SSID when possible)
- \* EAP-TTLS: fixed peer challenge generation for MSCHAPv2
- \* SME: do not use reassociation after explicit disconnection request (local or a notification from an AP)
- \* added support for sending debug info to Linux tracing (-T on command line)
- \* added support for using Deauthentication reason code 3 as an indication of P2P group termination
- \* added wps\_vendor\_ext\_m1 configuration parameter to allow vendor specific attributes to be added to WPS M1
- \* started using separate TLS library context for tunneled TLS (EAP-PEAP/TLS, EAP-TTLS/TLS, EAP-FAST/TLS) to support different CA certificate configuration between Phase 1 and Phase 2
- \* added optional "auto" parameter for

p2p\_connect to request automatic  
 GO Negotiation vs. join-a-group selection

- \* added disabled\_scan\_offload parameter to disable automatic scan offloading (sched\_scan)
- \* added optional persistent=<network id> parameter for p2p\_connect to allow forcing of a specific SSID/passphrase for GO Negotiation
- \* added support for OBSS scan requests and 20/40 BSS coexistence reports
- \* reject PD Request for unknown group
- \* removed scripts and notes related to Windows binary releases (which have not been used starting from 1.x)
- \* added initial support for WNM operations
  - Keep-alive based on BSS max idle period
  - WNM-Sleep Mode
  - minimal BSS Transition Management processing
- \* added autoscan module to control scanning behavior while not connected
  - autoscan\_periodic and autoscan\_exponential modules
- \* added new WPS NFC ctrl\_iface mechanism
  - added initial support NFC connection handover
  - removed obsoleted WPS\_OOB command (including support for deprecated UFD config\_method)
- \*
- added optional framework for external password storage ("ext:<name>")
- \* wpa\_cli: added optional support for controlling wpa\_supplicant remotely over UDP (CONFIG\_CTRL\_IFACE=udp-remote) for testing purposes
- \* wpa\_cli: extended tab completion to more commands
- \* changed SSID output to use printf-escaped strings instead of masking of non-ASCII characters
  - SSID can now be configured in the same format: ssid=P"abc\x00test"
- \* removed default ACM=1 from AC\_VO and AC\_VI
- \* added optional "ht40" argument for P2P ctrl\_iface commands to allow 40 MHz channels to be requested on the 5 GHz band
- \* added optional parameters for p2p\_invite command to specify channel when reinvoking a persistent group as the GO
- \* improved FIPS mode builds with OpenSSL
  - "make fips" with CONFIG\_FIPS=y to build wpa\_supplicant with the OpenSSL FIPS object module
  - replace low level OpenSSL AES API calls to use EVP
  - use OpenSSL keying material exporter when possible
  - do
- not export TLS keys in FIPS mode
  - remove MD5 from CONFIG\_FIPS=y builds
  - use OpenSSL function for PKBDF2 passphrase-to-PSK
  - use OpenSSL HMAC implementation
  - mix RAND\_bytes() output into random\_get\_bytes() to force OpenSSL DRBG to be used in FIPS mode
  - use OpenSSL CMAC implementation
- \* added mechanism to disable TLS Session Ticket extension
  - a workaround for servers that do not support TLS extensions that

- was enabled by default in recent OpenSSL versions
  - tls\_disable\_session\_ticket=1
  - automatically disable TLS Session Ticket extension by default when using EAP-TLS/PEAP/TTLS (i.e., only use it with EAP-FAST)
  - \* changed VENDOR-TEST EAP method to use proper private enterprise number (this will not interoperate with older versions)
  - \* disable network block temporarily on authentication failures
  - \* improved WPS AP selection during WPS PIN iteration
  - \* added support for configuring GCMP cipher for IEEE 802.11ad
  - \* added support for Wi-Fi Display
- extensions
- WFD\_SUBELEMENT\_SET ctrl\_iface command to configure WFD subelements
  - SET wifi\_display <0/1> to disable/enable WFD support
  - WFD service discovery
  - an external program is needed to manage the audio/video streaming and codecs
  - \* optimized scan result use for network selection
    - use the internal BSS table instead of raw scan results
    - allow unnecessary scans to be skipped if fresh information is available (e.g., after GAS/ANQP round for Interworking)
  - \* added support for 256-bit AES with internal TLS implementation
  - \* allow peer to propose channel in P2P invitation process for a persistent group
  - \* added disallow\_aps parameter to allow BSSIDs/SSIDs to be disallowed from network selection
  - \* re-enable the networks disabled during WPS operations
  - \* allow P2P functionality to be disabled per interface (p2p\_disabled=1)
  - \* added secondary device types into P2P\_PEER output
  - \* added an option to disable use of a separate P2P group interface
- (p2p\_no\_group\_iface=1)
- \* fixed P2P Bonjour SD to match entries with both compressed and not compressed domain name format and support multiple Bonjour PTR matches for the same key
  - \* use deauthentication instead of disassociation for all disconnection operations; this removes the now unused disassociate() wpa\_driver\_ops callback
  - \* optimized PSK generation on P2P GO by caching results to avoid multiple PBKDF2 operations
  - \* added okc=1 global configuration parameter to allow OKC to be enabled by default for all network blocks
  - \* added a workaround for WPS PBC session overlap detection to avoid interop issues with deployed station implementations that do not remove active PBC indication from Probe Request frames properly
  - \* added basic support for 60 GHz band
  - \* extend EAPOL frames processing workaround for roaming cases (postpone processing of unexpected EAPOL frame until association event to handle reordered events)

2012-05-10 - v1.0

- \* bsd: Add support for setting HT values in IFM\_MMASK.
- \* Delay STA entry removal until Deauth/Disassoc TX status in AP mode. This allows the driver to use PS buffering of Deauthentication and Disassociation frames when the STA is in power save sleep. Only available with drivers that provide TX status events for Deauth/Disassoc frames (nl80211).
- \* Drop oldest unknown BSS table entries first. This makes it less likely to hit connection issues in environments with huge number of visible APs.
- \* Add systemd support.
- \* Add support for setting the syslog facility from the config file at build time.
- \* atheros: Add support for IEEE 802.11w configuration.
- \* AP mode: Allow enable HT20 if driver supports it, by setting the config parameter ieee80211n.
- \* Allow AP mode to disconnect STAs based on low ACK condition (when the data connection is not working properly, e.g., due to the STA going outside the range of the AP). Disabled by default, enable by config option disassoc\_low\_ack.

\*

nl80211:

- Support GTK rekey offload.
- Support PMKSA candidate events. This adds support for RSN pre-authentication with nl80211 interface and drivers that handle roaming internally.
- \* dbus:
  - Add a DBus signal for EAP SM requests, emitted on the Interface object.
  - Export max scan sids supported by the driver as MaxScanSSID.
  - Add signal Certification for information about server certification.
  - Add BSSExpireAge and BSSExpireCount interface properties and support set/get, which allows for setting BSS cache expiration age and expiration scan count.
  - Add ConfigFile to AddInterface properties.
  - Add Interface.Country property and support to get/set the value.
  - Add DBus property CurrentAuthMode.
  - P2P DBus API added.
  - Emit property changed events (for property BSSs) when adding/removing BSSs.
  - Treat " in SSIDs of Interface.Scan as a request for broadcast scan, instead of ignoring it.
  - Add DBus getter/setter

for FastReauth.

- Raise PropertiesChanged on org.freedesktop.DBus.Properties.

\* wpa\_cli:



- Send AP-STA-DISCONNECTED event when an AP disconnects a station due to inactivity.
  - Make second argument to set command optional. This can be used to indicate a zero length value.
  - Add signal\_poll command.
  - Add bss\_expire\_age and bss\_expire\_count commands to set/get BSS cache expiration age and expiration scan count.
  - Add ability to set scan interval (the time in seconds wpa\_s waits before requesting a new scan after failing to find a suitable network in scan results) using scan\_interval command.
  - Add event CTRL-EVENT-ASSOC-REJECT for association rejected.
  - Add command get version, that returns wpa\_supplicant version string.
  - Add command sta\_autoconnect for disabling automatic reconnection on receiving disconnection event.
  - Setting bssid parameter to an empty string "" or any can now be used to clear the bssid\_set flag in a network block, i.e., to remove bssid filtering.
  - Add tdls\_testing command to add a special testing feature for changing TDLS behavior. Build param CONFIG\_TDLS\_TESTING must be enabled as well.
  - For interworking, add wpa\_cli commands interworking\_select, interworking\_connect, anqp\_get, fetch\_anqp, and stop\_fetch\_anqp.
  - Many P2P commands were added. See README-P2P.
  - Many WPS/WPS ER commands - see WPS/WPS ER sections for details.
  - Allow set command to change global config parameters.
  - Add log\_level command, which can be used to display the current debugging level and to change the log level during run time.
  - Add note command, which can be used to insert notes to the debug log.
  - Add internal line edit implementation. CONFIG\_WPA\_CLI\_EDIT=y can now be used to build wpa\_cli with internal implementation of line editing and history support. This can be used as a replacement for CONFIG\_READLINE=y.
- \* AP mode:
- Add max\_num\_sta config option, which can be used to limit the number of stations allowed to connect to the AP.
- \* Add WPA\_IGNORE\_CONFIG\_ERRORS build option to continue in case of bad config file.
- \* wext: Increase scan timeout from 5 to 10 seconds.
- \* Add blacklist command, allowing an external program to manage the BSS blacklist and display its current contents.
- \* WPS:
- Add wpa\_cli wps\_pin get command for generating random PINs. This can be used in a UI to generate a PIN without starting WPS (or P2P) operation.
  - Set RF bands based on driver capabilities, instead of hardcoding them.

- Add mechanism for indicating non-standard WPS errors.
  - Add CONFIG\_WPS\_REG\_DISABLE\_OPEN=y option to disable open networks by default.
  - Add wps\_ap\_pin cli command for wpa\_supplicant AP mode.
  - Add wps\_check\_pin cli command for processing PIN from user input. UIs can use this command to process a PIN entered by a user and to validate the checksum digit (if present).
  - Cancel WPS operation on PBC session overlap detection.
  - New wps\_cancel command in wpa\_cli will cancel a pending WPS operation.
  - wpa\_cli action: Add WPS\_EVENT\_SUCCESS and WPS\_EVENT\_FAIL handlers.
  - Trigger WPS config update on Manufacturer, Model Name, Model Number, and Serial Number changes.
  - Fragment size is now configurable for EAP-WSC peer. Use wpa\_cli set wps\_fragment\_size <val>.
  - Disable AP PIN after 10 consecutive failures. Slow down attacks on failures up to 10.
  - Allow AP to start in Enrollee mode without AP PIN for probing, to be compatible with Windows 7.
  - Add Config Error into WPS-FAIL events to provide more info to the user on how to resolve the issue.
  - Label and Display config methods are not allowed to be enabled at the same time, since it is unclear which PIN to use if both methods are advertised.
  - When controlling multiple interfaces:
    - apply WPS commands to all interfaces
- configured to use WPS
- apply WPS config changes to all interfaces that use WPS
  - when an attack is detected on any interface, disable AP PIN on all interfaces
- \* WPS ER:
- Add special AP Setup Locked mode to allow read only ER. ap\_setup\_locked=2 can now be used to enable a special mode where WPS ER can learn the current AP settings, but cannot change them.
  - Show SetSelectedRegistrar events as ctrl\_iface events
  - Add wps\_er\_set\_config to enroll a network based on a local network configuration block instead of having to (re-)learn the current AP settings with wps\_er\_learn.
  - Allow AP filtering based on IP address, add ctrl\_iface event for learned AP settings, add wps\_er\_config command to configure an AP.
- \* WPS 2.0: Add support for WPS 2.0 (CONFIG\_WPS2)
- Add build option CONFIG\_WPS\_EXTENSIBILITY\_TESTING to enable tool for testing protocol extensibility.
  - Add build option CONFIG\_WPS\_STRICT to allow disabling of
- WPS
- workarounds.
  - Add support for AuthorizedMACs attribute.

- \* TDLS:
  - Propagate TDLS related nl80211 capability flags from kernel and add them as driver capability flags. If the driver doesn't support capabilities, assume TDLS is supported internally. When TDLS is explicitly not supported, disable all user facing TDLS operations.
  - Allow TDLS to be disabled at runtime (mostly for testing).  
Use set tdfs\_disabled.
  - Honor AP TDLS settings that prohibit/allow TDLS.
  - Add a special testing feature for changing TDLS behavior. Use CONFIG\_TDLS\_TESTING build param to enable. Configure at runtime with tdfs\_testing cli command.
  - Add support for TDLS 802.11z.
- \* wlandtest: Add a tool wlandtest for IEEE802.11 protocol testing.  
wlandtest can be used to capture frames from a monitor interface for realtime capturing or from pcap files for offline analysis.
- \* Interworking: Support added for 802.11u. Enable in .config with CONFIG\_INTERWORKING.  
See wpa\_supplicant.conf for config parameters  
for interworking. wpa\_cli commands added to support this are interworking\_select, interworking\_connect, anqp\_get, fetch\_anqp, and stop\_fetch\_anqp.
- \* Android: Add build and runtime support for Android wpa\_supplicant.
- \* bgscan learn: Add new bgscan that learns BSS information based on previous scans, and uses that information to dynamically generate the list of channels for background scans.
- \* Add a new debug message level for excessive information. Use -ddd to enable.
- \* TLS: Add support for tls\_disable\_time\_checks=1 in client mode.
- \* Internal TLS:
  - Add support for TLS v1.1 (RFC 4346). Enable with build parameter CONFIG\_TLSV11.
  - Add domainComponent parser for X.509 names.
- \* Linux: Add RFKill support by adding an interface state "disabled".
- \* Reorder some IEs to get closer to IEEE 802.11 standard. Move WMM into end of Beacon, Probe Resp and (Re)Assoc Resp frames.  
Move HT IEs to be later in (Re)Assoc Resp.
- \* Solaris: Add support for wired 802.1X client.
- \* Wi-Fi Direct support. See README-P2P for more information.
- \* Many bugfixes.

2010-04-18 - v0.7.2

- \* nl80211: fixed number of issues with roaming
- \* avoid unnecessary roaming if multiple APs with similar signal strength are present in scan results
- \* add TLS client events and server probing to ease design of automatic detection of EAP parameters
- \* add option for server certificate matching (SHA256 hash of the

- certificate) instead of trusted CA certificate configuration
- \* `bsd`: Cleaned up driver wrapper and added various low-level configuration options
- \* `wpa_gui-qt4`: do not show too frequent WPS AP available events as tray messages
- \* `TNC`: fixed issues with fragmentation
- \* `EAP-TNC`: add `Flags` field into fragment acknowledgement (needed to interoperate with other implementations; may potentially breaks compatibility with older `wpa_supplicant`/`hostapd` versions)
- \* `wpa_cli`: added option for using a separate process to receive event messages to reduce latency in showing these  
(`CFLAGS += -DCONFIG_WPA_CLI_FORK=y` in `.config` to enable this)
- \* maximum BSS table size can now be configured (`bss_max_count`)
- \* BSSes to be included in the BSS table can be filtered based on configured SSIDs to save memory (`filter_ssids`)
- \* fix number of issues with IEEE 802.11r/FT; this version is not backwards compatible with old versions
- \* `nl80211`: add support for IEEE 802.11r/FT protocol (both over-the-air and over-the-DS)
- \* add `freq_list` network configuration parameter to allow the AP selection to filter out entries based on the operating channel
- \* add signal strength change events for `bgscan`; this allows more dynamic changes to background scanning interval based on changes in the signal strength with the current AP; this improves roaming within ESS quite a bit, e.g., with `bgscan="simple:30:-45:300"` in the network configuration block to request background scans less frequently when signal strength remains good and to automatically trigger background scans whenever signal strength drops noticeably  
(this is currently only available with `nl80211`)
- \* add BSSID and reason code (if available) to disconnect event messages
- \* `wpa_gui-qt4`: more complete support for translating the GUI with `linguist` and add German translation
- \* fix DH padding with internal crypto code (mainly, for WPS)
- \* do not trigger initial scan automatically anymore if there are no enabled networks

2010-01-16 - v0.7.1

- \* cleaned up driver wrapper API (`struct wpa_driver_ops`); the new API is not fully backwards compatible, so out-of-tree driver wrappers will need modifications
- \* cleaned up various module interfaces
- \* merge `hostapd` and `wpa_supplicant` developers' documentation into a single document
- \* `nl80211`: use explicit deauthentication to clear `cfg80211` state to avoid issues when roaming between APs
- \* `dbus`: major design changes in the new D-Bus API

(fi.w1.wpa\_supplicant1)

\*

nl80211: added support for IBSS networks

\* added internal debugging mechanism with backtrace support and memory allocation/freeing validation, etc. tests (CONFIG\_WPA\_TRACE=y)

\* added WPS ER unsubscription command to more cleanly unregister from receiving UPnP events when ER is terminated

\* cleaned up AP mode operations to avoid need for virtual driver\_ops wrapper

\* added BSS table to maintain more complete scan result information over multiple scans (that may include only partial results)

\* wpa\_gui-qt4: update Peers dialog information more dynamically while the dialog is kept open

\* fixed PKCS#12 use with OpenSSL 1.0.0

\* driver\_wext: Added cfg80211-specific optimization to avoid some unnecessary scans and to speed up association

2009-11-21 - v0.7.0

\* increased wpa\_cli ping interval to 5 seconds and made this configurable with a new command line options (-G<seconds>)

\* fixed scan buffer processing with WEXT to handle up to 65535 byte result

buffer (previously, limited to 32768 bytes)

\* allow multiple driver wrappers to be specified on command line (e.g., -Dnl80211,wext); the first one that is able to initialize the interface will be used

\* added support for multiple SSIDs per scan request to optimize scan\_ssid=1 operations in ap\_scan=1 mode (i.e., search for hidden SSIDs); this requires driver support and can currently be used only with nl80211

\* added support for WPS USB-A out-of-band mechanism with USB Flash Drives (UFD) (CONFIG\_WPS\_UFD=y)

\* driver\_ndis: add PAE group address to the multicast address list to fix wired IEEE 802.1X authentication

\* fixed IEEE 802.11r key derivation function to match with the standard (note: this breaks interoperability with previous version) [Bug 303]

\* added better support for drivers that allow separate authentication and association commands (e.g., mac80211-based Linux drivers with nl80211; SME in wpa\_supplicant); this allows over-the-air FT protocol

to be used (IEEE 802.11r)

\* fixed SHA-256 based key derivation function to match with the standard when using CCMP (for IEEE 802.11r and IEEE 802.11w) (note: this breaks interoperability with previous version) [Bug 307]

\* use shared driver wrapper files with hostapd

\* added AP mode functionality (CONFIG\_AP=y) with mode=2 in the network block; this can be used for open and WPA2-Personal networks (optionally, with WPS); this links in parts of hostapd functionality

into wpa\_supplicant

- \* wpa\_gui-qt4: added new Peers dialog to show information about peers (other devices, including APs and stations, etc. in the neighborhood)
- \* added support for WPS External Registrar functionality (configure APs and enroll new devices); can be used with wpa\_gui-qt4 Peers dialog and wpa\_cli commands wps\_er\_start, wps\_er\_stop, wps\_er\_pin, wps\_er\_pbc, wps\_er\_learn (this can also be used with a new 'none' driver wrapper if no wireless device or IEEE 802.1X on wired is needed)
- \* driver\_nl80211: multiple updates to provide support for new Linux nl80211/mac80211 functionality
- \* updated management frame protection to use IEEE Std 802.11w-2009
- \* fixed number of small WPS issues and added workarounds to interoperate with common deployed broken implementations
- \* added support for NFC out-of-band mechanism with WPS
- \* driver\_ndis: fixed wired IEEE 802.1X authentication with PAE group address frames
- \* added preliminary support for IEEE 802.11r RIC processing
- \* added support for specifying subset of enabled frequencies to scan (scan\_freq option in the network configuration block); this can speed up scanning process considerably if it is known that only a small subset of channels is actually used in the network (this is currently supported only with -Dnl80211)
- \* added a workaround for race condition between receiving the association event and the following EAPOL-Key
- \* added background scan and roaming infrastructure to allow network-specific optimizations to be used to improve roaming within an ESS (same SSID)
- \* added new DBus interface (fi.w1.wpa\_supplicant1)

2009-01-06 - v0.6.7

- \* added support for Wi-Fi Protected Setup (WPS) (wpa\_supplicant can now be configured to act as a WPS Enrollee to enroll credentials for a network using PIN and PBC methods; in addition, wpa\_supplicant can act as a wireless WPS Registrar to configure an AP); WPS support can be enabled by adding CONFIG\_WPS=y into .config and setting the runtime configuration variables in wpa\_supplicant.conf (see WPS section in the example configuration file); new wpa\_cli commands wps\_pin, wps\_pbc, and wps\_reg are used to manage WPS negotiation; see README-WPS for more details
- \* added support for EAP-AKA' (draft-arkko-eap-aka-kdf)
- \* added support for using driver\_test over UDP socket
- \* fixed PEAPv0 Cryptobinding interoperability issue with Windows Server 2008 NPS; optional cryptobinding is now enabled (again) by default
- \* fixed PSK editing in wpa\_gui

- \* changed EAP-GPSK to use the IANA assigned EAP method type 51
- \* added a Windows installer that includes WinPcap and all the needed DLLs; in addition, it set up the registry automatically so that user will only need start wpa\_gui to get prompted to start the wpasvc servide and add a new interface if needed through wpa\_gui dialog
- \* updated management frame protection to use IEEE 802.11w/D7.0

2008-11-23 - v0.6.6

- \* added Milenage SIM/USIM emulator for EAP-SIM/EAP-AKA (can be used to simulate test SIM/USIM card with a known private key; enable with CONFIG\_SIM\_SIMULATOR=y/CONFIG\_USIM\_SIMULATOR=y in .config and password="Ki:OPc"/password="Ki:OPc:SQN" in network configuration)
- \* added a new network configuration option, wpa\_ptk\_rekey, that can be used to enforce frequent PTK rekeying, e.g., to mitigate some attacks against TKIP deficiencies
- \* added an optional mitigation mechanism for certain attacks against TKIP by delaying Michael MIC error reports by a random amount of time between 0 and 60 seconds; this can be enabled with a build option CONFIG\_DELAYED\_MIC\_ERROR\_REPORT=y in .config
- \* fixed EAP-AKA to use RES Length field in AT\_RES as length in bits, not bytes
- \* updated OpenSSL code for EAP-FAST to use an updated version of the session ticket overriding API that was included into the upstream OpenSSL 0.9.9 tree on 2008-11-15 (no additional OpenSSL patch is needed with that version anymore)
- \* updated userspace MLME instructions to match with the current Linux mac80211 implementation; please also note that this can only be used with driver\_nl80211.c (the old code from driver\_wext.c was removed)
- \* added support (Linux only) for RoboSwitch chipsets (often found in consumer grade routers); driver interface 'roboswitch'
- \* fixed canceling of PMKSA caching when using drivers that generate RSN IE and refuse to drop PMKIDs that wpa\_supplicant does not know about

2008-11-01

- v0.6.5

- \* added support for SHA-256 as X.509 certificate digest when using the internal X.509/TLSv1 implementation
- \* updated management frame protection to use IEEE 802.11w/D6.0
- \* added support for using SHA256-based stronger key derivation for WPA2 (IEEE 802.11w)
- \* fixed FT (IEEE 802.11r) authentication after a failed association to use correct FTIE
- \* added support for configuring Phase 2 (inner/tunneled) authentication method with wpa\_gui-qt4

2008-08-10 - v0.6.4

- \* added support for EAP Sequences in EAP-FAST Phase 2
- \* added support for using TNC with EAP-FAST
- \* added driver\_ps3 for the PS3 Linux wireless driver
- \* added support for optional cryptobinding with PEAPv0
- \* fixed the OpenSSL patches (0.9.8g and 0.9.9) for EAP-FAST to allow fallback to full handshake if server rejects PAC-Opaque
- \* added fragmentation support for EAP-TNC
- \* added support for parsing PKCS #8 formatted private keys into the internal TLS implementation (both PKCS #1 RSA key and PKCS #8 encapsulated RSA key can now be used)
- \* added option of using faster, but larger, routines in the internal LibTomMath (for internal TLS implementation) to speed up DH and RSA calculations (CONFIG\_INTERNAL\_LIBTOMMATH\_FAST=y)
- \* fixed race condition between disassociation event and group key handshake to avoid getting stuck in incorrect state [Bug 261]
- \* fixed opportunistic key caching (proactive\_key\_caching)

2008-02-22 - v0.6.3

- \* removed 'nai' and 'eappsk' network configuration variables that were previously used for configuring user identity and key for EAP-PSK, EAP-PAX, EAP-SAKE, and EAP-GPSK. 'identity' field is now used as the replacement for 'nai' (if old configuration used a separate 'identity' value, that would now be configured as 'anonymous\_identity'). 'password' field is now used as the replacement for 'eappsk' (it can also be set using hexstring to present random binary data)
- \* removed '-w' command line parameter (wait for interface to be added, if needed); cleaner way of handling this functionality is to use an external mechanism (e.g., hotplug scripts) that start wpa\_supplicant when an interface is added
- \* updated FT support to use the latest draft, IEEE 802.11r/D9.0
- \* added ctrl\_iface monitor event (CTRL-EVENT-SCAN-RESULTS) for indicating when new scan results become available
- \* added new ctrl\_iface command, BSS, to allow scan results to be fetched without hitting the message size limits (this command can be used to iterate through the scan results one BSS at the time)
- \* fixed EAP-SIM not to include AT\_NONCE\_MT and AT\_SELECTED\_VERSION attributes in EAP-SIM Start/Response when using fast reauthentication
- \* fixed EAPOL not to end up in infinite loop when processing dynamic WEP keys with IEEE 802.1X
- \* fixed problems in getting NDIS events from WMI on Windows 2000

2008-01-01 - v0.6.2

- \* added support for Makefile builds to include debug-log-to-a-file functionality (CONFIG\_DEBUG\_FILE=y)



and -f<path> on command line)

- \* fixed EAP-SIM and EAP-AKA message parser to validate attribute lengths properly to avoid potential crash caused by invalid messages
- \* added data structure for storing allocated buffers (struct wpabuf); this does not affect wpa\_supplicant usage, but many of the APIs changed and various interfaces (e.g., EAP) is not compatible with old versions
- \* added support for protecting EAP-AKA/Identity messages with AT\_CHECKCODE (optional feature in RFC 4187)
- \* added support for protected result indication with AT\_RESULT\_IND for EAP-SIM and EAP-AKA (phase1="result\_ind=1")
- \* added driver\_wext workaround for race condition between scanning and association with drivers that take very long time to scan all channels (e.g., madwifi with dual-band cards); wpa\_supplicant is now using a longer hardcoded timeout for the scan if the driver supports notifications for scan completion (SIOCGIWSCAN event); this helps, e.g., in cases where wpa\_supplicant and madwifi driver ended up in loop where the driver did not even try to associate
- \* stop EAPOL timer tick when no timers are in use in order to reduce power consumption (no need to wake up the process once per second) [Bug 237]
- \* added support for privilege separation (run only minimal part of wpa\_supplicant functionality as root and rest as unprivileged, non-root process); see 'Privilege separation' in README for details; this is disabled by default and can be enabled with CONFIG\_PRIVSEP=y in .config
- \* changed scan results data structure to include all information elements to make it easier to support new IEs; old get\_scan\_result() driver\_ops is still supported for backwards compatibility (results are converted internally to the new format), but all drivers should start using the new get\_scan\_results2() to make them more likely to work with new features
- \* Qt4 version of wpa\_gui (wpa\_gui-qt4 subdirectory) is now native Qt4 application, i.e., it does not require Qt3Support anymore; Windows binary of wpa\_gui.exe is now from this directory and only requires QtCore4.dll and QtGui4.dll libraries
- \* updated Windows binary build to use Qt 4.3.3 and made Qt DLLs available as a separate package to make wpa\_gui installation easier: [http://w1.fi/wpa\\_supplicant/qt4/wpa\\_gui-qt433-windows-dll.zip](http://w1.fi/wpa_supplicant/qt4/wpa_gui-qt433-windows-dll.zip)
- \* added support for EAP-IKEv2 (draft-tschofenig-eap-ikev2-15.txt); only shared key/password authentication is supported in this version

2007-11-24 - v0.6.1

- \* added support for configuring password as NtPasswordHash (16-byte MD4 hash of password) in hash:<32 hex digits> format
- \* added support for fallback from abbreviated TLS handshake to

- full handshake when using EAP-FAST (e.g., due to an expired PAC-Opaque)
- \* updated EAP Generalized Pre-Shared Key (EAP-GPSK) to use the latest draft (draft-ietf-emu-eap-gpsk-07.txt)
- \* added support for drivers that take care of RSN 4-way handshake internally  
(WPA\_DRIVER\_FLAGS\_4WAY\_HANDSHAKE in get\_capa flags and WPA\_ALG\_PMK in set\_key)
- \* added an experimental port for Mac OS X (CONFIG\_DRIVER\_OSX=y in .config); this version supports only ap\_scan=2 mode and allow the driver to take care of the 4-way handshake
- \* fixed a buffer overflow in parsing TSF from scan results when using driver\_wext.c with a driver that includes the TSF (e.g., iw14965) [Bug 232]
- \* updated FT support to use the latest draft, IEEE 802.11r/D8.0
- \* fixed an integer overflow issue in the ASN.1 parser used by the (experimental) internal TLS implementation to avoid a potential buffer read overflow
- \* fixed a race condition with -W option (wait for a control interface monitor before starting) that could have caused the first messages to be lost
- \* added support for processing TNCC-TNCS-Messages to report recommendation (allow/none/isolate) when using TNC [Bug 243]

2007-05-28 - v0.6.0

- \* added network configuration parameter 'frequency' for setting initial channel for IBSS (ad hoc) networks
- \* added experimental IEEE 802.11r/D6.0 support
- \* updated EAP-SAKE to RFC 4763 and the IANA-allocated EAP type 48
- \* updated EAP-PSK to use the IANA-allocated EAP type 47
- \* fixed EAP-PAX key derivation
- \* fixed EAP-PSK bit ordering of the Flags field
- \* fixed EAP-PEAP/TTLS/FAST to use the correct EAP identifier in tunnelled identity request (previously, the identifier from the outer method was used, not the tunnelled identifier which could be different)
- \* added support for fragmentation of outer TLS packets during Phase 2 of EAP-PEAP/TTLS/FAST
- \* fixed EAP-TTLS AVP parser processing for too short AVP lengths
- \* added support for EAP-FAST authentication with inner methods that generate MSK (e.g., EAP-MSCHAPv2 that was previously only supported for PAC provisioning)
- \* added support for authenticated EAP-FAST provisioning
- \* added support for configuring maximum number of EAP-FAST PACs to store in a PAC list (fast\_max\_pac\_list\_len=<max> in phase1 string)
- \* added support for storing EAP-FAST PACs in binary format

(fast\_pac\_format=binary in phase1 string)

- \* fixed dbus ctrl\_iface to validate message interface before dispatching to avoid a possible segfault [Bug 190]
- \* fixed PeerKey key derivation to use the correct PRF label
- \* updated Windows binary build to link against OpenSSL 0.9.8d and added support for EAP-FAST
- \* updated EAP Generalized Pre-Shared Key (EAP-GPSK) to use the latest draft (draft-ietf-emu-eap-gpsk-04.txt)
- \* fixed EAP-AKA Notification processing to allow Notification to be processed after AKA Challenge response has been sent
- \* updated to use IEEE 802.11w/D2.0 for management frame protection (still experimental)
- \* fixed EAP-TTLS implementation not to crash on use of freed memory if TLS library initialization fails
- \* added support for EAP-TNC (Trusted Network Connect) (this version implements the EAP-TNC method and EAP-TTLS changes needed to run two methods in sequence (IF-T) and the IF-IMC and IF-TNCCS interfaces from TNCC)

2006-11-24 - v0.5.6

- \* added experimental, integrated TLSv1 client implementation with the needed X.509/ASN.1/RSA/bigint processing (this can be enabled by setting CONFIG\_TLS=internal and CONFIG\_INTERNAL\_LIBTOMMATH=y in .config); this can be useful, e.g., if the target system does not have a suitable TLS library and a minimal code size is required (total size of this internal TLS/crypto code is bit under 50 kB on x86 and the crypto code is shared by rest of the supplicant so some of it was already required; TLSv1/X.509/ASN.1/RSA added about 25 kB)
- \* removed STAKey handshake since PeerKey handshake has replaced it in IEEE 802.11ma and there are no known deployments of STAKey
- \* updated EAP Generalized Pre-Shared Key (EAP-GPSK) to use the latest draft (draft-ietf-emu-eap-gpsk-01.txt)
- \* added preliminary implementation of IEEE 802.11w/D1.0 (management frame protection)  
(Note:  
this requires driver support to work properly.)  
(Note2: IEEE 802.11w is an unapproved draft and subject to change.)
- \* fixed Windows named pipes ctrl\_iface to not stop listening for commands if client program opens a named pipe and closes it immediately without sending a command
- \* fixed USIM PIN status determination for the case that PIN is not needed (this allows EAP-AKA to be used with USIM cards that do not use PIN)
- \* added support for reading 3G USIM AID from EF\_DIR to allow EAP-AKA to be used with cards that do not support file selection based on partial AID
- \* added support for matching the subjectAltName of the authentication

server certificate against multiple name components (e.g.,  
altsubject\_match="DNS:server.example.com;DNS:server2.example.com")

- \* fixed EAP-SIM/AKA key derivation for re-authentication case (only affects IEEE 802.1X with dynamic WEP keys)
- \* changed ctrl\_iface network configuration 'get' operations to not return password/key material; if these fields are requested, "\*" will be returned if the password/key is set, but the value of the parameter is not exposed

2006-08-27 - v0.5.5

- \* added support for building Windows version with UNICODE defined (wide-char functions)
- \* driver\_ndis: fixed static WEP configuration to avoid race condition issues with some NDIS drivers between association and setting WEP keys
- \* driver\_ndis: added validation for IELength value in scan results to avoid crashes when using buggy NDIS drivers [Bug 165]
- \* fixed Release|Win32 target in the Visual Studio project files (previously, only Debug|Win32 target was set properly)
- \* changed control interface API call wpa\_ctrl\_pending() to allow it to return -1 on error (e.g., connection lost); control interface clients will need to make sure that they verify that the value is indeed >0 when determining whether there are pending messages
- \* added an alternative control interface backend for Windows targets:

Named Pipe (CONFIG\_CTRL\_IFACE=named\_pipe); this is now the default control interface mechanism for Windows builds (previously, UDP to localhost was used)

- \* changed ctrl\_interface configuration for UNIX domain sockets:
  - deprecated ctrl\_interface\_group variable (it may be removed in future versions)
  - allow both directory and group be configured with ctrl\_interface in following format: DIR=/var/run/wpa\_supplicant GROUP=wheel
  - ctrl\_interface=/var/run/wpa\_supplicant is still supported for the case when group is not changed
- \* added support for controlling more than one interface per process in Windows version
- \* added a workaround for a case where the AP is using unknown address (e.g., MAC address of the wired interface) as the source address for EAPOL-Key frames; previously, that source address was used as the destination for EAPOL-Key frames and in key derivation; now, BSSID is used even if the source address does not match with it

(this resolves an interoperability issue with Thomson SpeedTouch 580)

- \* added a workaround for UDP-based control interface (which was used in Windows builds before this release) to prevent packets with forged addresses from being accepted as local control requests

- \* removed ndis\_events.cpp and possibility of using external ndis\_events.exe; C version (ndis\_events.c) is fully functional and there is no desire to maintain two separate versions of this implementation
- \* ndis\_events: Changed NDIS event notification design to use WMI to learn the adapter description through Win32\_PnPEntity class; this should fix some cases where the adapter name was not recognized correctly (e.g., with some USB WLAN adapters, e.g., Ralink RT2500 USB) [Bug 113]
- \* fixed selection of the first network in ap\_scan=2 mode; previously, wpa\_supplicant could get stuck in SCANNING state when only the first network for enabled (e.g., after 'wpa\_cli select\_network 0')
- \* winsvc: added support for configuring ctrl\_interface parameters in registry (ctrl\_interface string value in HKLM\SOFTWARE\wpa\_supplicant\interfaces\0000 key); this new value is required to enable control interface (previously, this was hardcoded to be enabled)
- \* allow wpa\_gui subdirectory to be built with both Qt3 and Qt4
- \* converted wpa\_gui-qt4 subdirectory to use Qt4 specific project format

2006-06-20 - v0.5.4

- \* fixed build with CONFIG\_STAKEY=y [Bug 143]
- \* added support for doing MLME (IEEE 802.11 management frame processing) in wpa\_supplicant when using Devicescape IEEE 802.11 stack (wireless-dev.git tree)
- \* added a new network block configuration option, fragment\_size, to configure the maximum EAP fragment size
- \* driver\_ndis: Disable WZC automatically for the selected interface to avoid conflicts with two programs trying to control the radio; WZC will be re-enabled (if it was enabled originally) when wpa\_supplicant is terminated
- \* added an experimental TLSv1 client implementation (CONFIG\_TLS=internal) that can be used instead of an external TLS library, e.g., to reduce total size requirement on systems that do not include any TLS library by default (this is not yet complete; basic functionality is there, but certificate validation is not yet included)
- \* added PeerKey handshake implementation for IEEE 802.11e direct link setup (DLS) to replace STAKEy handshake
- \* fixed WPA PSK update through ctrl\_iface for the case where the old PSK was derived from an ASCII passphrase and the new PSK is set as a raw PSK (hex string)
- \* added new configuration option for identifying which network block was used (id\_str in wpa\_supplicant.conf; included on WPA\_EVENT\_CONNECT monitor event and as WPA\_ID\_STR environmental variable in wpa\_cli action scripts; in addition WPA\_ID variable is

set to the current unique identifier that wpa\_supplicant assigned automatically for the network and that can be used with GET\_NETWORK/SET\_NETWORK ctrl\_iface commands)

- \* wpa\_cli action script is now called only when the connect/disconnect status changes or when associating with a different network
- \* fixed configuration parser not to remove CCMP from group cipher list if WPA-None (adhoc) is used (pairwise=NONE in that case)
- \* fixed integrated NDIS events processing not to hang the process due to a missed change in eloop\_win.c API in v0.5.3 [Bug 155]
- \* added support for EAP Generalized Pre-Shared Key (EAP-GPSK, draft-clancy-emu-eap-shared-secret-00.txt)
- \* added Microsoft Visual Studio 2005 solution and project files for build wpa\_supplicant for Windows (see vs2005 subdirectory)
- \* eloop\_win: fixed unregistration of Windows events
- \* l2\_packet\_winpcap: fixed a deadlock in deinitializing l2\_packet at the end of RSN pre-authentication and added unregistration of a Windows event to avoid getting eloop\_win stuck with an invalid handle
- \* driver\_ndis: added support for selecting AP based on BSSID
- \*

added new environmental variable for wpa\_cli action scripts:

WPA\_CTRL\_DIR is the current control interface directory

- \* driver\_ndis: added support for using NDISUIO instead of WinPcap for OID set/query operations (CONFIG\_USE\_NDISUIO=y in .config); with new l2\_packet\_ndis (CONFIG\_L2\_PACKET=ndis), this can be used to build wpa\_supplicant without requiring WinPcap; note that using NDISUIO requires that WZC is disabled (net stop wzcsvc) since NDISUIO allows only one application to open the device
- \* changed NDIS driver naming to only include device GUID, e.g., {7EE3EFE5-C165-472F-986D-F6FBEDFE8C8D}, instead of including WinPcap specific \Device\NPF\_ prefix before the GUID; the prefix is still allowed for backwards compatibility, but it is not required anymore when specifying the interface
- \* driver\_ndis: re-initialize driver interface is the adapter is removed and re-inserted [Bug 159]
- \* driver\_madwifi: fixed TKIP and CCMP sequence number configuration on big endian hosts [Bug 146]

2006-04-27 - v0.5.3

- \* fixed EAP-GTC response to include correct user identity when run as phase 2 method of EAP-FAST (i.e., EAP-FAST did not work in v0.5.2)
- \* driver\_ndis: Fixed encryption mode configuration for unencrypted networks (some NDIS drivers ignored this, but others, e.g., Broadcom, refused to associate with open networks) [Bug 106]
- \* driver\_ndis: use BSSID OID polling to detect when IBSS network is formed even when ndis\_events code is included since some NDIS drivers

- do not generate media connect events in IBSS mode
- \* config\_winreg: allow global ctrl\_interface parameter to be configured in Windows registry
- \* config\_winreg: added support for saving configuration data into Windows registry
- \* added support for controlling network device operational state (dormant/up) for Linux 2.6.17 to improve DHCP processing (see <http://www.flamewarmaster.de/software/dhclient/> for a DHCP client that can use this information)
- \*
- driver\_wext: added support for WE-21 change to SSID configuration
- \* driver\_wext: fixed privacy configuration for static WEP keys mode [Bug 140]
- \* added an optional driver\_ops callback for MLME-SETPROTECTION.request primitive
- \* added support for EAP-SAKE (no EAP method number allocated yet, so this is using the same experimental type 255 as EAP-PSK)
- \* added support for dynamically loading EAP methods (.so files) instead of requiring them to be statically linked in; this is disabled by default (see CONFIG\_DYNAMIC\_EAP\_METHODS in defconfig for information on how to use this)

2006-03-19 - v0.5.2

- \* do not try to use USIM APDUs when initializing PC/SC for SIM card access for a network that has not enabled EAP-AKA
- \* fixed EAP phase 2 Nak for EAP-{PEAP,TTLS,FAST} (this was broken in v0.5.1 due to the new support for expanded EAP types)
- \* added support for generating EAP Expanded Nak
- \* try to fetch scan results once before requesting new scan when starting up in ap\_scan=1 mode (this can speed up initial association a lot with, e.g., madwifi-ng driver)
- \* added support for receiving EAPOL frames from a Linux bridge interface (-bbr0 on command line)
- \* fixed EAPOL re-authentication for sessions that used PMKSA caching
- \* changed EAP method registration to use a dynamic list of methods instead of a static list generated at build time
- \* fixed PMKSA cache deinitialization not to use freed memory when removing PMKSA entries
- \* fixed a memory leak in EAP-TTLS re-authentication
- \* reject WPA/WPA2 message 3/4 if it does not include any valid WPA/RSN IE
- \* driver\_wext: added fallback to use SIOCSIWENCODER for setting auth\_alg if the driver does not support SIOCSIWAUTH

2006-01-29 - v0.5.1

- \* driver\_test: added better support for multiple APs and STAs by using a directory with sockets that include MAC address for each device in

the name (driver\_param=test\_dir=/tmp/test)

- \* added support for EAP expanded type (vendor specific EAP methods)
- \* added AP\_SCAN command into ctrl\_iface so that ap\_scan configuration option can be changed if needed
- \* wpa\_cli/wpa\_gui: skip non-socket files in control directory when using UNIX domain sockets; this avoids selecting an incorrect interface (e.g., a PID file could be in this directory, even though use of this directory for something else than socket files is not recommended)
- \* fixed TLS library deinitialization after RSN pre-authentication not to disable TLS library for normal authentication
- \* driver\_wext: Remove null-termination from SSID length if the driver used it; some Linux drivers do this and they were causing problems in wpa\_supplicant not finding matching configuration block. This change would break a case where the SSID actually ends in '\0', but that is not likely to happen in real use.
- \* fixed PMKSA cache processing not to trigger deauthentication if the current PMKSA cache entry is replaced with a valid new entry
- \*

fixed PC/SC initialization for ap\_scan != 1 modes (this fixes EAP-SIM and EAP-AKA with real SIM/USIM card when using ap\_scan=0 or ap\_scan=2)

2005-12-18 - v0.5.0 (beginning of 0.5.x development releases)

- \* added experimental STAKEy handshake implementation for IEEE 802.11e direct link setup (DLS); note: this is disabled by default in both build and runtime configuration (can be enabled with CONFIG\_STAKEY=y and stakey=1)
- \* fixed EAP-SIM and EAP-AKA pseudonym and fast re-authentication to decrypt AT\_ENCR\_DATA attributes correctly
- \* fixed EAP-AKA to allow resynchronization within the same session
- \* made code closer to ANSI C89 standard to make it easier to port to other C libraries and compilers
- \* started moving operating system or C library specific functions into wrapper functions defined in os.h and implemented in os\_\*.c to make code more portable
- \* wpa\_supplicant can now be built with Microsoft Visual C++ (e.g., with the freely available Toolkit 2003 version or Visual C++ 2005 Express Edition and Platform SDK); see nmake.mak for an example makefile for nmake
- \* added support for using Windows registry for command line parameters (CONFIG\_MAIN=main\_winsvc) and configuration data (CONFIG\_BACKEND=winreg); see win\_example.reg for an example registry contents; this version can be run both as a Windows service and as a normal application; 'wpasvc.exe app' to start as applicant, 'wpasvc.exe reg <full path to wpasvc.exe>' to register a service,



'net start wpa\_supplicant' to start the service, 'wpa\_supplicant.exe unreg' to unregister a service

- \* made it possible to link ndis\_events.exe functionality into wpa\_supplicant.exe by defining CONFIG\_NDIS\_EVENTS\_INTEGRATED
- \* added better support for multiple control interface backends (CONFIG\_CTRL\_IFACE option); currently, 'unix' and 'udp' are supported
- \* fixed PC/SC code to use correct length for GSM AUTH command buffer and to not use pioRecvPci with SCardTransmit() calls;

these were not causing visible problems with pcsc-lite, but Windows Wincard.dll refused the previously used parameters; this fixes EAP-SIM and EAP-AKA authentication using SIM/USIM card under Windows

- \* added new event loop implementation for Windows using WaitForMultipleObject() instead of select() in order to allow waiting for non-socket objects; this can be selected with CONFIG\_ELOOP=eloop\_win in .config
- \* added support for selecting l2\_packet implementation in .config (CONFIG\_L2\_PACKET; following options are available now: linux, pcap, winpcap, freebsd, none)
- \* added new l2\_packet implementation for WinPcap (CONFIG\_L2\_PACKET=winpcap) that uses a separate receive thread to reduce latency in EAPOL receive processing from about 100 ms to about 3 ms
- \* added support for EAP-FAST key derivation using other ciphers than RC4-128-SHA for authentication and AES128-SHA for provisioning
- \* added support for configuring CA certificate as DER file and as a configuration blob
- \* fixed private key configuration as configuration blob and added support for using PKCS#12 as a blob
- \* tls\_gnutls: added support for using PKCS#12 files; added support for session resumption
- \* added support for loading trusted CA certificates from Windows certificate store: ca\_cert="cert\_store://<name>", where <name> is likely CA (Intermediate CA certificates) or ROOT (root certificates)
- \* added C version of ndis\_events.cpp and made it possible to build this with MinGW so that CONFIG\_NDIS\_EVENTS\_INTEGRATED can be used more easily on cross-compilation builds
- \* added wpa\_supplicant.exe into Windows binary release; this is an alternative version of wpa\_supplicant.exe with configuration backend using Windows registry and with the entry point designed to run as a Windows service
- \* integrated ndis\_events.exe functionality into wpa\_supplicant.exe and wpa\_supplicant.exe and removed this additional tool from the Windows binary release since it is not needed anymore
- \* load wincard.dll functions dynamically when building with MinGW since MinGW does not yet include wincard library

2005-11-20 - v0.4.7 (beginning of 0.4.x stable releases)

- \* l2\_packet\_pcap: fixed wired IEEE 802.1X authentication with libpcap and WinPcap to receive frames sent to PAE group address
- \* disable EAP state machine when IEEE 802.1X authentication is not used in order to get rid of bogus "EAP failed" messages
- \* fixed OpenSSL error reporting to go through all pending errors to avoid confusing reports of old errors being reported at later point during handshake
- \* fixed configuration file updating to not write empty variables (e.g., proto or key\_mgmt) that the file parser would not accept
- \* fixed ADD\_NETWORK ctrl\_iface command to use the same default values for variables as empty network definitions read from config file would get
- \* fixed EAP state machine to not discard EAP-Failure messages in many cases (e.g., during TLS handshake)
- \*
- fixed a infinite loop in private key reading if the configured file cannot be parsed successfully
- \* driver\_madwifi: added support for madwifi-ng
- \* wpa\_gui: do not display password/PSK field contents
- \* wpa\_gui: added CA certificate configuration
- \* driver\_ndis: fixed scan request in ap\_scan=2 mode not to change SSID
- \* driver\_ndis: include Beacon IEs in AssocInfo in order to notice if the new AP is using different WPA/RSN IE
- \* use longer timeout for IEEE 802.11 association to avoid problems with drivers that may take more than five second to associate

2005-10-27 - v0.4.6

- \* allow fallback to WPA, if mixed WPA+WPA2 networks have mismatch in RSN IE, but WPA IE would match with wpa\_supplicant configuration
- \* added support for named configuration blobs in order to avoid having to use file system for external files (e.g., certificates); variables can be set to "blob://<blob name>" instead of file path to use a named blob; supported fields: pac\_file, client\_cert,

private\_key

- \* fixed RSN pre-authentication (it was broken in the clean up of WPA state machine interface in v0.4.5)
- \* driver\_madwifi: set IEEE80211\_KEY\_GROUP flag for group keys to make sure the driver configures broadcast decryption correctly
- \* added ca\_path (and ca\_path2) configuration variables that can be used to configure OpenSSL CA path, e.g., /etc/ssl/certs, for using the system-wide trusted CA list
- \* added support for starting wpa\_supplicant without a configuration file (-C argument must be used to set ctrl\_interface parameter for this case; in addition, -p argument can be used to provide driver\_param; these new arguments can also be used with a

configuration to override the values from the configuration)  
\* added global control interface that can be optionally used for adding and removing network interfaces dynamically (-g command line argument for both wpa\_supplicant and wpa\_cli) without having to restart wpa\_supplicant process

\*

wpa\_gui:

- try to save configuration whenever something is modified
- added WEP key configuration
- added possibility to edit the current network configuration
- \* driver\_ndis: fixed driver polling not to increase frequency on each received EAPOL frame due to incorrectly cancelled timeout
- \* added simple configuration file examples (in examples subdirectory)
- \* fixed driver\_wext.c to filter wireless events based on ifindex to avoid interfaces receiving events from other interfaces
- \* delay sending initial EAPOL-Start couple of seconds to speed up authentication for the most common case of Authenticator starting EAP authentication immediately after association

2005-09-25 - v0.4.5

- \* added a workaround for clearing keys with ndiswrapper to allow roaming from WPA enabled AP to plaintext one
- \* added docbook documentation (doc/docbook) that can be used to generate, e.g., man pages
- \* l2\_packet\_linux: use socket type SOCK\_DGRAM instead of SOCK\_RAW for PF\_PACKET

in order to prepare for network devices that do not use

Ethernet headers (e.g., network stack with native IEEE 802.11 frames)

- \* use receipt of EAPOL-Key frame as a lower layer success indication for EAP state machine to allow recovery from dropped EAP-Success frame
- \* cleaned up internal EAPOL frame processing by not including link layer (Ethernet) header during WPA and EAPOL/EAP processing; this header is added only when transmitted the frame; this makes it easier to use wpa\_supplicant on link layers that use different header than Ethernet
- \* updated EAP-PSK to use draft 9 by default since this can now be tested with hostapd; removed support for draft 3, including server\_nai configuration option from network blocks
- \* driver\_wired: add PAE address to the multicast address list in order to be able to receive EAPOL frames with drivers that do not include these multicast addresses by default
- \* driver\_wext: add support for WE-19
- \* added support for multiple configuration backends (CONFIG\_BACKEND option); currently, only 'file' is supported (i.e., the format used in wpa\_supplicant.conf)
- \* added support for updating configuration ('wpa\_cli save\_config');

this is disabled by default and can be enabled with global  
update\_config=1 variable in wpa\_supplicant.conf; this allows wpa\_cli  
and wpa\_gui to store the configuration changes in a permanent store  
\* added GET\_NETWORK ctrl\_iface command  
(e.g., 'wpa\_cli get\_network 0 ssid')

2005-08-21 - v0.4.4

- \* replaced OpenSSL patch for EAP-FAST support  
(openssl-tls-extensions.patch) with a more generic and correct  
patch (the new patch is not compatible with the previous one, so the  
OpenSSL library will need to be patched with the new patch in order  
to be able to build wpa\_supplicant with EAP-FAST support)
- \* added support for using Windows certificate store (through CryptoAPI)  
for client certificate and private key operations (EAP-TLS)  
(see wpa\_supplicant.conf  
for more information on how to configure  
this with private\_key)
- \* ported wpa\_gui to Windows
- \* added Qt4 version of wpa\_gui (wpa\_gui-qt4 directory); this can be  
built with the open source version of the Qt4 for Windows
- \* allow non-WPA modes (e.g., IEEE 802.1X with dynamic WEP) to be used  
with drivers that do not support WPA
- \* ndis\_events: fixed Windows 2000 support
- \* added support for enabling/disabling networks from the list of all  
configured networks ('wpa\_cli enable\_network <network id>' and  
'wpa\_cli disable\_network <network id>')
- \* added support for adding and removing network from the current  
configuration ('wpa\_cli add\_network' and 'wpa\_cli remove\_network  
<network id>'); added networks are disabled by default and they can  
be enabled with enable\_network command once the configuration is done  
for the new network; note: configuration file is not yet updated, so  
these new networks are lost when wpa\_supplicant is restarted
- \* added support for setting  
network configuration parameters through  
the control interface, for example:  
wpa\_cli set\_network 0 ssid "\"my network\""
- \* fixed parsing of strings that include both " and # within double  
quoted area (e.g., "start"#end")
- \* added EAP workaround for PEAP session resumption: allow outer,  
i.e., not tunneled, EAP-Success to terminate session since; this can  
be disabled with eap\_workaround=0  
(this was allowed for PEAPv1 before, but now it is also allowed for  
PEAPv0 since at least one RADIUS authentication server seems to be  
doing this for PEAPv0, too)
- \* wpa\_gui: added preliminary support for adding new networks to the  
wpa\_supplicant configuration (double click on the scan results to  
open network configuration)

2005-06-26 - v0.4.3

- \* removed interface for external EAPOL/EAP supplicant (e.g., Xsupplicant), (CONFIG\_XSUPPLICANT\_IFACE) since it is not required anymore and is unlikely to be used by anyone
- \* driver\_ndis: fixed WinPcap 3.0 support
- \* fixed
- build with CONFIG\_DNET\_PCAP=y on Linux
- \* l2\_packet: moved different implementations into separate files (l2\_packet\_\*.c)

2005-06-12 - v0.4.2

- \* driver\_ipw: updated driver structures to match with ipw2200-1.0.4 (note: ipw2100-1.1.0 is likely to require an update to work with this)
- \* added support for using ap\_scan=2 mode with multiple network blocks; wpa\_supplicant will go through the networks one by one until the driver reports a successful association; this uses the same order for networks as scan\_ssid=1 scans, i.e., the priority field is ignored and the network block order in the file is used instead
- \* fixed a potential issue in RSN pre-authentication ending up using freed memory if pre-authentication times out
- \* added support for matching alternative subject name extensions of the authentication server certificate; new configuration variables altsubject\_match and altsubject\_match2
- \* driver\_ndis: added support for IEEE 802.1X authentication with wired NDIS drivers
- \* added support for querying private key password (EAP-TLS) through the control interface (wpa\_cli/wpa\_gui) if one is not included in the configuration file
- \* driver\_broadcom: fixed couple of memory leaks in scan result processing
- \* EAP-PAX is now registered as EAP type 46
- \* fixed EAP-PAX MAC calculation
- \* fixed EAP-PAX CK and ICK key derivation
- \* added support for using password with EAP-PAX (as an alternative to entering key with eappsk); SHA-1 hash of the password will be used as the key in this case
- \* added support for arbitrary driver interface parameters through the configuration file with a new driver\_param field; this adds a new driver\_ops function set\_param()
- \* added possibility to override l2\_packet module with driver interface API (new send\_eapol handler); this can be used to implement driver specific TX/RX functions for EAPOL frames
- \* fixed ctrl\_interface\_group processing for the case where gid is entered as a number, not group name
- \* driver\_test: added support for testing hostapd with wpa\_supplicant

by using test driver interface without any kernel drivers or network cards

2005-05-22 - v0.4.1

- \* driver\_madwifi: fixed WPA/WPA2 mode configuration to allow EAPOL packets to be encrypted; this was apparently broken by the changed ioctl order in v0.4.0
- \* driver\_madwifi: added preliminary support for compiling against 'BSD' branch of madwifi CVS tree
- \* added support for EAP-MSCHAPv2 password retries within the same EAP authentication session
- \* added support for password changes with EAP-MSCHAPv2 (used when the password has expired)
- \* added support for reading additional certificates from PKCS#12 files and adding them to the certificate chain
- \* fixed association with IEEE 802.1X (no WPA) when dynamic WEP keys were used
- \* fixed a possible double free in EAP-TTLS fast-reauthentication when identity or password is entered through control interface
- \* display EAP Notification messages to user through control interface with "CTRL-EVENT-EAP-NOTIFICATION" prefix
- \* added GUI version of wpa\_cli, wpa\_gui; this is not build automatically with 'make'; use 'make wpa\_gui' to build (this requires Qt development tools)
- \* added 'disconnect' command to control interface for setting wpa\_supplicant in state where it will not associate before 'reassociate' command has been used
- \* added support for selecting a network from the list of all configured networks ('wpa\_cli select\_network <network id>'; this disabled all other networks; to re-enable, 'wpa\_cli select\_network any')
- \* added support for getting scan results through control interface
- \* added EAP workaround for PEAPv1 session resumption: allow outer, i.e., not tunneled, EAP-Success to terminate session since; this can be disabled with eap\_workaround=0

2005-04-25 - v0.4.0 (beginning of 0.4.x development releases)

- \* added a new build time option, CONFIG\_NO\_STDOUT\_DEBUG, that can be used to reduce the size of the wpa\_supplicant considerably if debugging code is not needed
- \* fixed EAPOL-Key validation to drop packets with invalid Key Data Length; such frames could have crashed wpa\_supplicant due to buffer overflow
- \* added support for wired authentication (IEEE 802.1X on wired Ethernet); driver interface 'wired'
- \* obsoleted set\_wpa() handler in the driver interface API (it can be replaced by moving enable/disable functionality into init()/deinit())

- (calls to set\_wpa() are still present for backwards compatibility, but they may be removed in the future)
- \* driver\_madwifi: fixed association in plaintext mode
  - \* modified the EAP workaround that accepts EAP-Success with incorrect Identifier to be even less strict about verification in order to interoperate with some authentication servers
  - \* added support for sending TLS alerts
  - \* added support for 'any' SSID wildcard; if ssid is not configured or is set to an empty string, any SSID will be accepted for non-WPA AP
  - \* added support for asking PIN (for SIM) from frontends (e.g., wpa\_cli); if a PIN is needed, but not included in the configuration file, a control interface request is sent and EAP processing is delayed until the PIN is available
  - \* added support for using external devices (e.g., a smartcard) for private key operations in EAP-TLS (CONFIG\_SMARTCARD=y in .config); new wpa\_supplicant.conf variables:
    - global: openssl\_engine\_path, pkcs11\_engine\_path, pkcs11\_module\_path
    - network: engine, engine\_id, key\_id
  - \* added experimental support for EAP-PAX
  - \* added monitor mode for wpa\_cli (-a<path to a program to run>) that allows external commands (e.g., shell scripts) to be run based on wpa\_supplicant events, e.g., when authentication has been completed and data connection is ready; other related wpa\_cli arguments:
    - B (run in background), -P (write PID file); wpa\_supplicant has a new command line argument (-W) that can be used to make it wait until a control interface command is received in order to avoid missing events
  - \* added support for opportunistic WPA2 PMKSA key caching (disabled by default, can be enabled with proactive\_key\_caching=1)
  - \* fixed RSN IE in 4-Way Handshake message 2/4 for the case where Authenticator rejects PMKSA caching attempt and the driver is not using assoc\_info events
  - \* added -P<pid file> argument for wpa\_supplicant to write the current process id into a file

2005-02-12 - v0.3.7 (beginning of 0.3.x stable releases)

- \* added new phase1 option parameter, include\_tls\_length=1, to force wpa\_supplicant to add TLS Message Length field to all TLS messages even if the packet is not fragmented; this may be needed with some authentication servers
- \* fixed WPA/RSN IE verification in message 3 of 4-Way Handshake when using drivers that take care of AP selection (e.g., when using ap\_scan=2)
- \* fixed reprocessing of pending request after ctrl\_iface requests for

identity/password/otp

- \* fixed ctrl\_iface requests for identity/password/otp in Phase 2 of EAP-PEAP and EAP-TTLS
- \* all drivers using driver\_wext: set interface up and select Managed mode when starting wpa\_supplicant; set interface down when exiting
- \* renamed driver\_ipw2100.c to driver\_ipw.c since it now supports both ipw2100 and ipw2200; please note that this also changed the configuration variable in .config to CONFIG\_DRIVER\_IPW

2005-01-24 - v0.3.6

- \* fixed a busy loop introduced in v0.3.5 for scan result processing when no matching AP is found

2005-01-23 - v0.3.5

- \* added a workaround for an interoperability issue with a Cisco AP when using WPA2-PSK
- \* fixed non-WPA IEEE 802.1X to use the same authentication timeout as WPA with IEEE 802.1X (i.e., timeout 10 -> 70 sec to allow retransmission of dropped frames)
- \* fixed issues with 64-bit CPUs and SHA1 cleanup in previous version (e.g., segfault when processing EAPOL-Key frames)
- \* fixed EAP workaround and fast reauthentication configuration for RSN pre-authentication; previously these were disabled and pre-authentication would fail if the used authentication server requires EAP workarounds
- \* added support for blacklisting APs that fail or timeout authentication in ap\_scan=1 mode so that all APs are tried in cases where the ones with strongest signal level are failing authentication
- \* fixed CA certificate loading after a failed EAP-TLS/PEAP/TTLS authentication attempt
- \* allow EAP-PEAP/TTLS fast reauthentication only if Phase 2 succeeded in the previous authentication (previously, only Phase 1 success was verified)

2005-01-09 - v0.3.4

- \* added preliminary support for IBSS (ad-hoc) mode configuration (mode=1 in network block); this included a new key\_mgmt mode WPA-NONE, i.e., TKIP or CCMP with a fixed key (based on psk) and no key management; see wpa\_supplicant.conf for more details and an example on how to configure this (note: this is currently implemented only for driver\_hostapd.c, but the changes should be trivial to add in associate() handler for other drivers, too (assuming the driver supports WPA-None)
- \* added preliminary port for native Windows (i.e., no cygwin) using mingw



2005-01-02 - v0.3.3

- \* added optional support for GNU Readline and History Libraries for wpa\_cli (CONFIG\_READLINE)
- \* cleaned up EAP state machine <-> method interface and number of small problems with error case processing not terminating on EAP-Failure but waiting for timeout
- \* added couple of workarounds for interoperability issues with a Cisco AP when using WPA2
- \* added support for EAP-FAST (draft-cam-winget-eap-fast-00.txt); Note: This requires a patch for openssl to add support for TLS extensions and number of workarounds for operations without certificates. Proof of concept type of experimental patch is included in openssl-tls-extensions.patch.

2004-12-19 - v0.3.2

- \* fixed private key loading for cases where passphrase is not set
- \* fixed Windows/cygwin L2 packet handler freeing; previous version could cause a segfault when RSN pre-authentication was completed
- \* added support for PMKSA caching with drivers that generate RSN IEs (e.g., NDIS); currently, this is only implemented in driver\_ndis.c, but similar code can be easily added to driver\_ndiswrapper.c once ndiswrapper gets full support for RSN PMKSA caching
- \* improved recovery from PMKID mismatches by requesting full EAP authentication in case of failed PMKSA caching attempt
- \* driver\_ndis: added support for NDIS NdisMIncidentStatus() events (this requires that ndis\_events is ran while wpa\_supplicant is running)
- \* driver\_ndis: use ADD\_WEP/REMOVE\_WEP when configuring WEP keys
- \* added support for driver interfaces to replace the interface name based on driver/OS specific mapping, e.g., in case of driver\_ndis, this allows the beginning of the adapter description to be used as the interface name
- \*
- added support for CR+LF (Windows-style) line ends in configuration file
- \* driver\_ndis: enable radio before starting scanning, disable radio when exiting
- \* modified association event handler to set portEnabled = FALSE before clearing port Valid in order to reset EAP state machine and avoid problems with new authentication getting ignored because of state machines ending up in AUTHENTICATED/SUCCESS state based on old information
- \* added support for driver events to add PMKID candidates in order to allow drivers to give priority to most likely roaming candidates
- \* driver\_hostap: moved PrivacyInvoked configuration to associate() function so that this will not be set for plaintext connections
- \* added KEY\_MGMT\_802\_1X\_NO\_WPA as a new key\_mgmt type so that driver

- interface can distinguish plaintext and IEEE 802.1X (no WPA) authentication
- \* fixed static WEP key configuration to use broadcast/default type for all keys (previously, the default TX key was configured as pairwise/unicast key)
- \* driver\_ndis: added legacy WPA capability detection for non-WPA2 drivers
- \* added support for setting static WEP keys for IEEE 802.1X without dynamic WEP keying (eapol\_flags=0)

2004-12-12 - v0.3.1

- \* added support for reading PKCS#12 (PFX) files (as a replacement for PEM/DER) to get certificate and private key (CONFIG\_PKCS12)
  - \* fixed compilation with CONFIG\_PCSC=y
  - \* added new ap\_scan mode, ap\_scan=2, for drivers that take care of association, but need to be configured with security policy and SSID, e.g., ndiswrapper and NDIS driver; this mode should allow such drivers to work with hidden SSIDs and optimized roaming; when ap\_scan=2 is used, only the first network block in the configuration file is used and this configuration should have explicit security policy (i.e., only one option in the lists) for key\_mgmt, pairwise, group, proto variables
  - \* added experimental port of wpa\_supplicant for Windows
    - driver\_ndis.c
- driver interface (NDIS OIDs)
- currently, this requires cygwin and WinPcap
  - small utility, win\_if\_list, can be used to get interface name
- \* control interface can now be removed at build time; add CONFIG\_CTRL\_IFACE=y to .config to maintain old functionality
  - \* optional Xsupplicant interface can now be removed at build time; (CONFIG\_XSUPPLICANT\_IFACE=y in .config to bring it back)
  - \* added auth\_alg to driver interface associate() parameters to make it easier for drivers to configure authentication algorithm as part of the association

2004-12-05 - v0.3.0 (beginning of 0.3.x development releases)

- \* driver\_broadcom: added new driver interface for Broadcom wl.o driver (a generic driver for Broadcom IEEE 802.11a/g cards)
- \* wpa\_cli: fixed parsing of -p <path> command line argument
- \* PEAPv1: fixed tunneled EAP-Success reply handling to reply with TLS ACK, not tunneled EAP-Success (of which only the first byte was actually send due to a bug in previous code);  
this seems to  
interoperate with most RADIUS servers that implements PEAPv1
- \* PEAPv1: added support for terminating PEAP authentication on tunneled EAP-Success message; this can be configured by adding  
peap\_outer\_success=0 on phase1 parameters in wpa\_supplicant.conf

- (some RADIUS servers require this whereas others require a tunneled reply
- \* PEAPv1: changed phase1 option peaplabel to use default to 0, i.e., to the old label for key derivation; previously, the default was 1, but it looks like most existing PEAPv1 implementations use the old label which is thus more suitable default option
  - \* added support for EAP-PSK (draft-bersani-eap-psk-03.txt)
  - \* fixed parsing of wep\_tx\_keyidx
  - \* added support for configuring list of allowed Phase 2 EAP types (for both EAP-PEAP and EAP-TTLS) instead of only one type
  - \* added support for configuring IEEE 802.11 authentication algorithm (auth\_alg; mainly for using Shared Key authentication with static WEP keys)
  - \* added support for EAP-AKA (with UMTS SIM)
  - \* fixed couple of errors in PCSC handling that could have caused random-looking errors for EAP-SIM
  - \* added support for EAP-SIM pseudonyms and fast re-authentication
  - \* added support for EAP-TLS/PEAP/TTLS fast re-authentication (TLS session resumption)
  - \* added support for EAP-SIM with two challenges (phase1="sim\_min\_num\_chal=3" can be used to require three challenges)
  - \* added support for configuring DH/DSA parameters for an ephemeral DH key exchange (EAP-TLS/PEAP/TTLS) using new configuration parameters dh\_file and dh\_file2 (phase 2); this adds support for using DSA keys and optional DH key exchange to achieve forward secrecy with RSA keys
  - \* added support for matching subject of the authentication server certificate with a substring when using EAP-TLS/PEAP/TTLS; new configuration variables subject\_match and subject\_match2
  - \* changed SSID configuration in driver\_wext.c (used by many driver interfaces) to use ssid\_len+1 as the length for SSID since some Linux drivers expect this
  - \* fixed couple of unaligned reads in scan result parsing to fix WPA connection on some platforms (e.g., ARM)
  - \* added driver interface for Intel ipw2100 driver
  - \* added support for LEAP with WPA
  - \* added support for larger scan results report (old limit was 4 kB of data, i.e., about 35 or so APs) when using Linux wireless extensions v17 or newer
  - \* fixed a bug in PMKSA cache processing: skip sending of EAPOL-Start only if there is a PMKSA cache entry for the current AP
  - \* fixed error handling for case where reading of scan results fails: must schedule a new scan or wpa\_supplicant will remain waiting forever
  - \* changed debug output to remove shared password/key material by default; all key information can be included with -K command line argument to match the previous behavior

- \* added support for timestamping debug log messages (disabled by default, can be enabled with -t command line argument)
- \*
- set pairwise/group cipher suite for non-WPA IEEE 802.1X to WEP-104 if keys are not configured to be used; this fixes IEEE 802.1X mode with drivers that use this information to configure whether Privacy bit can be in Beacon frames (e.g., ndiswrapper)
- \* avoid clearing driver keys if no keys have been configured since last key clear request; this seems to improve reliability of group key handshake for ndiswrapper & NDIS driver which seems to be suffering of some kind of timing issue when the keys are cleared again after association
- \* changed driver interface API:
  - WPA\_SUPPLICANT\_DRIVER\_VERSION define can be used to determine which version is being used (now, this is set to 2; previously, it was not defined)
  - pass pointer to private data structure to all calls
  - the new API is not backwards compatible; all in-tree driver interfaces has been converted to the new API
- \* added support for controlling multiple interfaces (radios) per wpa\_supplicant process; each interface needs to be listed on the command line (-c, -i, -D arguments) with -N as a separator (-cwpa1.conf -iwlan0 -Dhostap -N -cwpa2.conf -iath0 -Dmadwifi)
- \* added a workaround for EAP servers that incorrectly use same Id for sequential EAP packets
- \* changed libpcap/libdnet configuration to use .config variable, CONFIG\_DNET\_PCAP, instead of requiring Makefile modification
- \* improved downgrade attack detection in IE verification of msg 3/4: verify both WPA and RSN IEs, if present, not only the selected one; reject the AP if an RSN IE is found in msg 3/4, but not in Beacon or Probe Response frame, and RSN is enabled in wpa\_supplicant configuration
- \* fixed WPA msg 3/4 processing to allow Key Data field contain other IEs than just one WPA IE
- \* added support for FreeBSD and driver interface for the BSD net80211 layer (CONFIG\_DRIVER\_BSD=y in .config); please note that some of the required kernel mods have not yet been committed
- \*
- made EAP workarounds configurable; enabled by default, can be disabled with network block option eap\_workaround=0

2004-07-17 - v0.2.4 (beginning of 0.2.x stable releases)

- \* resolved couple of interoperability issues with EAP-PEAPv1 and Phase 2 (inner EAP) fragment reassembly
- \* driver\_madwifi: fixed WEP key configuration for IEEE 802.1X when the AP is using non-zero key index for the unicast key and key index zero for the broadcast key

- \* driver\_hostap: fixed IEEE 802.1X WEP key updates and re-authentication by allowing unencrypted EAPOL frames when not using WPA
- \* added a new driver interface, 'wext', which uses only standard, driver independent functionality in Linux wireless extensions; currently, this can be used only for non-WPA IEEE 802.1X mode, but eventually, this is to be extended to support full WPA/WPA2 once Linux wireless extensions get support for this
- \* added support for mode in which the driver is responsible for AP scanning and selection; this is disabled by default and can be enabled with global ap\_scan=0 variable in wpa\_supplicant.conf; this mode can be used, e.g., with generic 'wext' driver interface to use wpa\_supplicant as IEEE 802.1X Supplicant with any Linux driver supporting wireless extensions.
- \* driver\_madwifi: fixed WPA2 configuration and scan\_ssid=1 (e.g., operation with an AP that does not include SSID in the Beacon frames)
- \* added support for new EAP authentication methods: EAP-TTLS/EAP-OTP, EAP-PEAPv0/OTP, EAP-PEAPv1/OTP, EAP-OTP
- \* added support for asking one-time-passwords from frontends (e.g., wpa\_cli); this 'otp' command works otherwise like 'password' command, but the password is used only once and the frontend will be asked for a new password whenever a request from authenticator requires a password; this can be used with both EAP-OTP and EAP-GTC
- \* changed wpa\_cli to automatically re-establish connection so that it does not need to be re-started when wpa\_supplicant is terminated and started again
- \* improved user data (identity/password/otp) requests through frontends: process pending EAPOL packets after getting new information so that full authentication does not need to be restarted; in addition, send pending requests again whenever a new frontend is attached
- \* changed control frontends to use a new directory for socket files to make it easier for wpa\_cli to automatically select between interfaces and to provide access control for the control interface; wpa\_supplicant.conf: ctrl\_interface is now a path (/var/run/wpa\_supplicant is the recommended path) and ctrl\_interface\_group can be used to select which group gets access to the control interface; wpa\_cli: by default, try to connect to the first interface available in /var/run/wpa\_supplicant; this path can be overridden with -p option and an interface can be selected with -i option (i.e., in most common cases, wpa\_cli does not need to get any arguments)
- \* added support for LEAP
- \* added driver interface for Linux ndiswrapper
- \* added priority option for network blocks in the configuration file;

this allows networks to be grouped based on priority (the scan results are searched for matches with network blocks in this order)

2004-06-20 - v0.2.3

- \* sort scan results to improve AP selection
- \* fixed control interface socket removal for some error cases
- \* improved scan requesting and authentication timeout
- \* small improvements/bug fixes for EAP-MSCHAPv2, EAP-PEAP, and TLS processing
- \* PEAP version can now be forced with phase1="peapver=<ver>" (mostly for testing; by default, the highest version supported by both the Supplicant and Authentication Server is selected automatically)
- \* added support for madwifi driver (Atheros ar521x)
- \* added a workaround for cases where AP sets Install Tx/Rx bit for WPA Group Key messages when pairwise keys are used (without this, the Group Key would be used for Tx and the AP would drop frames from the station)
- \* added GSM SIM/USIM interface for GSM authentication algorithm for EAP-SIM; this requires psc-lite
- \* added support for ATMEL AT76C5XXx driver
- \* fixed IEEE 802.1X WEP key derivation in the case where Authenticator does not include key data in the EAPOL-Key frame (i.e., part of EAP keying material is used as data encryption key)
- \* added support for using plaintext and static WEP networks (key\_mgmt=NONE)

2004-05-31 - v0.2.2

- \* added support for new EAP authentication methods:
  - EAP-TTLS/EAP-MD5-Challenge
  - EAP-TTLS/EAP-GTC
  - EAP-TTLS/EAP-MSCHAPv2
  - EAP-TTLS/EAP-TLS
  - EAP-TTLS/MSCHAPv2
  - EAP-TTLS/MSCHAP
  - EAP-TTLS/PAP
  - EAP-TTLS/CHAP
  - EAP-PEAP/TLS
  - EAP-PEAP/GTC
  - EAP-PEAP/MD5-Challenge
  - EAP-GTC
  - EAP-SIM (not yet complete; needs GSM/SIM authentication interface)
- \* added support for anonymous identity (to be used when identity is sent in plaintext; real identity will be used within TLS protected

tunnel (e.g., with EAP-TTLS)

- \* added event messages from wpa\_supplicant to frontends, e.g., wpa\_cli

- \* added support for requesting identity and password information using control interface; in other words, the password for EAP-PEAP or EAP-TTLS does not need to be included in the configuration file since a frontend (e.g., wpa\_cli) can ask it from the user
- \* improved RSN pre-authentication to use a candidate list and process all candidates from each scan; not only one per scan
- \* fixed RSN IE and WPA IE capabilities field parsing
- \* ignore Tx bit in GTK IE when Pairwise keys are used
- \* avoid making new scan requests during IEEE 802.1X negotiation
- \* use openssl/libcrypto for MD5 and SHA-1 when compiling wpa\_supplicant with TLS support (this replaces the included implementation with library code to save about 8 kB since the library code is needed anyway for TLS)
- \* fixed WPA-PSK only mode when compiled without IEEE 802.1X support (i.e., without CONFIG\_IEEE8021X\_EAPOL=y in .config)

2004-05-06 - v0.2.1

- \* added support for internal IEEE 802.1X (actually, IEEE 802.1aa/D6.1)

Supplicant

- EAPOL state machines for Supplicant [IEEE 802.1aa/D6.1]
- EAP peer state machine [draft-ietf-eap-statemachine-02.pdf]
- EAP-MD5 (cannot be used with WPA-RADIUS) [draft-ietf-eap-rfc2284bis-09.txt]
- EAP-TLS [RFC 2716]
- EAP-MSCHAPv2 (currently used only with EAP-PEAP)
- EAP-PEAP/MSCHAPv2 [draft-josefsson-pppext-eap-tls-eap-07.txt] [draft-kamath-pppext-eap-mschapv2-00.txt] (PEAP version 0, 1, and parts of 2; only 0 and 1 are enabled by default; tested with FreeRADIUS, Microsoft IAS, and Funk Odyssey)
- new configuration file options: eap, identity, password, ca\_cert, client\_cert, privatekey, private\_key\_passwd
- Xsupplicant is not required anymore, but it can be used by disabling the internal IEEE 802.1X Supplicant with -e command line option
- this code is not included in the default build; Makefile

need to

- be edited for this (uncomment lines for selected functionality)
- EAP-TLS and EAP-PEAP require openssl libraries
- \* use module prefix in debug messages (WPA, EAP, EAP-TLS, ..)
- \* added support for non-WPA IEEE 802.1X mode with dynamic WEP keys (i.e., complete IEEE 802.1X/EAP authentication and use IEEE 802.1X EAPOL-Key frames instead of WPA key handshakes)
- \* added support for IEEE 802.11i/RSN (WPA2)
  - improved PTK Key Handshake
  - PMKSA caching, pre-authentication
- \* fixed wpa\_supplicant to ignore possible extra data after WPA EAPOL-Key packets (this fixes 'Invalid EAPOL-Key MIC when using

TPTK' error from message 3 of 4-Way Handshake in case the AP includes extra data after the EAPOL-Key)

- \* added interface for external programs (frontends) to control wpa\_supplicant
- CLI example (wpa\_cli) with interactive mode and command line mode
- replaced SIGUSR1 status/statistics with the new control interface
- \* made some feature compile time configurable
- .config file for make
- driver interfaces (hostap, hermes, ..)
- EAPOL/EAP functions

2004-02-15 - v0.2.0

- \* Initial version of wpa\_supplicant

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supplicant/ChangeLog

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/\*

- \* Interworking (IEEE 802.11u)
- \* Copyright (c) 2011-2013, Qualcomm Atheros, Inc.
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- \* BSS table
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\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supplicant/bss.h

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- \* wpa\_gui - SignalBar class



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\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/wpa\_gui-qt4/signalbar.h  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/wpa\_gui-qt4/signalbar.cpp

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/\*  
\* WPA SupPLICant - Basic AP mode support routines  
\* Copyright (c) 2003-2009, Jouni Malinen <j@w1.fi>  
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\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/ap.h  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/ap.c

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/\*  
\* WPA SupPLICant / WinMain() function for Windows-based applications  
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\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/main\_winmain.c

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```
/*  
* libwpa_test - Test program for libwpa_client.* library linking  
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```

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```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa_supPLICant/libwpa_test.c  
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```

```
/*  
* wpa_supPLICant - IBSS RSN  
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```

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```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa_supPLICant/ibss_rsn.h  
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```

```
/*  
* wpa_supPLICant - DPP  
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* Copyright (c) 2018, The Linux Foundation  
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Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa_supPLICant/dpp_supPLICant.c  
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```

```
/*  
* WPA SupPLICant - auto scan periodic module  
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```

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\* wpa\_supPLICANT - Wi-Fi Display

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\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wifi\_display.c

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\* WPA SupPLICANT - Glue code to setup EAPOL and RSN modules

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\* WPA SupPLICANT - background scan and roaming interface

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\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/bgscan.c

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\* WPA SupPLICANT / UNIX domain socket -based control interface

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\* WPA SupPLICant / dbus-based control interface (WPS)

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\* WPA SupPLICant / Control interface (shared code for all backends)

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\* WPA SupPLICant / main() function for UNIX like OSes and MinGW

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\* WPA SupPLICant - ASCII passphrase to WPA PSK tool

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\* wpa\_gui - Peers class  
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\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wpa\_gui-qt4/peers.h  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wpa\_gui-qt4/peers.cpp  
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\* wpa\_gui - Application startup  
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\* WPA Supplicant / Configuration file structures  
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Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supplicant-1-tar-gz/wpa\_supplicant/config.h

No license file was found, but licenses were detected in source scan.

/\*

\* WPA Supplicant - background scan and roaming module: learn  
\* Copyright (c) 2009-2010, Jouni Malinen <j@w1.fi>

\*

\* This software may be distributed under the terms of the BSD license.  
\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supplicant-1-tar-gz/wpa\_supplicant/bgscan\_learn.c

No license file was found, but licenses were detected in source scan.

/\*

\* WPA Supplicant / Configuration backend: Windows registry  
\* Copyright (c) 2003-2008, Jouni Malinen <j@w1.fi>

\*

\* This software may be distributed under the terms of the BSD license.  
\* See README for more details.

\*

\* This file implements a configuration backend for Windows registry. All the  
\* configuration information is stored in the registry and the format for  
\* network configuration fields is same as described in the sample  
\* configuration file, wpa\_supplicant.conf.

\*

\* Configuration data is in  
\* \a HKEY\_LOCAL\_MACHINE\SOFTWARE\%wpa\_supplicant\configs  
\* key. Each configuration profile has its own key under this. In terms of text  
\* files, each profile would map to a separate text file with possibly multiple  
\* networks. Under each profile, there is a networks key that lists all  
\* networks as a subkey. Each network has set of values in the same way as  
\* network block in the configuration file.

In addition, blobs subkey has

\* possible blobs as values.

\*

\* Example network configuration block:

\* \verbatim

```
HKEY_LOCAL_MACHINE\SOFTWARE\wpa_supplicant\configs\test\networks\0000
  ssid="example"
  key_mgmt=WPA-PSK
\endverbatim
*/
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/config_winreg.c
No license file was found, but licenses were detected in source scan.
```

```
/*
```

```
* wpa_gui - EventHistory class
* Copyright (c) 2005-2006, Jouni Malinen <j@w1.fi>
*
* This software may be distributed under the terms of the BSD license.
* See README for more details.
*/
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/wpa_gui-qt4/eventhistory.h
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/wpa_gui-qt4/eventhistory.cpp
No license file was found, but licenses were detected in source scan.
```

```
# Example wpa_supplicant build time configuration
```

```
#
```

```
# This file lists the configuration options that are used when building the
# wpa_supplicant binary. All lines starting with # are ignored. Configuration
# option lines must be commented out complete, if they are not to be included,
# i.e., just setting VARIABLE=n is not disabling that variable.
```

```
#
```

```
# This file is included in Makefile, so variables like CFLAGS and LIBS can also
# be modified from here. In most cases, these lines should use += in order not
# to override previous values of the variables.
```

```
# Uncomment following two lines and fix the paths if you have installed OpenSSL
```

```
# or GnuTLS in non-default location
```

```
#CFLAGS += -I/usr/local/openssl/include
```

```
#LIBS += -L/usr/local/openssl/lib
```

```
# Some Red Hat versions seem to include kerberos header files from OpenSSL, but
```

```
# the kerberos files are not in the default include path. Following line can be
```

```
# used to fix build
```

```
issues on such systems (krb5.h not found).
```

```
#CFLAGS += -I/usr/include/kerberos
```

```

# Driver interface for generic Linux wireless extensions
# Note: WEXT is deprecated in the current Linux kernel version and no new
# functionality is added to it. nl80211-based interface is the new
# replacement for WEXT and its use allows wpa_supplicant to properly control
# the driver to improve existing functionality like roaming and to support new
# functionality.
CONFIG_DRIVER_WEXT=y

# Driver interface for Linux drivers using the nl80211 kernel interface
CONFIG_DRIVER_NL80211=y

# QCA vendor extensions to nl80211
#CONFIG_DRIVER_NL80211_QCA=y

# driver_nl80211.c requires libnl. If you are compiling it yourself
# you may need to point hostapd to your version of libnl.
#
#CFLAGS += -I$<path to libnl include files>
#LIBS += -L$<path to libnl library files>

# Use libnl v2.0 (or 3.0) libraries.
#CONFIG_LIBNL20=y

# Use libnl 3.2 libraries (if this is selected, CONFIG_LIBNL20 is ignored)
#CONFIG_LIBNL32=y

#
# Driver interface for FreeBSD net80211 layer (e.g., Atheros driver)
#CONFIG_DRIVER_BSD=y
#CFLAGS += -I/usr/local/include
#LIBS += -L/usr/local/lib
#LIBS_p += -L/usr/local/lib
#LIBS_c += -L/usr/local/lib

# Driver interface for Windows NDIS
#CONFIG_DRIVER_NDIS=y
#CFLAGS += -I/usr/include/w32api/ddk
#LIBS += -L/usr/local/lib
# For native build using mingw
#CONFIG_NATIVE_WINDOWS=y
# Additional directories for cross-compilation on Linux host for mingw target
#CFLAGS += -I/opt/mingw/mingw32/include/ddk
#LIBS += -L/opt/mingw/mingw32/lib
#CC=mingw32-gcc
# By default, driver_ndis uses WinPcap for low-level operations. This can be
# replaced with the following option which replaces WinPcap calls with NDISUIO.
# However, this requires that WZC is disabled (net stop wzcsvc) before starting

```



```
# wpa_supplicant.
# CONFIG_USE_NDISUIO=y

# Driver interface for wired Ethernet drivers
CONFIG_DRIVER_WIRED=y

# Driver interface for MACsec capable Qualcomm Atheros drivers
#CONFIG_DRIVER_MACSEC_QCA=y

# Driver
interface for Linux MACsec drivers
#CONFIG_DRIVER_MACSEC_LINUX=y

# Driver interface for the Broadcom RoboSwitch family
#CONFIG_DRIVER_ROBOSWITCH=y

# Driver interface for no driver (e.g., WPS ER only)
#CONFIG_DRIVER_NONE=y

# Solaris libraries
#LIBS += -lsocket -ldlpi -lnsl
#LIBS_c += -lsocket

# Enable IEEE 802.1X Supplicant (automatically included if any EAP method or
# MACsec is included)
CONFIG_IEEE8021X_EAPOL=y

# EAP-MD5
CONFIG_EAP_MD5=y

# EAP-MSCHAPv2
CONFIG_EAP_MSCHAPV2=y

# EAP-TLS
CONFIG_EAP_TLS=y

# EAL-PEAP
CONFIG_EAP_PEAP=y

# EAP-TTLS
CONFIG_EAP_TTLS=y

# EAP-FAST
# Note: If OpenSSL is used as the TLS library, OpenSSL 1.0 or newer is needed
# for EAP-FAST support. Older OpenSSL releases would need to be patched, e.g.,
# with openssl-0.9.8x-tls-extensions.patch, to add the needed functions.
#CONFIG_EAP_FAST=y
```

```
# EAP-GTC
CONFIG_EAP_GTC=y

# EAP-OTP
CONFIG_EAP_OTP=y

# EAP-SIM (enable CONFIG_PCSC, if EAP-SIM is used)
#CONFIG_EAP_SIM=y

# EAP-PSK (experimental; this is
_not_needed for WPA-PSK)
#CONFIG_EAP_PSK=y

# EAP-pwd (secure authentication using only a password)
#CONFIG_EAP_PWD=y

# EAP-PAX
#CONFIG_EAP_PAX=y

# LEAP
CONFIG_EAP_LEAP=y

# EAP-AKA (enable CONFIG_PCSC, if EAP-AKA is used)
#CONFIG_EAP_AKA=y

# EAP-AKA' (enable CONFIG_PCSC, if EAP-AKA' is used).
# This requires CONFIG_EAP_AKA to be enabled, too.
#CONFIG_EAP_AKA_PRIME=y

# Enable USIM simulator (Milenage) for EAP-AKA
#CONFIG_USIM_SIMULATOR=y

# EAP-SAKE
#CONFIG_EAP_SAKE=y

# EAP-GPSK
#CONFIG_EAP_GPSK=y
# Include support for optional SHA256 cipher suite in EAP-GPSK
#CONFIG_EAP_GPSK_SHA256=y

# EAP-TNC and related Trusted Network Connect support (experimental)
#CONFIG_EAP_TNC=y

# Wi-Fi Protected Setup (WPS)
#CONFIG_WPS=y
# Enable WPS external registrar functionality
#CONFIG_WPS_ER=y
# Disable credentials for an open network by default when acting as a WPS
```

```
# registrar.
#CONFIG_WPS_REG_DISABLE_OPEN=y
# Enable WPS support with NFC config method
#CONFIG_WPS_NFC=y

# EAP-IKEv2
#CONFIG_EAP_IKEV2=y

#
EAP-EKE
#CONFIG_EAP_EKE=y

# MACsec
#CONFIG_MACSEC=y

# PKCS#12 (PFX) support (used to read private key and certificate file from
# a file that usually has extension .p12 or .pfx)
CONFIG_PKCS12=y

# Smartcard support (i.e., private key on a smartcard), e.g., with openssl
# engine.
CONFIG_SMARTCARD=y

# PC/SC interface for smartcards (USIM, GSM SIM)
# Enable this if EAP-SIM or EAP-AKA is included
#CONFIG_PCSC=y

# Support HT overrides (disable HT/HT40, mask MCS rates, etc.)
#CONFIG_HT_OVERRIDES=y

# Support VHT overrides (disable VHT, mask MCS rates, etc.)
#CONFIG_VHT_OVERRIDES=y

# Development testing
#CONFIG_EAPOL_TEST=y

# Select control interface backend for external programs, e.g, wpa_cli:
# unix = UNIX domain sockets (default for Linux/*BSD)
# udp = UDP sockets using localhost (127.0.0.1)
# udp6 = UDP IPv6 sockets using localhost (::1)
# named_pipe = Windows Named Pipe (default for Windows)
# udp-remote = UDP sockets with remote access (only for tests systems/purpose)
#
udp6-remote = UDP IPv6 sockets with remote access (only for tests purpose)
# y = use default (backwards compatibility)
# If this option is commented out, control interface is not included in the
# build.
CONFIG_CTRL_IFACE=y
```

```
# Include support for GNU Readline and History Libraries in wpa_cli.
# When building a wpa_cli binary for distribution, please note that these
# libraries are licensed under GPL and as such, BSD license may not apply for
# the resulting binary.
#CONFIG_READLINE=y

# Include internal line edit mode in wpa_cli. This can be used as a replacement
# for GNU Readline to provide limited command line editing and history support.
#CONFIG_WPA_CLI_EDIT=y

# Remove debugging code that is printing out debug message to stdout.
# This can be used to reduce the size of the wpa_supplicant considerably
# if debugging code is not needed. The size reduction can be around 35%
# (e.g., 90 kB).
#CONFIG_NO_STDOUT_DEBUG=y

# Remove WPA support, e.g., for wired-only IEEE 802.1X supplicant,
# to save
# 35-50 kB in code size.
#CONFIG_NO_WPA=y

# Remove IEEE 802.11i/WPA-Personal ASCII passphrase support
# This option can be used to reduce code size by removing support for
# converting ASCII passphrases into PSK. If this functionality is removed, the
# PSK can only be configured as the 64-octet hexstring (e.g., from
# wpa_passphrase). This saves about 0.5 kB in code size.
#CONFIG_NO_WPA_PASSPHRASE=y

# Disable scan result processing (ap_mode=1) to save code size by about 1 kB.
# This can be used if ap_scan=1 mode is never enabled.
#CONFIG_NO_SCAN_PROCESSING=y

# Select configuration backend:
# file = text file (e.g., wpa_supplicant.conf; note: the configuration file
# path is given on command line, not here; this option is just used to
# select the backend that allows configuration files to be used)
# winreg = Windows registry (see win_example.reg for an example)
CONFIG_BACKEND=file

# Remove configuration write functionality (i.e., to allow the configuration
# file to be updated
# based on runtime configuration changes). The runtime
# configuration can still be changed, the changes are just not going to be
# persistent over restarts. This option can be used to reduce code size by
# about 3.5 kB.
#CONFIG_NO_CONFIG_WRITE=y
```

# Remove support for configuration blobs to reduce code size by about 1.5 kB.

#CONFIG\_NO\_CONFIG\_BLOBS=y

# Select program entry point implementation:

# main = UNIX/POSIX like main() function (default)

# main\_winsvc = Windows service (read parameters from registry)

# main\_none = Very basic example (development use only)

#CONFIG\_MAIN=main

# Select wrapper for operating system and C library specific functions

# unix = UNIX/POSIX like systems (default)

# win32 = Windows systems

# none = Empty template

#CONFIG\_OS=unix

# Select event loop implementation

# eloop = select() loop (default)

# eloop\_win = Windows events and WaitForMultipleObject() loop

#CONFIG\_ELOOP=eloop

# Should we use poll instead of select? Select is used by default.

#CONFIG\_ELOOP\_POLL=y

#

Should we use epoll instead of select? Select is used by default.

#CONFIG\_ELOOP\_EPOLL=y

# Should we use kqueue instead of select? Select is used by default.

#CONFIG\_ELOOP\_KQUEUE=y

# Select layer 2 packet implementation

# linux = Linux packet socket (default)

# pcap = libpcap/libdnet/WinPcap

# freebsd = FreeBSD libpcap

# winpcap = WinPcap with receive thread

# ndis = Windows NDISUIO (note: requires CONFIG\_USE\_NDISUIO=y)

# none = Empty template

#CONFIG\_L2\_PACKET=linux

# Disable Linux packet socket workaround applicable for station interface

# in a bridge for EAPOL frames. This should be uncommented only if the kernel

# is known to not have the regression issue in packet socket behavior with

# bridge interfaces (commit 'bridge: respect RFC2863 operational state').

#CONFIG\_NO\_LINUX\_PACKET\_SOCKET\_WAR=y

# IEEE 802.11w (management frame protection), also known as PMF

# Driver support is also needed for IEEE 802.11w.

#CONFIG\_IEEE80211W=y

```

# Select TLS implementation
# openssl
  = OpenSSL (default)
# gnutls = GnuTLS
# internal = Internal TLSv1 implementation (experimental)
# linux = Linux kernel AF_ALG and internal TLSv1 implementation (experimental)
# none = Empty template
#CONFIG_TLS=openssl

# TLS-based EAP methods require at least TLS v1.0. Newer version of TLS (v1.1)
# can be enabled to get a stronger construction of messages when block ciphers
# are used. It should be noted that some existing TLS v1.0 -based
# implementation may not be compatible with TLS v1.1 message (ClientHello is
# sent prior to negotiating which version will be used)
#CONFIG_TLSV11=y

# TLS-based EAP methods require at least TLS v1.0. Newer version of TLS (v1.2)
# can be enabled to enable use of stronger crypto algorithms. It should be
# noted that some existing TLS v1.0 -based implementation may not be compatible
# with TLS v1.2 message (ClientHello is sent prior to negotiating which version
# will be used)
#CONFIG_TLSV12=y

# Select which ciphers to use by default with OpenSSL
  if the user does not
# specify them.
#CONFIG_TLS_DEFAULT_CIPHERS="DEFAULT:!EXP:!LOW"

# If CONFIG_TLS=internal is used, additional library and include paths are
# needed for LibTomMath. Alternatively, an integrated, minimal version of
# LibTomMath can be used. See beginning of libtommath.c for details on benefits
# and drawbacks of this option.
#CONFIG_INTERNAL_LIBTOMMATH=y
#ifdef CONFIG_INTERNAL_LIBTOMMATH
#LTM_PATH=/usr/src/libtommath-0.39
#CFLAGS += -I$(LTM_PATH)
#LIBS += -L$(LTM_PATH)
#LIBS_p += -L$(LTM_PATH)
#endif
# At the cost of about 4 kB of additional binary size, the internal LibTomMath
# can be configured to include faster routines for exptmod, sqr, and div to
# speed up DH and RSA calculation considerably
#CONFIG_INTERNAL_LIBTOMMATH_FAST=y

# Include NDIS event processing through WMI into wpa_supplicant/wpasvc.
# This is only for Windows builds and requires WMI-related header files and
# WbemUuid.Lib from Platform SDK even when building with MinGW.

```

```
#CONFIG_NDIS_EVENTS_INTEGRATED=y
#PLATFORMSDKLIB="/opt/Program
Files/Microsoft Platform SDK/Lib"

# Add support for old DBus control interface
# (fi.epitest.hostap.WPASupplicant)
#CONFIG_CTRL_IFACE_DBUS=y

# Add support for new DBus control interface
# (fi.w1.hostap.wpa_supplicant1)
#CONFIG_CTRL_IFACE_DBUS_NEW=y

# Add introspection support for new DBus control interface
#CONFIG_CTRL_IFACE_DBUS_INTRO=y

# Add support for loading EAP methods dynamically as shared libraries.
# When this option is enabled, each EAP method can be either included
# statically (CONFIG_EAP_<method>=y) or dynamically (CONFIG_EAP_<method>=dyn).
# Dynamic EAP methods are build as shared objects (eap_*.so) and they need to
# be loaded in the beginning of the wpa_supplicant configuration file
# (see load_dynamic_eap parameter in the example file) before being used in
# the network blocks.
#
# Note that some shared parts of EAP methods are included in the main program
# and in order to be able to use dynamic EAP methods using these parts,
the
# main program must have been build with the EAP method enabled (=y or =dyn).
# This means that EAP-TLS/PEAP/TTLS/FAST cannot be added as dynamic libraries
# unless at least one of them was included in the main build to force inclusion
# of the shared code. Similarly, at least one of EAP-SIM/AKA must be included
# in the main build to be able to load these methods dynamically.
#
# Please also note that using dynamic libraries will increase the total binary
# size. Thus, it may not be the best option for targets that have limited
# amount of memory/flash.
#CONFIG_DYNAMIC_EAP_METHODS=y

# IEEE Std 802.11r-2008 (Fast BSS Transition) for station mode
#CONFIG_IEEE80211R=y

# Add support for writing debug log to a file (/tmp/wpa_supplicant-log-#.txt)
#CONFIG_DEBUG_FILE=y

# Send debug messages to syslog instead of stdout
#CONFIG_DEBUG_SYSLOG=y
# Set syslog facility for debug messages
#CONFIG_DEBUG_SYSLOG_FACILITY=LOG_DAEMON
```

```
# Add support for sending all debug messages (regardless of debug
verbosity)
# to the Linux kernel tracing facility. This helps debug the entire stack by
# making it easy to record everything happening from the driver up into the
# same file, e.g., using trace-cmd.
#CONFIG_DEBUG_LINUX_TRACING=y

# Add support for writing debug log to Android logcat instead of standard
# output
#CONFIG_ANDROID_LOG=y

# Enable privilege separation (see README 'Privilege separation' for details)
#CONFIG_PRIVSEP=y

# Enable mitigation against certain attacks against TKIP by delaying Michael
# MIC error reports by a random amount of time between 0 and 60 seconds
#CONFIG_DELAYED_MIC_ERROR_REPORT=y

# Enable tracing code for developer debugging
# This tracks use of memory allocations and other registrations and reports
# incorrect use with a backtrace of call (or allocation) location.
#CONFIG_WPA_TRACE=y
# For BSD, uncomment these.
#LIBS += -lexecinfo
#LIBS_p += -lexecinfo
#LIBS_c += -lexecinfo

# Use libbfd to get more details for developer debugging
# This enables use
# of libbfd to get more detailed symbols for the backtraces
# generated by CONFIG_WPA_TRACE=y.
#CONFIG_WPA_TRACE_BFD=y
# For BSD, uncomment these.
#LIBS += -lbfd -liberty -lz
#LIBS_p += -lbfd -liberty -lz
#LIBS_c += -lbfd -liberty -lz

# wpa_supplicant depends on strong random number generation being available
# from the operating system. os_get_random() function is used to fetch random
# data when needed, e.g., for key generation. On Linux and BSD systems, this
# works by reading /dev/urandom. It should be noted that the OS entropy pool
# needs to be properly initialized before wpa_supplicant is started. This is
# important especially on embedded devices that do not have a hardware random
# number generator and may by default start up with minimal entropy available
# for random number generation.
#
# As a safety net, wpa_supplicant is by default trying to internally collect
# additional entropy for generating random data to mix in with the data fetched
```



```
# from the OS. This by itself is
# not considered to be very strong, but it may
# help in cases where the system pool is not initialized properly. However, it
# is very strongly recommended that the system pool is initialized with enough
# entropy either by using hardware assisted random number generator or by
# storing state over device reboots.
#
# wpa_supplicant can be configured to maintain its own entropy store over
# restarts to enhance random number generation. This is not perfect, but it is
# much more secure than using the same sequence of random numbers after every
# reboot. This can be enabled with -e<entropy file> command line option. The
# specified file needs to be readable and writable by wpa_supplicant.
#
# If the os_get_random() is known to provide strong random data (e.g., on
# Linux/BSD, the board in question is known to have reliable source of random
# data from /dev/urandom), the internal wpa_supplicant random pool can be
# disabled. This will save some in binary size and CPU use. However, this
# should
# only be considered for builds that are known to be used on devices
# that meet the requirements described above.
#CONFIG_NO_RANDOM_POOL=y

# IEEE 802.11n (High Throughput) support (mainly for AP mode)
#CONFIG_IEEE80211N=y

# IEEE 802.11ac (Very High Throughput) support (mainly for AP mode)
# (depends on CONFIG_IEEE80211N)
#CONFIG_IEEE80211AC=y

# Wireless Network Management (IEEE Std 802.11v-2011)
# Note: This is experimental and not complete implementation.
#CONFIG_WNM=y

# Interworking (IEEE 802.11u)
# This can be used to enable functionality to improve interworking with
# external networks (GAS/ANQP to learn more about the networks and network
# selection based on available credentials).
#CONFIG_INTERWORKING=y

# Hotspot 2.0
#CONFIG_HS20=y

# Enable interface matching in wpa_supplicant
#CONFIG_MATCH_IFACE=y

# Disable roaming in wpa_supplicant
#CONFIG_NO_ROAMING=y
```

```
# AP mode operations with wpa_supplicant
# This can be used for controlling AP mode operations with wpa_supplicant.
It
# should be noted that this is mainly aimed at simple cases like
# WPA2-Personal while more complex configurations like WPA2-Enterprise with an
# external RADIUS server can be supported with hostapd.
#CONFIG_AP=y

# P2P (Wi-Fi Direct)
# This can be used to enable P2P support in wpa_supplicant. See README-P2P for
# more information on P2P operations.
#CONFIG_P2P=y

# Enable TDLS support
#CONFIG_TDLS=y

# Wi-Fi Direct
# This can be used to enable Wi-Fi Direct extensions for P2P using an external
# program to control the additional information exchanges in the messages.
#CONFIG_WIFI_DISPLAY=y

# Autoscan
# This can be used to enable automatic scan support in wpa_supplicant.
# See wpa_supplicant.conf for more information on autoscan usage.
#
# Enabling directly a module will enable autoscan support.
# For exponential module:
#CONFIG_AUTOSCAN_EXPONENTIAL=y
# For periodic module:
#CONFIG_AUTOSCAN_PERIODIC=y

# Password (and passphrase, etc.) backend for external storage
# These optional
mechanisms can be used to add support for storing passwords
# and other secrets in external (to wpa_supplicant) location. This allows, for
# example, operating system specific key storage to be used
#
# External password backend for testing purposes (developer use)
#CONFIG_EXT_PASSWORD_TEST=y

# Enable Fast Session Transfer (FST)
#CONFIG_FST=y

# Enable CLI commands for FST testing
#CONFIG_FST_TEST=y

# OS X builds. This is only for building eapol_test.
#CONFIG_OSX=y
```

```
# Automatic Channel Selection
# This will allow wpa_supplicant to pick the channel automatically when channel
# is set to "0".
#
# TODO: Extend parser to be able to parse "channel=acs_survey" as an alternative
# to "channel=0". This would enable us to eventually add other ACS algorithms in
# similar way.
#
# Automatic selection is currently only done through initialization, later on
# we hope to do background checks to keep us moving to more ideal channels as
# time goes by. ACS is currently only supported through the nl80211
driver and
# your driver must have survey dump capability that is filled by the driver
# during scanning.
#
# TODO: In analogy to hostapd be able to customize the ACS survey algorithm with
# a newly to create wpa_supplicant.conf variable acs_num_scans.
#
# Supported ACS drivers:
# * ath9k
# * ath5k
# * ath10k
#
# For more details refer to:
# http://wireless.kernel.org/en/users/Documentation/acs
#CONFIG_ACS=y

# Support Multi Band Operation
#CONFIG_MBO=y

# Fast Initial Link Setup (FILS) (IEEE 802.11ai)
# Note: This is an experimental and not yet complete implementation. This
# should not be enabled for production use.
#CONFIG_FILS=y
# FILS shared key authentication with PFS
#CONFIG_FILS_SK_PFS=y

# Support RSN on IBSS networks
# This is needed to be able to use mode=1 network profile with proto=RSN and
# key_mgmt=WPA-PSK (i.e., full key management instead of WPA-None).
#CONFIG_IBSS_RSN=y

# External PMKSA cache control
# This can be used to enable control interface commands that
allow the current
# PMKSA cache entries to be fetched and new entries to be added.
#CONFIG_PMKSA_CACHE_EXTERNAL=y
```

```
# Mesh Networking (IEEE 802.11s)
#CONFIG_MESH=y

# Background scanning modules
# These can be used to request wpa_supplicant to perform background scanning
# operations for roaming within an ESS (same SSID). See the bgscan parameter in
# the wpa_supplicant.conf file for more details.
# Periodic background scans based on signal strength
#CONFIG_BGSCAN_SIMPLE=y
# Learn channels used by the network and try to avoid bgscans on other
# channels (experimental)
#CONFIG_BGSCAN_LEARN=y

# Opportunistic Wireless Encryption (OWE)
# Experimental implementation of draft-harkins-owe-07.txt
#CONFIG_OWE=y
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/defconfig
No license file was found, but licenses were detected in source scan.
```

```
/*
```

```
* wpa_supplicant - D-Bus introspection
* Copyright (c) 2006, Dan Williams <dcbw@redhat.com> and Red Hat, Inc.
* Copyright (c) 2009, Witold Sowa <witold.sowa@gmail.com>
* Copyright (c) 2010, Jouni Malinen <j@w1.fi>
*
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*/
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/dbus/dbus_new_introspect.c
No license file was found, but licenses were detected in source scan.
```

```
/*
```

```
* WPA SupPLICANT / dbus-based control interface
* Copyright (c) 2006, Dan Williams <dcbw@redhat.com> and Red Hat, Inc.
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*
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*/
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-
```

gz/wpa\_supplicant/dbus/dbus\_new\_handlers.h

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supplicant/dbus/dbus\_new.h

No license file was found, but licenses were detected in source scan.

/\*

\* wpa\_supplicant module tests

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Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-

gz/wpa\_supplicant/wpas\_module\_tests.c

No license file was found, but licenses were detected in source scan.

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\* WPA SupPLICANT / dbus-based control interface (P2P)

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\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-

gz/wpa\_supplicant/dbus/dbus\_new\_handlers\_p2p.c

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\* EAP method registration

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\*

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Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supplicant/eap\_register.c

No license file was found, but licenses were detected in source scan.

/\*

\* wpa\_supplicant - P2P service discovery

\* Copyright (c) 2009-2010, Atheros Communications

\* Copyright (c) 2010-2014, Jouni Malinen <j@w1.fi>

\*

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\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/p2p\_supPLICANT\_sd.c

No license file was found, but licenses were detected in source scan.

/\*

\* WPA SupPLICANT - background scan and roaming module: simple

\* Copyright (c) 2009-2010, Jouni Malinen <j@w1.fi>

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Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/bgscan\_simple.c

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\* wpa\_gui - WpaMsg class for storing event messages

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Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wpa\_gui-qt4/wpamsg.h

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\* wpa\_supPLICANT D-Bus control interface - internal definitions

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\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/dbus/dbus\_common\_i.h

No license file was found, but licenses were detected in source scan.

```
/*
 * wpa_gui - NetworkConfig class
 * Copyright (c) 2005-2006, Jouni Malinen <j@w1.fi>
 *
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 * See README for more details.
 */
```

Found in path(s):

```
*/opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supPLICANT/wpa_gui-qt4/networkconfig.h
*/opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supPLICANT/wpa_gui-qt4/networkconfig.cpp
```

No license file was found, but licenses were detected in source scan.

```
/*
 * wpa_supPLICANT - WNM
 * Copyright (c) 2011-2013, Qualcomm Atheros, Inc.
 *
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 * See README for more details.
 */
```

Found in path(s):

```
*/opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supPLICANT/wnm_sta.c
```

No license file was found, but licenses were detected in source scan.

```
/*
 * win_if_list - Display network interfaces with description (for Windows)
 * Copyright (c) 2004-2006, Jouni Malinen <j@w1.fi>
 *
 * This software may be distributed under the terms of the BSD license.
 * See README for more details.
 *
 * This small tool is for the Windows build to provide an easy way of fetching
 * a list of available network interfaces.
 */
```

Found in path(s):

```
*/opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supPLICANT/win_if_list.c
```

No license file was found, but licenses were detected in source scan.

```
/*
 * wpa_gui - AddInterface class
 * Copyright (c) 2008, Jouni Malinen <j@w1.fi>
 *
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```

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/wpa\_gui-qt4/addinterface.h

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/wpa\_gui-qt4/addinterface.cpp

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/\*

\* WPA SupPLICant - Driver event processing

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\*

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\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/events.c

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/\*

\* wpa\_supPLICant - Off-channel Action frame TX/RX

\* Copyright (c) 2009-2010, Atheros Communications

\* Copyright (c) 2011, Qualcomm Atheros

\*

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Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/offchannel.c

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/offchannel.h

No license file was found, but licenses were detected in source scan.

/\*

\* wpa\_supPLICant - DPP

\* Copyright (c) 2017, Qualcomm Atheros, Inc.

\*

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\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/dpp\_supPLICant.h

No license file was found, but licenses were detected in source scan.

/\*



\* wpa\_gui - UserDataRequest class  
\* Copyright (c) 2005-2006, Jouni Malinen <j@w1.fi>  
\*  
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\* See README for more details.  
\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wpa\_gui-qt4/userdatarequest.cpp  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wpa\_gui-qt4/userdatarequest.h

No license file was found, but licenses were detected in source scan.

## WPA SupPLICANT

=====

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#### Features

-----

Supported WPA/IEEE 802.11i features:

-

WPA-PSK ("WPA-Personal")

- WPA with EAP (e.g., with RADIUS authentication server) ("WPA-Enterprise")

Following authentication methods are supported with an integrate IEEE 802.1X

Supplicant:

\* EAP-TLS

\* EAP-PEAP/MSCHAPv2 (both PEAPv0 and PEAPv1)

\* EAP-PEAP/TLS (both PEAPv0 and PEAPv1)

\* EAP-PEAP/GTC (both PEAPv0 and PEAPv1)

\* EAP-PEAP/OTP (both PEAPv0 and PEAPv1)

\* EAP-PEAP/MD5-Challenge (both PEAPv0 and PEAPv1)

\* EAP-TTLS/EAP-MD5-Challenge

\* EAP-TTLS/EAP-GTC

\* EAP-TTLS/EAP-OTP

\* EAP-TTLS/EAP-MSCHAPv2

\* EAP-TTLS/EAP-TLS

\* EAP-TTLS/MSCHAPv2

\* EAP-TTLS/MSCHAP

\* EAP-TTLS/PAP

\* EAP-TTLS/CHAP

\* EAP-SIM

\* EAP-AKA

\* EAP-AKA'

\* EAP-PSK

\* EAP-PAX

\* EAP-SAKE

\* EAP-IKEv2

\* EAP-GPSK

- \* EAP-pwd
- \* LEAP (note: requires special support from the driver for IEEE 802.11 authentication)
- (following methods are supported, but since they do not generate keying material, they cannot be used with WPA or IEEE 802.1X WEP keying)
- \* EAP-MD5-Challenge
- \* EAP-MSCHAPv2
- \* EAP-GTC
- \* EAP-OTP
- key management for CCMP, TKIP, WEP104, WEP40
- RSN/WPA2 (IEEE 802.11i)
- \* pre-authentication
- \* PMKSA caching

Supported TLS/crypto libraries:

- OpenSSL (default)
- GnuTLS

Internal TLS/crypto implementation (optional):

- can be used in place of an external TLS/crypto library
- TLSv1
- X.509 certificate processing
- PKCS #1
- ASN.1
- RSA
- bignum
- minimal size (ca. 50 kB binary, parts of which are already needed for WPA; TLSv1/X.509/ASN.1/RSA/bignum parts are about 25 kB on x86)

Requirements

-----

Current hardware/software requirements:

- Linux kernel 2.4.x or 2.6.x with Linux Wireless Extensions v15 or newer
- FreeBSD 6-CURRENT
- NetBSD-current
- Microsoft Windows with WinPcap (at least WinXP, may work with other versions)
- drivers:

Linux drivers that support cfg80211/nl80211. Even though there are number of driver specific interface included in wpa\_supplicant, please note that Linux drivers are moving to use generic wireless configuration interface driver\_nl80211 (-Dnl80211 on wpa\_supplicant command line) should be the default option to start with before falling back to driver specific interface.

Linux drivers that support WPA/WPA2 configuration with the generic

Linux wireless extensions (WE-18 or newer). Obsoleted by nl80211.

In theory, any driver that supports Linux wireless extensions can be used with IEEE 802.1X (i.e., not WPA) when using ap\_scan=0 option in configuration file.

Wired Ethernet drivers (with ap\_scan=0)

BSD net80211 layer (e.g., Atheros driver)

At the moment, this is for FreeBSD 6-CURRENT branch and NetBSD-current.

Windows NDIS

The current Windows port requires WinPcap (<http://winpcap.polito.it/>).

See README-Windows.txt for more information.

wpa\_supplicant was designed to be portable for different drivers and operating systems. Hopefully, support for more wlan cards and OSes will be added in the future. See developer's documentation ([http://hostap.epitest.fi/wpa\\_supplicant/devel/](http://hostap.epitest.fi/wpa_supplicant/devel/)) for more information about the design of wpa\_supplicant and porting to other drivers. One main goal is to add full WPA/WPA2 support to Linux wireless extensions to allow new drivers to be supported without having to implement new driver-specific interface code in wpa\_supplicant.

Optional libraries for layer2 packet processing:

- libpcap (tested with 0.7.2, most relatively recent versions assumed to work, this is likely to be available with most distributions, <http://tcpdump.org/>)
- libdnet (tested with v1.4, most versions assumed to work, <http://libdnet.sourceforge.net/>)

These libraries are not used in the default Linux build. Instead, internal Linux specific implementation is used. libpcap/libdnet are more portable and they can be used by adding CONFIG\_L2\_PACKET=pcap into .config. They may also be selected automatically for other operating systems. In case of Windows builds, WinPcap is used by default (CONFIG\_L2\_PACKET=winpcap).

Optional libraries for EAP-TLS, EAP-PEAP, and EAP-TTLS:

- OpenSSL (tested with 1.0.1 and 1.0.2 versions; assumed to work with most relatively recent versions; this is likely to be available with most distributions, <http://www.openssl.org/>)
- GnuTLS
- internal TLSv1 implementation

One of these libraries is needed when EAP-TLS, EAP-PEAP, EAP-TTLS, or EAP-FAST support is enabled. WPA-PSK mode does not require this or EAPOL/EAP implementation. A configuration file, .config, for compilation is needed to enable IEEE 802.1X/EAPOL and EAP methods. Note that EAP-MD5, EAP-GTC, EAP-OTP, and EAP-MSCHAPV2 cannot be used alone with WPA, so they should only be enabled if testing the EAPOL/EAP state machines. However, there can be used as inner authentication algorithms with EAP-PEAP and EAP-TTLS.

See Building and installing section below for more detailed information about the wpa\_supplicant build time configuration.

## WPA

---

The original security mechanism of IEEE 802.11 standard was not designed to be strong and has proven to be insufficient for most networks that require some kind of security. Task group I (Security) of IEEE 802.11 working group (<http://www.ieee802.org/11/>) has worked to address the flaws of the base standard and has in practice completed its work in May 2004. The IEEE 802.11i amendment to the IEEE 802.11 standard was approved in June 2004 and published in July 2004.

Wi-Fi Alliance (<http://www.wi-fi.org/>) used a draft version of the IEEE 802.11i work (draft 3.0) to define a subset of the security enhancements that can be implemented with existing wlan hardware. This is called Wi-Fi Protected Access<TM> (WPA). This has now become a mandatory component of interoperability testing and certification done by Wi-Fi Alliance. Wi-Fi provides information about WPA at its web site ([http://www.wi-fi.org/OpenSection/protected\\_access.asp](http://www.wi-fi.org/OpenSection/protected_access.asp)).

IEEE 802.11 standard defined wired equivalent privacy (WEP) algorithm for protecting wireless networks. WEP uses RC4 with 40-bit keys, 24-bit initialization vector (IV), and CRC32 to protect against packet forgery. All these choices have proven to be insufficient: key space is too small against current attacks, RC4 key scheduling is insufficient (beginning of the pseudorandom stream should be skipped), IV space is too small and IV reuse makes attacks easier, there is no replay protection, and non-keyed authentication does not protect against bit flipping packet data.

WPA is an intermediate solution for the security issues. It uses Temporal Key Integrity Protocol (TKIP) to replace WEP. TKIP is a compromise on strong security and possibility to use existing

hardware. It still uses RC4 for the encryption like WEP, but with per-packet RC4 keys. In addition, it implements replay protection, keyed packet authentication mechanism (Michael MIC).

Keys can be managed using two different mechanisms. WPA can either use an external authentication server (e.g., RADIUS) and EAP just like IEEE 802.1X is using or pre-shared keys without need for additional servers. Wi-Fi calls these "WPA-Enterprise" and "WPA-Personal", respectively. Both mechanisms will generate a master session key for the Authenticator (AP) and Supplicant (client station).

WPA implements a new key handshake (4-Way Handshake and Group Key Handshake) for generating and exchanging data encryption keys between the Authenticator and Supplicant. This handshake is also used to verify that both Authenticator and Supplicant know the master session key. These handshakes are identical regardless of the selected key management mechanism (only the method for generating master session key changes).

#### IEEE 802.11i / WPA2

-----

The design for parts of IEEE 802.11i that were not included in WPA has finished (May 2004) and this amendment to IEEE 802.11 was approved in June 2004. Wi-Fi Alliance is using the final IEEE 802.11i as a new version of WPA called WPA2. This includes, e.g., support for more robust encryption algorithm (CCMP: AES in Counter mode with CBC-MAC) to replace TKIP and optimizations for handoff (reduced number of messages in initial key handshake, pre-authentication, and PMKSA caching).

#### wpa\_supplicant

-----

wpa\_supplicant is an implementation of the WPA Supplicant component, i.e., the part that runs in the client stations. It implements WPA key negotiation with a WPA Authenticator and EAP authentication with Authentication Server. In addition, it controls the roaming and IEEE 802.11 authentication/association of the wlan driver.

wpa\_supplicant is designed to be a "daemon" program that runs in the background and acts as the backend component controlling the wireless connection. wpa\_supplicant supports separate frontend programs and an

example text-based frontend, wpa\_cli, is included with wpa\_supplicant.

Following steps are used when associating with an AP using WPA:

- wpa\_supplicant requests the kernel driver to scan neighboring BSSes
- wpa\_supplicant selects a BSS based on its configuration
- wpa\_supplicant requests the kernel driver to associate with the chosen BSS
- If WPA-EAP: integrated IEEE 802.1X Supplicant completes EAP authentication with the authentication server (proxied by the Authenticator in the AP)
- If WPA-EAP: master key is received from the IEEE 802.1X Supplicant
- If WPA-PSK: wpa\_supplicant uses PSK as the master session key
- wpa\_supplicant completes WPA 4-Way Handshake and Group Key Handshake with the Authenticator (AP)
- wpa\_supplicant configures encryption keys for unicast and broadcast
- normal data packets can be transmitted and received

#### Building and installing

-----

In order to be able to build wpa\_supplicant, you will first need to select which parts of it will be included. This is done by creating a build time configuration file, .config, in the wpa\_supplicant root directory. Configuration options are text lines using following format: CONFIG\_<option>=y. Lines starting with # are considered comments and are ignored. See defconfig file for an example configuration and a list of available options and additional notes.

The build time configuration can be used to select only the needed features and limit the binary size and requirements for external libraries. The main configuration parts are the selection of which driver interfaces (e.g., nl80211, wext, ..) and which authentication methods (e.g., EAP-TLS, EAP-PEAP, ..) are included.

Following build time configuration options are used to control IEEE 802.1X/EAPOL and EAP state machines and all EAP methods. Including TLS, PEAP, or TTLS will require linking wpa\_supplicant with OpenSSL library for TLS implementation. Alternatively, GnuTLS or the internal TLSv1 implementation can be used for TLS functionality.

```
CONFIG_IEEE8021X_EAPOL=y
CONFIG_EAP_MD5=y
CONFIG_EAP_MSCHAPV2=y
```

```
CONFIG_EAP_TLS=y
CONFIG_EAP_PEAP=y
CONFIG_EAP_TTLS=y
CONFIG_EAP_GTC=y
CONFIG_EAP_OTP=y
CONFIG_EAP_SIM=y
CONFIG_EAP_AKA=y
CONFIG_EAP_AKA_PRIME=y
CONFIG_EAP_PSK=y
CONFIG_EAP_SAKE=y
CONFIG_EAP_GPSK=y
CONFIG_EAP_PAX=y
CONFIG_EAP_LEAP=y
CONFIG_EAP_IKEV2=y
CONFIG_EAP_PWD=y
```

Following

option can be used to include GSM SIM/USIM interface for GSM/UMTS authentication algorithm (for EAP-SIM/EAP-AKA/EAP-AKA'). This requires psc-lite (<http://www.linuxnet.com/>) for smart card access.

```
CONFIG_PCSC=y
```

Following options can be added to .config to select which driver interfaces are included.

```
CONFIG_DRIVER_NL80211=y
CONFIG_DRIVER_WEXT=y
CONFIG_DRIVER_BSD=y
CONFIG_DRIVER_NDIS=y
```

Following example includes some more features and driver interfaces that are included in the wpa\_supplicant package:

```
CONFIG_DRIVER_NL80211=y
CONFIG_DRIVER_WEXT=y
CONFIG_DRIVER_BSD=y
CONFIG_DRIVER_NDIS=y
CONFIG_IEEE8021X_EAPOL=y
CONFIG_EAP_MD5=y
CONFIG_EAP_MSCHAPV2=y
CONFIG_EAP_TLS=y
CONFIG_EAP_PEAP=y
CONFIG_EAP_TTLS=y
CONFIG_EAP_GTC=y
CONFIG_EAP_OTP=y
CONFIG_EAP_SIM=y
CONFIG_EAP_AKA=y
```



```
CONFIG_EAP_PSK=y
CONFIG_EAP_SAKE=y
CONFIG_EAP_GPSK=y
CONFIG_EAP_PAX=y
CONFIG_EAP_LEAP=y
CONFIG_EAP_IKEV2=y
CONFIG_PCSC=y
```

#### EAP-PEAP and EAP-TTLS

will automatically include configured EAP methods (MD5, OTP, GTC, MSCHAPV2) for inner authentication selection.

After you have created a configuration file, you can build `wpa_supplicant` and `wpa_cli` with 'make' command. You may then install the binaries to a suitable system directory, e.g., `/usr/local/bin`.

Example commands:

```
# build wpa_supplicant and wpa_cli
make
# install binaries (this may need root privileges)
cp wpa_cli wpa_supplicant /usr/local/bin
```

You will need to make a configuration file, e.g., `/etc/wpa_supplicant.conf`, with network configuration for the networks you are going to use. Configuration file section below includes explanation fo the configuration file format and includes various examples. Once the configuration is ready, you can test whether the configuration work by first running `wpa_supplicant` with following command to start it on foreground with debugging enabled:

```
wpa_supplicant -iwlan0 -c/etc/wpa_supplicant.conf -d
```

Assuming everything goes fine, you can start using following command to start `wpa_supplicant` on background without debugging:

```
wpa_supplicant -iwlan0 -c/etc/wpa_supplicant.conf -B
```

Please note that if you included more than one driver interface in the build time configuration (`.config`), you may need to specify which interface to use by including `-D<driver name>` option on the command line. See following section for more details on command line options for `wpa_supplicant`.

## Command line options

### usage:

```
wpa_supplicant [-BddfhhKLqqtuvW] [-P<pid file>] [-g<global ctrl>] \  
  [-G<group>] \  
  -i<iface> -c<config file> [-C<ctrl>] [-D<driver>] [-p<driver_param>] \  
  [-b<br_iface> [-MN -i<iface> -c<conf> [-C<ctrl>] [-D<driver>] \  
  [-p<driver_param>] [-b<br_iface>] [-m<P2P Device config file>] ...
```

### options:

- b = optional bridge interface name
- B = run daemon in the background
- c = Configuration file
- C = ctrl\_interface parameter (only used if -c is not)
- i = interface name
- d = increase debugging verbosity (-dd even more)
- D = driver name (can be multiple drivers: nl80211,wext)
- f = Log output to default log location (normally /tmp)
- g = global ctrl\_interface
- G = global ctrl\_interface group
- K = include keys (passwords, etc.) in debug output
- t = include timestamp in debug messages
- h = show this help text
- L = show license (BSD)
- p = driver parameters
- P = PID file
- q = decrease debugging verbosity (-qq even less)
- u = enable DBus control interface
- v = show version
- W = wait for a control interface monitor before starting
- M = start describing matching interface
- N = start describing new interface
- m = Configuration file for the P2P Device

### drivers:

- nl80211 = Linux nl80211/cfg80211
- wext = Linux wireless extensions (generic)
- wired = wpa\_supplicant wired Ethernet driver
- roboswitch = wpa\_supplicant Broadcom switch driver
- bsd = BSD 802.11 support (Atheros, etc.)
- ndis = Windows NDIS driver

### In most common

cases, wpa\_supplicant is started with

```
wpa_supplicant -B -c/etc/wpa_supplicant.conf -iwlan0
```

This makes the process fork into background.

The easiest way to debug problems, and to get debug log for bug reports, is to start wpa\_supplicant on foreground with debugging enabled:

```
wpa_supplicant -c/etc/wpa_supplicant.conf -iwlan0 -d
```

If the specific driver wrapper is not known beforehand, it is possible to specify multiple comma separated driver wrappers on the command line. wpa\_supplicant will use the first driver wrapper that is able to initialize the interface.

```
wpa_supplicant -Dnl80211,wext -c/etc/wpa_supplicant.conf -iwlan0
```

wpa\_supplicant can control multiple interfaces (radios) either by running one process for each interface separately or by running just one process and list of options at command line. Each interface is separated with -N argument. As an example, following command would start wpa\_supplicant for two interfaces:

```
wpa_supplicant \  
-c wpa1.conf -i wlan0 -D nl80211 -N \  
\  
-c wpa2.conf -i wlan1 -D wext
```

If the interfaces on which wpa\_supplicant is to run are not known or do not exist, wpa\_supplicant can match an interface when it arrives. Each matched interface is separated with -M argument and the -i argument now allows for pattern matching.

As an example, the following command would start wpa\_supplicant for a specific wired interface called lan0, any interface starting with wlan and lastly any other interface. Each match has its own configuration file, and for the wired interface a specific driver has also been given.

```
wpa_supplicant \  
-M -c wpa_wired.conf -ilan0 -D wired \  
-M -c wpa1.conf -iwlan* \  
-M -c wpa2.conf
```

If the interface is added in a Linux bridge (e.g., br0), the bridge interface needs to be configured to wpa\_supplicant in addition to the

main interface:

```
wpa_supplicant -cw.conf -Dnl80211 -iwlan0 -bbr0
```

## Configuration file

-----

wpa\_supplicant is configured using a text file that lists all accepted networks and security policies, including pre-shared keys. See example configuration file, wpa\_supplicant.conf, for detailed information about the configuration format and supported fields.

Changes to configuration file can be reloaded by sending SIGHUP signal to wpa\_supplicant ('killall -HUP wpa\_supplicant'). Similarly, reloading can be triggered with 'wpa\_cli reconfigure' command.

Configuration file can include one or more network blocks, e.g., one for each used SSID. wpa\_supplicant will automatically select the best network based on the order of network blocks in the configuration file, network security level (WPA/WPA2 is preferred), and signal strength.

Example configuration files for some common configurations:

1) WPA-Personal (PSK) as home network and WPA-Enterprise with EAP-TLS as work network

```
# allow frontend (e.g., wpa_cli) to be used by all users in 'wheel' group
ctrl_interface=/var/run/wpa_supplicant
ctrl_interface_group=wheel
#
# home network; allow all valid ciphers
network={
    ssid="home"
    scan_ssid=1
    key_mgmt=WPA-PSK
    psk="very
secret passphrase"
}
#
# work network; use EAP-TLS with WPA; allow only CCMP and TKIP ciphers
network={
    ssid="work"
    scan_ssid=1
    key_mgmt=WPA-EAP
    pairwise=CCMP TKIP
```

```
group=CCMP TKIP
eap=TLS
identity="user@example.com"
ca_cert="/etc/cert/ca.pem"
client_cert="/etc/cert/user.pem"
private_key="/etc/cert/user.prv"
private_key_passwd="password"
}
```

- 2) WPA-RADIUS/EAP-PEAP/MSCHAPv2 with RADIUS servers that use old peaplabel  
(e.g., Funk Odyssey and SBR, Meetinghouse Aegis, Interlink RAD-Series)

```
ctrl_interface=/var/run/wpa_supplicant
ctrl_interface_group=wheel
network={
ssid="example"
scan_ssid=1
key_mgmt=WPA-EAP
eap=PEAP
identity="user@example.com"
password="foobar"
ca_cert="/etc/cert/ca.pem"
phase1="peaplabel=0"
phase2="auth=MSCHAPV2"
}
```

- 3) EAP-TTLS/EAP-MD5-Challenge configuration with anonymous identity for the  
unencrypted use. Real identity is sent only within an encrypted TLS tunnel.

```
ctrl_interface=/var/run/wpa_supplicant
ctrl_interface_group=wheel
network={
ssid="example"
scan_ssid=1
key_mgmt=WPA-EAP
eap=TTLS
identity="user@example.com"
anonymous_identity="anonymous@example.com"
password="foobar"
ca_cert="/etc/cert/ca.pem"
phase2="auth=MD5"
}
```

- 4)

IEEE 802.1X (i.e., no WPA) with dynamic WEP keys (require both unicast and broadcast); use EAP-TLS for authentication

```
ctrl_interface=/var/run/wpa_supplicant
ctrl_interface_group=wheel
network={
    ssid="1x-test"
    scan_ssid=1
    key_mgmt=IEEE8021X
    eap=TLS
    identity="user@example.com"
    ca_cert="/etc/cert/ca.pem"
    client_cert="/etc/cert/user.pem"
    private_key="/etc/cert/user.prv"
    private_key_passwd="password"
    eapol_flags=3
}
```

5) Catch all example that allows more or less all configuration modes. The configuration options are used based on what security policy is used in the selected SSID. This is mostly for testing and is not recommended for normal use.

```
ctrl_interface=/var/run/wpa_supplicant
ctrl_interface_group=wheel
network={
    ssid="example"
    scan_ssid=1
    key_mgmt=WPA-EAP
    WPA-PSK IEEE8021X NONE
    pairwise=CCMP TKIP
    group=CCMP TKIP WEP104 WEP40
    psk="very secret passphrase"
    eap=TTLS PEAP TLS
    identity="user@example.com"
    password="foobar"
    ca_cert="/etc/cert/ca.pem"
    client_cert="/etc/cert/user.pem"
    private_key="/etc/cert/user.prv"
    private_key_passwd="password"
    phase1="peaplabel=0"
    ca_cert2="/etc/cert/ca2.pem"
    client_cert2="/etc/cer/user.pem"
    private_key2="/etc/cer/user.prv"
    private_key2_passwd="password"
}
```

6) Authentication for wired Ethernet. This can be used with 'wired' or 'roboswitch' interface (-Dwired or -Droboswitch on command line).

```
ctrl_interface=/var/run/wpa_supplicant
ctrl_interface_group=wheel
ap_scan=0
network={
  key_mgmt=IEEE8021X
  eap=MD5
  identity="user"
  password="password"
  eapol_flags=0
}
```

#### Certificates

-----

Some EAP authentication methods require use of certificates. EAP-TLS uses both server side and client certificates whereas EAP-PEAP and EAP-TTLS only require the server side certificate. When client certificate is used, a matching private key file has to also be included in configuration. If the private key uses a passphrase, this has to be configured in wpa\_supplicant.conf ("private\_key\_passwd").

wpa\_supplicant supports X.509 certificates in PEM and DER formats. User certificate and private key can be included in the same file.

If the user certificate and private key is received in PKCS#12/PFX format, they need to be converted to suitable PEM/DER format for wpa\_supplicant. This can be done, e.g., with following commands:

```
# convert client certificate and private key to PEM format
openssl pkcs12 -in example.pfx -out user.pem -clcerts
# convert CA certificate (if included in PFX file) to PEM format
openssl pkcs12 -in example.pfx -out ca.pem -cacerts -nokeys
```

#### wpa\_cli

-----

wpa\_cli is a text-based frontend program for interacting with wpa\_supplicant. It is used to query current status, change

configuration, trigger events, and request interactive user input.

wpa\_cli can show the current authentication status, selected security mode, dot11 and dot1x MIBs, etc. In addition, it can configure some variables like EAPOL state machine parameters and trigger events like reassociation and IEEE 802.1X logoff/logon. wpa\_cli provides a user interface to request authentication information, like username and password, if these are not included in the configuration. This can be used to implement, e.g., one-time-passwords or generic token card authentication where the authentication is based on a challenge-response that uses an external device for generating the response.

The control interface of wpa\_supplicant can be configured to allow non-root user access (ctrl\_interface\_group in the configuration file). This makes it possible to run wpa\_cli with a normal user account.

wpa\_cli supports two modes: interactive and command line. Both modes share the same command set and the main difference is in interactive mode providing access to unsolicited messages (event messages, username/password requests).

Interactive mode is started when wpa\_cli is executed without including the command as a command line parameter. Commands are then entered on the wpa\_cli prompt. In command line mode, the same commands are entered as command line arguments for wpa\_cli.

Interactive authentication parameters request

When wpa\_supplicant need authentication parameters, like username and password, which are not present in the configuration file, it sends a request message to all attached frontend programs, e.g., wpa\_cli in interactive mode. wpa\_cli shows these requests with "CTRL-REQ-<type>-<id>:<text>" prefix. <type> is IDENTITY, PASSWORD, or OTP (one-time-password). <id> is a unique identifier for the current network. <text> is description of the request. In case of OTP request, it includes the challenge from the authentication server.

The reply to these requests can be given with 'identity', 'password', and 'otp' commands. <id> needs to be copied from the the matching request. 'password' and 'otp' commands can be used regardless of whether the request was for PASSWORD or OTP. The main difference between these two commands is that values given with 'password' are



remembered as long as wpa\_supplicant is running whereas values given with 'otp' are used only once and then forgotten, i.e., wpa\_supplicant will ask frontend for a new value for every use. This can be used to implement one-time-password lists and generic token card -based authentication.

Example request for password and a matching reply:

```
CTRL-REQ-PASSWORD-1:Password needed for SSID foobar  
> password 1 mysecretpassword
```

Example request for generic token card challenge-response:

```
CTRL-REQ-OTP-2:Challenge 1235663 needed for SSID foobar  
> otp 2 9876
```

wpa\_cli commands

```
status = get current WPA/EAPOL/EAP status  
mib = get MIB variables (dot1x, dot11)  
help = show this usage help  
interface [ifname] = show interfaces/select interface  
level <debug level>  
= change debug level  
license = show full wpa_cli license  
logoff = IEEE 802.1X EAPOL state machine logoff  
logon = IEEE 802.1X EAPOL state machine logon  
set = set variables (shows list of variables when run without arguments)  
pmksa = show PMKSA cache  
reassociate = force reassociation  
reconfigure = force wpa_supplicant to re-read its configuration file  
preauthenticate <BSSID> = force preauthentication  
identity <network id> <identity> = configure identity for an SSID  
password <network id> <password> = configure password for an SSID  
pin <network id> <pin> = configure pin for an SSID  
otp <network id> <password> = configure one-time-password for an SSID  
passphrase <network id> <passphrase> = configure private key passphrase  
for an SSID  
bssid <network id> <BSSID> = set preferred BSSID for an SSID  
list_networks = list configured networks  
select_network <network id> = select a network (disable others)  
enable_network <network id> = enable a network  
disable_network  
<network id> = disable a network  
add_network = add a network  
remove_network <network id> = remove a network  
set_network <network id> <variable> <value> = set network variables (shows
```

list of variables when run without arguments)  
get\_network <network id> <variable> = get network variables  
save\_config = save the current configuration  
disconnect = disconnect and wait for reassociate command before connecting  
scan = request new BSS scan  
scan\_results = get latest scan results  
get\_capability <eap/pairwise/group/key\_mgmt/proto/auth\_alg> = get capabilities  
terminate = terminate wpa\_supplicant  
quit = exit wpa\_cli

wpa\_cli command line options

```
wpa_cli [-p<path to ctrl sockets>] [-i<ifname>] [-hvB] [-a<action file>] \  
  [-P<pid file>] [-g<global ctrl>] [command..]  
-h = help (show this usage text)  
-v = shown version information  
-a = run in daemon mode executing the action file based on events from  
  wpa_supplicant  
-B = run a daemon in the background  
default path: /var/run/wpa_supplicant  
default interface: first interface found in socket path
```

Using wpa\_cli to run external program on connect/disconnect

-----  
wpa\_cli can be used to run external programs whenever wpa\_supplicant connects or disconnects from a network. This can be used, e.g., to update network configuration and/or trigger DHCP client to update IP addresses, etc.

One wpa\_cli process in "action" mode needs to be started for each interface. For example, the following command starts wpa\_cli for the default interface (-i can be used to select the interface in case of more than one interface being used at the same time):

```
wpa_cli -a/sbin/wpa_action.sh -B
```

The action file (-a option, /sbin/wpa\_action.sh in this example) will be executed whenever wpa\_supplicant completes authentication (connect event) or detects disconnection. The action script will be called with two command line arguments: interface name and event (CONNECTED or DISCONNECTED). If the action script needs to get more information about the current network, it can use 'wpa\_cli status' to query wpa\_supplicant for more information.

Following example can be used as a simple template for an action script:

```
#!/bin/sh

IFNAME=$1
CMD=$2

if [ "$CMD" = "CONNECTED" ]; then
    SSID=`wpa_cli -i$IFNAME status | grep ^ssid= | cut -f2- -d=`
    # configure network, signal DHCP client, etc.
fi

if [ "$CMD" = "DISCONNECTED" ]; then
    # remove network configuration, if needed
    SSID=
fi
```

Integrating with pcmcia-cs/cardmgr scripts

-----

wpa\_supplicant needs to be running when using a wireless network with WPA. It can be started either from system startup scripts or from pcmcia-cs/cardmgr scripts (when using PC Cards). WPA handshake must be completed before data frames can be exchanged, so wpa\_supplicant should be started before DHCP client.

For example, following small changes to pcmcia-cs scripts can be used to enable WPA support:

Add MODE="Managed" and WPA="y" to the network scheme in /etc/pcmcia/wireless.opts.

Add the following block to the end of 'start' action handler in /etc/pcmcia/wireless:

```
if [ "$WPA" = "y" -a -x /usr/local/bin/wpa_supplicant ]; then
/usr/local/bin/wpa_supplicant -B -c/etc/wpa_supplicant.conf \
-i$DEVICE
fi
```

Add the following block to the end of 'stop' action handler (may need to be separated from other actions) in /etc/pcmcia/wireless:

```
if [ "$WPA" = "y" -a -x /usr/local/bin/wpa_supplicant ]; then
```

```
killall wpa_supplicant
fi
```

This will make cardmgr start wpa\_supplicant when the card is plugged in.

#### Dynamic interface add and operation without configuration files

-----

wpa\_supplicant can be started without any configuration files or network interfaces. When used in this way, a global (i.e., per wpa\_supplicant process) control interface is used to add and remove network interfaces.

Each network interface can then be configured through a per-network interface control interface. For example, following commands show how to start wpa\_supplicant without any network interfaces and then add a network interface and configure a network (SSID):

```
# Start wpa_supplicant in the background
wpa_supplicant -g/var/run/wpa_supplicant-global -B

# Add a new interface (wlan0, no configuration file, driver=nl80211, and
# enable control interface)
wpa_cli -g/var/run/wpa_supplicant-global interface_add wlan0 \
"" nl80211 /var/run/wpa_supplicant

# Configure a network using the newly added network interface:
wpa_cli -iwlan0 add_network
wpa_cli -iwlan0 set_network 0 ssid ""test""
wpa_cli -iwlan0 set_network 0 key_mgmt WPA-PSK
wpa_cli -iwlan0 set_network 0 psk ""12345678""
wpa_cli -iwlan0 set_network 0 pairwise TKIP
wpa_cli -iwlan0 set_network 0 group TKIP
wpa_cli -iwlan0 set_network 0 proto WPA
wpa_cli -iwlan0 enable_network 0

# At this point, the new network interface should start
trying to associate
# with the WPA-PSK network using SSID test.

# Remove network interface
wpa_cli -g/var/run/wpa_supplicant-global interface_remove wlan0
```

Privilege separation

-----

To minimize the size of code that needs to be run with root privileges (e.g., to control wireless interface operation), wpa\_supplicant supports optional privilege separation. If enabled, this separates the privileged operations into a separate process (wpa\_priv) while leaving rest of the code (e.g., EAP authentication and WPA handshakes) into an unprivileged process (wpa\_supplicant) that can be run as non-root user. Privilege separation restricts the effects of potential software errors by containing the majority of the code in an unprivileged process to avoid full system compromise.

Privilege separation is not enabled by default and it can be enabled by adding CONFIG\_PRIVSEP=y to the build configuration (.config). When enabled, the privileged operations (driver wrapper and l2\_packet) are linked into a separate daemon program, wpa\_priv. The unprivileged program, wpa\_supplicant, will be built with a special driver/l2\_packet wrappers that communicate with the privileged wpa\_priv process to perform the needed operations. wpa\_priv can control what privileged are allowed.

wpa\_priv needs to be run with network admin privileges (usually, root user). It opens a UNIX domain socket for each interface that is included on the command line; any other interface will be off limits for wpa\_supplicant in this kind of configuration. After this, wpa\_supplicant can be run as a non-root user (e.g., all standard users on a laptop or as a special non-privileged user account created just for this purpose to limit access to user files even further).

Example configuration:

- create user group for users that are allowed to use wpa\_supplicant ('wpa\_priv' in this example) and assign users that should be able to use wpa\_supplicant into that group
- create /var/run/wpa\_priv directory for UNIX domain sockets and control user access by setting it accessible only for the wpa\_priv group:

```
mkdir /var/run/wpa_priv
chown root:wpa_priv /var/run/wpa_priv
chmod 0750 /var/run/wpa_priv
```
- start wpa\_priv as root (e.g., from system startup scripts) with the enabled interfaces configured on the command line:

```
wpa_priv -B -P /var/run/wpa_priv.pid nl80211:wlan0
```
- run wpa\_supplicant as non-root with a user that is in wpa\_priv group:

```
wpa_supplicant -i ath0 -c wpa_supplicant.conf
```

wpa\_priv does not use the network interface before wpa\_supplicant is

started, so it is fine to include network interfaces that are not available at the time wpa\_priv is started. As an alternative, wpa\_priv can be started when an interface is added (hotplug/udev/etc. scripts). wpa\_priv can control multiple interface with one process, but it is also possible to run multiple wpa\_priv processes at the same time, if desired.

It should be noted that the interface used between wpa\_supplicant and wpa\_priv does not include all the capabilities of the wpa\_supplicant driver interface and at times, this interface lacks update especially for recent addition. Consequently, use of wpa\_priv does come with the price of somewhat reduced available functionality. The next section describing how wpa\_supplicant can be used with reduced privileges without having to handle the complexity of separate wpa\_priv. While that approve does not provide separation for network admin capabilities, it does allow other root privileges to be dropped without the drawbacks of the wpa\_priv process.

#### Linux capabilities instead of privileged process

-----

wpa\_supplicant performs operations that need special permissions, e.g., to control the network connection. Traditionally this has been achieved by running wpa\_supplicant as a privileged process with effective user id 0 (root). Linux capabilities can be used to provide restricted set of capabilities to match the functions needed by wpa\_supplicant.

The minimum set of capabilities needed for the operations is CAP\_NET\_ADMIN and CAP\_NET\_RAW.

setcap(8) can be used to set file capabilities. For example:

```
sudo setcap cap_net_raw,cap_net_admin+ep wpa_supplicant
```

Please note that this would give anyone being able to run that wpa\_supplicant binary access to the additional capabilities. This can further be limited by file owner/group and mode bits. For example:

```
sudo chown wpas wpa_supplicant
sudo chmod 0100 wpa_supplicant
```

This combination of setcap, chown, and chmod commands would allow wpas user to execute wpa\_supplicant with additional network admin/raw capabilities.

Common way style of creating a control interface socket in

/var/run/wpa\_supplicant could not be done by this user, but this directory could be created before starting the wpa\_supplicant and set to suitable mode to allow wpa\_supplicant to create sockets there. Alternatively, other directory or abstract socket namespace could be used for the control interface.

#### External

requests for radio control

External programs can request wpa\_supplicant to not start offchannel operations during other tasks that may need exclusive control of the radio. The RADIO\_WORK control interface command can be used for this.

"RADIO\_WORK add <name> [freq=<MHz>] [timeout=<seconds>]" command can be used to reserve a slot for radio access. If freq is specified, other radio work items on the same channel may be completed in parallel. Otherwise, all other radio work items are blocked during execution. Timeout is set to 10 seconds by default to avoid blocking wpa\_supplicant operations for excessive time. If a longer (or shorter) safety timeout is needed, that can be specified with the optional timeout parameter. This command returns an identifier for the radio work item.

Once the radio work item has been started, "EXT-RADIO-WORK-START <id>" event message is indicated that the external processing can start. Once the operation has been completed, "RADIO\_WORK done <id>" is used to indicate that to wpa\_supplicant. This allows other radio works to be performed. If this command is forgotten (e.g., due to the external program terminating), wpa\_supplicant will time out the radio work item and send "EXT-RADIO-WORK-TIMEOUT <id>" event to indicate that this has happened. "RADIO\_WORK done <id>" can also be used to cancel items that have not yet been started.

For example, in wpa\_cli interactive mode:

```
> radio_work add test
1
<3>EXT-RADIO-WORK-START 1
> radio_work show
ext:test@wlan0:0:1:2.487797
> radio_work done 1
OK
> radio_work show
```

```
> radio_work done 3
OK
> radio_work show
ext:test freq=2412 timeout=30@wlan0:2412:1:28.583483
<3>EXT-RADIO-WORK-TIMEOUT 2
```

```
> radio_work add test2 freq=2412 timeout=60
5
<3>EXT-RADIO-WORK-START 5
> radio_work add test3
6
> radio_work add test4
7
> radio_work show
ext:test2 freq=2412 timeout=60@wlan0:2412:1:9.751844
ext:test3@wlan0:0:0:5.071812
ext:test4@wlan0:0:0:3.143870
> radio_work done
6
OK
> radio_work show
ext:test2 freq=2412 timeout=60@wlan0:2412:1:16.287869
ext:test4@wlan0:0:0:9.679895
> radio_work done 5
OK
<3>EXT-RADIO-WORK-START 7
<3>EXT-RADIO-WORK-TIMEOUT 7
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supPLICANT/README
No license file was found, but licenses were detected in source scan.
```

```
/*
* IEEE 802.1X-2010 KaY Interface
* Copyright (c) 2013-2014, Qualcomm Atheros, Inc.
*
* This software may be distributed under the terms of the BSD license.
* See README for more details.
*/
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supPLICANT/wpas_kay.c
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supPLICANT/wpas_kay.h
No license file was found, but licenses were detected in source scan.
```

```
/*
* wpa_supPLICANT - P2P
```



\* Copyright (c) 2009-2010, Atheros Communications  
\* Copyright (c) 2010-2014, Jouni Malinen <j@w1.fi>  
\*  
\* This software may be distributed under the terms of the BSD license.  
\* See README for more details.  
\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/p2p\_supPLICANT.c  
No license file was found, but licenses were detected in source scan.

/\*

\* WPA SupPLICANT / UDP socket -based control interface  
\* Copyright (c) 2004-2016, Jouni Malinen <j@w1.fi>  
\*  
\* This software may be distributed under the terms of the BSD license.  
\* See README for more details.  
\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/ctrl\_iface\_udp.c  
No license file was found, but licenses were detected in source scan.

/\*

\* wpa\_gui - StringQuery class  
\* Copyright (c) 2009, Atheros Communications  
\*  
\* This software may be distributed under the terms of the BSD license.  
\* See README for more details.  
\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wpa\_gui-qt4/stringquery.h  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wpa\_gui-qt4/stringquery.cpp  
No license file was found, but licenses were detected in source scan.

/\*

\* wpa\_supPLICANT - P2P  
\* Copyright (c) 2009-2010, Atheros Communications  
\*  
\* This software may be distributed under the terms of the BSD license.  
\* See README for more details.  
\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/p2p\_supPLICANT.h

No license file was found, but licenses were detected in source scan.

```
/*
* wpa_supplicant - Internal driver interface wrappers
* Copyright (c) 2003-2015, Jouni Malinen <j@w1.fi>
*
* This software may be distributed under the terms of the BSD license.
* See README for more details.
*/
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/driver_i.h
```

No license file was found, but licenses were detected in source scan.

```
/*
* Interworking (IEEE 802.11u)
* Copyright (c) 2011-2012, Qualcomm Atheros
*
* This software may be distributed under the terms of the BSD license.
* See README for more details.
*/
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/interworking.h
```

No license file was found, but licenses were detected in source scan.

```
/*
* nfc_pw_token - Tool for building NFC password tokens for WPS
* Copyright (c) 2012, Jouni Malinen <j@w1.fi>
*
* This software may be distributed under the terms of the BSD license.
* See README for more details.
*/
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/nfc_pw_token.c
```

No license file was found, but licenses were detected in source scan.

```
/*
* WPA SupPLICANT - auto scan exponential module
* Copyright (c) 2012, Intel Corporation. All rights reserved.
*
* This software may be distributed under the terms of the BSD license.
* See README for more details.
*/
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-
```

gz/wpa\_supplicant/autoscan\_exponential.c

No license file was found, but licenses were detected in source scan.

/\*

\* WPA Supplicant / privileged helper program  
\* Copyright (c) 2007-2009, Jouni Malinen <j@w1.fi>

\*

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\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supplicant-1-tar-gz/wpa\_supplicant/wpa\_priv.c

No license file was found, but licenses were detected in source scan.

/\*

\* Copyright (c) 2009, Atheros Communications, Inc.  
\* Copyright (c) 2011-2013, Qualcomm Atheros, Inc.

\*

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\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supplicant-1-tar-gz/wpa\_supplicant/hs20\_supplicant.c

No license file was found, but licenses were detected in source scan.

/\*

\* wpa\_supplicant D-Bus control interface - common definitions  
\* Copyright (c) 2006, Dan Williams <dcw@redhat.com> and Red Hat, Inc.  
\* Copyright (c) 2009, Witold Sowa <witold.sowa@gmail.com>  
\* Copyright (c) 2009, Jouni Malinen <j@w1.fi>

\*

\* This software may be distributed under the terms of the BSD license.  
\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supplicant-1-tar-gz/wpa\_supplicant/dbus/dbus\_common.h

No license file was found, but licenses were detected in source scan.

/\*

\* wpa\_supplicant - MBO  
\*  
\* Copyright(c) 2015 Intel Deutschland GmbH  
\* Contact Information:  
\* Intel Linux Wireless <ilw@linux.intel.com>

\* Intel Corporation, 5200 N.E. Elam Young Parkway, Hillsboro, OR 97124-6497

\*

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\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/mbo.c

No license file was found, but licenses were detected in source scan.

/\*

\* WPA SupPLICANT - Mesh RSN routines

\* Copyright (c) 2013-2014, cozybit, Inc. All rights reserved.

\*

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\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/mesh\_rsn.h

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/mesh\_rsn.c

No license file was found, but licenses were detected in source scan.

/\*

\* WPA SupPLICANT - test code

\* Copyright (c) 2003-2013, Jouni Malinen <j@w1.fi>

\*

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\* See README for more details.

\*

\* IEEE 802.1X SupPLICANT test code (to be used in place of wpa\_supPLICANT.c).

\* Not used in production version.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/eapol\_test.c

No license file was found, but licenses were detected in source scan.

/\*

\* WPA SupPLICANT - auto scan

\* Copyright (c) 2012, Intel Corporation. All rights reserved.

\* Copyright 2015 Intel Deutschland GmbH

\*

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\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/autoscan.c  
No license file was found, but licenses were detected in source scan.

/\*

\* wpa\_supPLICant - Radio Measurements  
\* Copyright (c) 2003-2016, Jouni Malinen <j@w1.fi>

\*

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\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/rrm.c  
No license file was found, but licenses were detected in source scan.

/\*

\* WPA SupPLICant / main() function for Win32 service  
\* Copyright (c) 2003-2006, Jouni Malinen <j@w1.fi>

\*

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\* See README for more details.

\*

\* The root of wpa\_supPLICant configuration in registry is  
\* HKEY\_LOCAL\_MACHINE\\SOFTWARE\\%wpa\_supPLICant. This level includes global  
\* parameters and a 'interfaces' subkey with all the interface configuration  
\* (adapter to confname mapping). Each such mapping is a subkey that has  
\* 'adapter' and 'config' values.

\*

\* This program can be run either as a normal command line application, e.g.,  
\* for debugging, with 'wpa\_supPLICant.exe app' or as a Windows service. Service need  
\* to be registered with 'wpa\_supPLICant.exe reg <full path to wpa\_supPLICant.exe>'. After  
\* this, it can be started like any other Windows service (e.g., 'net start  
\* wpa\_supPLICant') or it can be configured to start automatically through the Services  
\* tool in administrative tasks. The service can be unregistered with  
\* 'wpa\_supPLICant.exe unreg'.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/main\_winsvc.c  
No license file was found, but licenses were detected in source scan.

/\*

\* wpa\_supPLICant - SME  
\* Copyright (c) 2009-2014, Jouni Malinen <j@w1.fi>

\*

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\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/sme.c

No license file was found, but licenses were detected in source scan.

/\*

\* wpa\_supPLICANT / WPS integration

\* Copyright (c) 2008-2014, Jouni Malinen <j@w1.fi>

\*

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\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wps\_supPLICANT.c

No license file was found, but licenses were detected in source scan.

/\*

\* wpa\_supPLICANT - Event notifications

\* Copyright (c) 2009-2010, Jouni Malinen <j@w1.fi>

\*

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\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/notify.h

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/notify.c

No license file was found, but licenses were detected in source scan.

/\*

\* WPA SupPLICANT - Basic mesh mode routines

\* Copyright (c) 2013-2014, cozybit, Inc. All rights reserved.

\*

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\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/mesh.c

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/mesh.h

No license file was found, but licenses were detected in source scan.

/\*

\* wpa\_gui - ScanResultsItem class

\* Copyright (c) 2015, Adrian Nowicki <adinowicki@gmail.com>

\*

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\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wpa\_gui-qt4/scanresultsitem.cpp

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wpa\_gui-qt4/scanresultsitem.h

No license file was found, but licenses were detected in source scan.

/\*

\* WPA SupPLICANT / Network configuration structures

\* Copyright (c) 2003-2013, Jouni Malinen <j@w1.fi>

\*

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\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/config\_ssid.h

No license file was found, but licenses were detected in source scan.

/\*

\* Generic advertisement service (GAS) query

\* Copyright (c) 2009, Atheros Communications

\* Copyright (c) 2011, Qualcomm Atheros

\*

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\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/gas\_query.h

No license file was found, but licenses were detected in source scan.

/\*

\* WPA SupPLICANT

\* Copyright (c) 2003-2017, Jouni Malinen <j@w1.fi>

\*

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\* See README for more details.

\*

\* This file implements functions for registering and unregistering

\* %wpa\_supPLICANT interfaces. In addition, this file contains number of

\* functions for managing network connections.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/wpa\_supPLICant.c  
No license file was found, but licenses were detected in source scan.

/\*

\* WPA SupPLICant - command line interface for wpa\_supPLICant daemon

\* Copyright (c) 2004-2017, Jouni Malinen <j@w1.fi>

\*

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\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/wpa\_cli.c

No license file was found, but licenses were detected in source scan.

/\*

\* WPA SupPLICant / dbus-based control interface (WPS)

\* Copyright (c) 2006, Dan Williams <dcbw@redhat.com> and Red Hat, Inc.

\* Copyright (c) 2009, Witold Sowa <witold.sowa@gmail.com>

\*

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\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/dbus/dbus\_new\_handlers\_wps.c

No license file was found, but licenses were detected in source scan.

/\*

\* WPA SupPLICant / Configuration backend: empty starting point

\* Copyright (c) 2003-2005, Jouni Malinen <j@w1.fi>

\*

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\* See README for more details.

\*

\* This file implements dummy example of a configuration backend. None of the

\* functions are actually implemented so this can be used as a simple

\* compilation test or a starting point for a new configuration backend.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/config\_none.c

No license file was found, but licenses were detected in source scan.

/\*

\* binder interface for wpa\_supPLICant daemon

\* Copyright (c) 2004-2016, Jouni Malinen <j@w1.fi>



\* Copyright (c) 2004-2016, Roshan Pius <rpius@google.com>  
\*  
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\* See README for more details.  
\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/binder/binder.cpp  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/binder/binder\_manager.h  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/binder/binder\_manager.cpp  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/binder/binder\_i.h  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/binder/iface.cpp  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/binder/iface.h  
\*  
/opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/binder/binder\_constants.cpp  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/binder/binder.h  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/binder/binder\_constants.h  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/binder/supPLICant.cpp  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/binder/supPLICant.h  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICant-1-tar-gz/wpa\_supPLICant/binder/fi/w1/wpa\_supPLICant/ISupPLICantCallbacks.aidl  
No license file was found, but licenses were detected in source scan.

# Example wpa\_supPLICant build time configuration

#

# This file lists the configuration options that are used when building the  
# wpa\_supPLICant binary. All lines starting with # are ignored. Configuration  
# option lines must be commented out complete, if they are not to be included,  
# i.e., just setting VARIABLE=n is not disabling that variable.

#

# This file is included in Makefile, so variables like CFLAGS and LIBS can also  
# be modified from here. In most cases, these lines should use += in order not  
# to override previous values of the variables.

# Uncomment following two lines and fix the paths if you have installed OpenSSL

# or GnuTLS in non-default location

#CFLAGS += -I/usr/local/openssl/include

#LIBS += -L/usr/local/openssl/lib

# Some Red Hat versions seem to include kerberos header files from OpenSSL, but

# the kerberos files are not in the default include path. Following line can be

# used to fix build

```
issues on such systems (krb5.h not found).
#CFLAGS += -I/usr/include/kerberos

# Driver interface for generic Linux wireless extensions
# Note: WEXT is deprecated in the current Linux kernel version and no new
# functionality is added to it. nl80211-based interface is the new
# replacement for WEXT and its use allows wpa_supplicant to properly control
# the driver to improve existing functionality like roaming and to support new
# functionality.
#CONFIG_DRIVER_WEXT=y

# Driver interface for Linux drivers using the nl80211 kernel interface
#CONFIG_DRIVER_NL80211=y
CONFIG_LIBNL20=y

# QCA vendor extensions to nl80211
CONFIG_DRIVER_NL80211_QCA=y

# Driver interface for FreeBSD net80211 layer (e.g., Atheros driver)
#CONFIG_DRIVER_BSD=y
#CFLAGS += -I/usr/local/include
#LIBS += -L/usr/local/lib
#LIBS_p += -L/usr/local/lib
#LIBS_c += -L/usr/local/lib

# Driver interface for Windows NDIS
#CONFIG_DRIVER_NDIS=y
#CFLAGS += -I/usr/include/w32api/ddk
#LIBS += -L/usr/local/lib
# For native build using
mingw
#CONFIG_NATIVE_WINDOWS=y
# Additional directories for cross-compilation on Linux host for mingw target
#CFLAGS += -I/opt/mingw/mingw32/include/ddk
#LIBS += -L/opt/mingw/mingw32/lib
#CC=mingw32-gcc
# By default, driver_ndis uses WinPcap for low-level operations. This can be
# replaced with the following option which replaces WinPcap calls with NDISUIO.
# However, this requires that WZC is disabled (net stop wscsvc) before starting
# wpa_supplicant.
# CONFIG_USE_NDISUIO=y

# Driver interface for wired Ethernet drivers
#CONFIG_DRIVER_WIRED=y

# Driver interface for the Broadcom RoboSwitch family
#CONFIG_DRIVER_ROBOSWITCH=y
```

```
# Driver interface for no driver (e.g., WPS ER only)
#CONFIG_DRIVER_NONE=y

# Solaris libraries
#LIBS += -lsocket -ldlpi -lnsl
#LIBS_c += -lsocket

# Enable IEEE 802.1X Supplicant (automatically included if any EAP method is
# included)
CONFIG_IEEE8021X_EAPOL=y

# EAP-MD5
CONFIG_EAP_MD5=y

# EAP-MSCHAPv2
CONFIG_EAP_MSCHAPV2=y

# EAP-TLS
CONFIG_EAP_TLS=y

# EAP-PEAP
CONFIG_EAP_PEAP=y

#
# EAP-TTLS
CONFIG_EAP_TTLS=y

# EAP-FAST
# Note: If OpenSSL is used as the TLS library, OpenSSL 1.0 or newer is needed
# for EAP-FAST support. Older OpenSSL releases would need to be patched, e.g.,
# with openssl-0.9.8x-tls-extensions.patch, to add the needed functions.
#CONFIG_EAP_FAST=y

# EAP-GTC
CONFIG_EAP_GTC=y

# EAP-OTP
CONFIG_EAP_OTP=y

# EAP-SIM (enable CONFIG_PCSC, if EAP-SIM is used)
CONFIG_EAP_SIM=y

# EAP-PSK (experimental; this is not needed for WPA-PSK)
#CONFIG_EAP_PSK=y

# EAP-pwd (secure authentication using only a password)
CONFIG_EAP_PWD=y
```

```
# EAP-PAX
#CONFIG_EAP_PAX=y

# LEAP
CONFIG_EAP_LEAP=y

# EAP-AKA (enable CONFIG_PCSC, if EAP-AKA is used)
CONFIG_EAP_AKA=y

# EAP-AKA' (enable CONFIG_PCSC, if EAP-AKA' is used).
# This requires CONFIG_EAP_AKA to be enabled, too.
CONFIG_EAP_AKA_PRIME=y

# Enable USIM simulator (Milenage) for EAP-AKA
#CONFIG_USIM_SIMULATOR=y

# EAP-SAKE
#CONFIG_EAP_SAKE=y

# EAP-GPSK
#CONFIG_EAP_GPSK=y
# Include support for
# optional SHA256 cipher suite in EAP-GPSK
#CONFIG_EAP_GPSK_SHA256=y

# EAP-TNC and related Trusted Network Connect support (experimental)
#CONFIG_EAP_TNC=y

# Wi-Fi Protected Setup (WPS)
CONFIG_WPS=y
# Enable WPS external registrar functionality
CONFIG_WPS_ER=y
# Disable credentials for an open network by default when acting as a WPS
# registrar.
#CONFIG_WPS_REG_DISABLE_OPEN=y
# Enable WPS support with NFC config method
CONFIG_WPS_NFC=y

# EAP-IKEv2
#CONFIG_EAP_IKEV2=y

# EAP-EKE
#CONFIG_EAP_EKE=y

# PKCS#12 (PFX) support (used to read private key and certificate file from
# a file that usually has extension .p12 or .pfx)
CONFIG_PKCS12=y
```

```
# Smartcard support (i.e., private key on a smartcard), e.g., with openssl
# engine.
CONFIG_SMARTCARD=y

# PC/SC interface for smartcards (USIM, GSM SIM)
# Enable this if EAP-SIM or EAP-AKA is included
#CONFIG_PCSC=y

# Support HT overrides (disable HT/HT40, mask MCS rates, etc.)
#CONFIG_HT_OVERRIDES=y

# Support VHT overrides (disable VHT, mask MCS
# rates, etc.)
#CONFIG_VHT_OVERRIDES=y

# Development testing
#CONFIG_EAPOL_TEST=y

# Select control interface backend for external programs, e.g, wpa_cli:
# unix = UNIX domain sockets (default for Linux/*BSD)
# udp = UDP sockets using localhost (127.0.0.1)
# udp6 = UDP IPv6 sockets using localhost (::1)
# named_pipe = Windows Named Pipe (default for Windows)
# udp-remote = UDP sockets with remote access (only for tests systems/purpose)
# udp6-remote = UDP IPv6 sockets with remote access (only for tests purpose)
# y = use default (backwards compatibility)
# If this option is commented out, control interface is not included in the
# build.
CONFIG_CTRL_IFACE=y

# Include support for GNU Readline and History Libraries in wpa_cli.
# When building a wpa_cli binary for distribution, please note that these
# libraries are licensed under GPL and as such, BSD license may not apply for
# the resulting binary.
#CONFIG_READLINE=y

# Include internal line edit mode in wpa_cli. This can be used as a
# replacement
# for GNU Readline to provide limited command line editing and history support.
CONFIG_WPA_CLI_EDIT=y

# Remove debugging code that is printing out debug message to stdout.
# This can be used to reduce the size of the wpa_supplicant considerably
# if debugging code is not needed. The size reduction can be around 35%
# (e.g., 90 kB).
#CONFIG_NO_STDOUT_DEBUG=y

# Remove WPA support, e.g., for wired-only IEEE 802.1X supplicant, to save
```

```

# 35-50 kB in code size.
#CONFIG_NO_WPA=y

# Remove IEEE 802.11i/WPA-Personal ASCII passphrase support
# This option can be used to reduce code size by removing support for
# converting ASCII passphrases into PSK. If this functionality is removed, the
# PSK can only be configured as the 64-octet hexstring (e.g., from
# wpa_passphrase). This saves about 0.5 kB in code size.
#CONFIG_NO_WPA_PASSPHRASE=y

# Disable scan result processing (ap_mode=1) to save code size by about 1 kB.
# This can be used if ap_scan=1 mode is never enabled.
#CONFIG_NO_SCAN_PROCESSING=y

#
# Select configuration backend:
# file = text file (e.g., wpa_supplicant.conf; note: the configuration file
# path is given on command line, not here; this option is just used to
# select the backend that allows configuration files to be used)
# winreg = Windows registry (see win_example.reg for an example)
CONFIG_BACKEND=file

# Remove configuration write functionality (i.e., to allow the configuration
# file to be updated based on runtime configuration changes). The runtime
# configuration can still be changed, the changes are just not going to be
# persistent over restarts. This option can be used to reduce code size by
# about 3.5 kB.
#CONFIG_NO_CONFIG_WRITE=y

# Remove support for configuration blobs to reduce code size by about 1.5 kB.
#CONFIG_NO_CONFIG_BLOBS=y

# Select program entry point implementation:
# main = UNIX/POSIX like main() function (default)
# main_winsvc = Windows service (read parameters from registry)
# main_none = Very basic example (development
# use only)
#CONFIG_MAIN=main

# Select wrapper for operating system and C library specific functions
# unix = UNIX/POSIX like systems (default)
# win32 = Windows systems
# none = Empty template
CONFIG_OS=unix

# Select event loop implementation
# eloop = select() loop (default)
# eloop_win = Windows events and WaitForMultipleObject() loop

```

```
CONFIG_ELOOP=eloop

# Should we use poll instead of select? Select is used by default.
#CONFIG_ELOOP_POLL=y

# Should we use epoll instead of select? Select is used by default.
#CONFIG_ELOOP_EPOLL=y

# Should we use kqueue instead of select? Select is used by default.
#CONFIG_ELOOP_KQUEUE=y

# Select layer 2 packet implementation
# linux = Linux packet socket (default)
# pcap = libpcap/libdnet/WinPcap
# freebsd = FreeBSD libpcap
# winpcap = WinPcap with receive thread
# ndis = Windows NDISUIO (note: requires CONFIG_USE_NDISUIO=y)
# none = Empty template
CONFIG_L2_PACKET=linux

# Disable Linux packet socket workaround applicable for station interface
#
# in a bridge for EAPOL frames. This should be uncommented only if the kernel
# is known to not have the regression issue in packet socket behavior with
# bridge interfaces (commit 'bridge: respect RFC2863 operational state').
#CONFIG_NO_LINUX_PACKET_SOCKET_WAR=y

# IEEE 802.11w (management frame protection), also known as PMF
# Driver support is also needed for IEEE 802.11w.
CONFIG_IEEE80211W=y

# Select TLS implementation
# openssl = OpenSSL (default)
# gnutls = GnuTLS
# internal = Internal TLSv1 implementation (experimental)
# none = Empty template
#CONFIG_TLS=openssl

# TLS-based EAP methods require at least TLS v1.0. Newer version of TLS (v1.1)
# can be enabled to get a stronger construction of messages when block ciphers
# are used. It should be noted that some existing TLS v1.0 -based
# implementation may not be compatible with TLS v1.1 message (ClientHello is
# sent prior to negotiating which version will be used)
#CONFIG_TLSV11=y

# TLS-based EAP methods require at least TLS
# v1.0. Newer version of TLS (v1.2)
# can be enabled to enable use of stronger crypto algorithms. It should be
```

```

# noted that some existing TLS v1.0 -based implementation may not be compatible
# with TLS v1.2 message (ClientHello is sent prior to negotiating which version
# will be used)
#CONFIG_TLSV12=y

# Select which ciphers to use by default with OpenSSL if the user does not
# specify them.
#CONFIG_TLS_DEFAULT_CIPHERS="DEFAULT:!EXP:!LOW"

# If CONFIG_TLS=internal is used, additional library and include paths are
# needed for LibTomMath. Alternatively, an integrated, minimal version of
# LibTomMath can be used. See beginning of libtommath.c for details on benefits
# and drawbacks of this option.
#CONFIG_INTERNAL_LIBTOMMATH=y
#ifdef CONFIG_INTERNAL_LIBTOMMATH
#LTM_PATH=/usr/src/libtommath-0.39
#CFLAGS += -I$(LTM_PATH)
#LIBS += -L$(LTM_PATH)
#LIBS_p += -L$(LTM_PATH)
#endif
# At the cost of about 4 kB of additional binary size, the internal LibTomMath
# can be configured to include faster
# routines for exptmod, sqr, and div to
# speed up DH and RSA calculation considerably
#CONFIG_INTERNAL_LIBTOMMATH_FAST=y

# Include NDIS event processing through WMI into wpa_supplicant/wpasvc.
# This is only for Windows builds and requires WMI-related header files and
# WbemUuid.Lib from Platform SDK even when building with MinGW.
#CONFIG_NDIS_EVENTS_INTEGRATED=y
#PLATFORMSDKLIB="/opt/Program Files/Microsoft Platform SDK/Lib"

# Add support for old DBus control interface
# (fi.epitest.hostap.WPASupplicant)
#CONFIG_CTRL_IFACE_DBUS=y

# Add support for new DBus control interface
# (fi.w1.hostap.wpa_supplicant1)
#CONFIG_CTRL_IFACE_DBUS_NEW=y

# Add introspection support for new DBus control interface
#CONFIG_CTRL_IFACE_DBUS_INTRO=y

# Add support for Binder control interface
# Only applicable for Android platforms.
#CONFIG_CTRL_IFACE_BINDER=y

# Add support for loading EAP methods dynamically as shared libraries.

```



```
# When this option is enabled, each EAP method can be either included
# statically
# (CONFIG_EAP_<method>=y) or dynamically (CONFIG_EAP_<method>=dyn).
# Dynamic EAP methods are build as shared objects (eap_*.so) and they need to
# be loaded in the beginning of the wpa_supplicant configuration file
# (see load_dynamic_eap parameter in the example file) before being used in
# the network blocks.
#
# Note that some shared parts of EAP methods are included in the main program
# and in order to be able to use dynamic EAP methods using these parts, the
# main program must have been build with the EAP method enabled (=y or =dyn).
# This means that EAP-TLS/PEAP/TTLS/FAST cannot be added as dynamic libraries
# unless at least one of them was included in the main build to force inclusion
# of the shared code. Similarly, at least one of EAP-SIM/AKA must be included
# in the main build to be able to load these methods dynamically.
#
# Please also note that using dynamic libraries will increase the total binary
# size. Thus, it may not be the best option for targets that have
# limited
# amount of memory/flash.
#CONFIG_DYNAMIC_EAP_METHODS=y

# IEEE Std 802.11r-2008 (Fast BSS Transition) for station mode
CONFIG_IEEE80211R=y

# Add support for writing debug log to a file (/tmp/wpa_supplicant-log-#.txt)
#CONFIG_DEBUG_FILE=y

# Send debug messages to syslog instead of stdout
#CONFIG_DEBUG_SYSLOG=y
# Set syslog facility for debug messages
#CONFIG_DEBUG_SYSLOG_FACILITY=LOG_DAEMON

# Add support for sending all debug messages (regardless of debug verbosity)
# to the Linux kernel tracing facility. This helps debug the entire stack by
# making it easy to record everything happening from the driver up into the
# same file, e.g., using trace-cmd.
#CONFIG_DEBUG_LINUX_TRACING=y

# Add support for writing debug log to Android logcat instead of standard
# output
CONFIG_ANDROID_LOG=y

# Enable privilege separation (see README 'Privilege separation' for details)
#CONFIG_PRIVSEP=y

# Enable mitigation against certain attacks against TKIP by delaying Michael
# MIC error reports
```

```
by a random amount of time between 0 and 60 seconds
#CONFIG_DELAYED_MIC_ERROR_REPORT=y

# Enable tracing code for developer debugging
# This tracks use of memory allocations and other registrations and reports
# incorrect use with a backtrace of call (or allocation) location.
#CONFIG_WPA_TRACE=y
# For BSD, uncomment these.
#LIBS += -lexecinfo
#LIBS_p += -lexecinfo
#LIBS_c += -lexecinfo

# Use libbfd to get more details for developer debugging
# This enables use of libbfd to get more detailed symbols for the backtraces
# generated by CONFIG_WPA_TRACE=y.
#CONFIG_WPA_TRACE_BFD=y
# For BSD, uncomment these.
#LIBS += -lbfd -liberty -lz
#LIBS_p += -lbfd -liberty -lz
#LIBS_c += -lbfd -liberty -lz

# wpa_supplicant depends on strong random number generation being available
# from the operating system. os_get_random() function is used to fetch random
# data when needed, e.g., for key generation. On Linux and BSD systems, this
# works by reading /dev/urandom. It should be noted that the OS
entropy pool
# needs to be properly initialized before wpa_supplicant is started. This is
# important especially on embedded devices that do not have a hardware random
# number generator and may by default start up with minimal entropy available
# for random number generation.
#
# As a safety net, wpa_supplicant is by default trying to internally collect
# additional entropy for generating random data to mix in with the data fetched
# from the OS. This by itself is not considered to be very strong, but it may
# help in cases where the system pool is not initialized properly. However, it
# is very strongly recommended that the system pool is initialized with enough
# entropy either by using hardware assisted random number generator or by
# storing state over device reboots.
#
# wpa_supplicant can be configured to maintain its own entropy store over
# restarts to enhance random number generation. This is not perfect, but it is
# much more secure than using the same sequence of random numbers
after every
# reboot. This can be enabled with -e<entropy file> command line option. The
# specified file needs to be readable and writable by wpa_supplicant.
#
# If the os_get_random() is known to provide strong random data (e.g., on
# Linux/BSD, the board in question is known to have reliable source of random
```

```
# data from /dev/urandom), the internal wpa_supplicant random pool can be
# disabled. This will save some in binary size and CPU use. However, this
# should only be considered for builds that are known to be used on devices
# that meet the requirements described above.

# Wpa_supplicant's random pool is not necessary on Android. Randomness is
# already provided by the entropymixer service which ensures sufficient
# entropy is maintained across reboots. Commit b410eb1913 'Initialize
# /dev/urandom earlier in boot' seeds /dev/urandom with that entropy before
# either wpa_supplicant or hostapd are run.
CONFIG_NO_RANDOM_POOL=y

# IEEE 802.11n (High Throughput) support (mainly for
# AP mode)
CONFIG_IEEE80211N=y

# IEEE 802.11ac (Very High Throughput) support (mainly for AP mode)
# (depends on CONFIG_IEEE80211N)
#CONFIG_IEEE80211AC=y

# Wireless Network Management (IEEE Std 802.11v-2011)
# Note: This is experimental and not complete implementation.
CONFIG_WNM=y

# Interworking (IEEE 802.11u)
# This can be used to enable functionality to improve interworking with
# external networks (GAS/ANQP to learn more about the networks and network
# selection based on available credentials).
CONFIG_INTERWORKING=y

# Hotspot 2.0
CONFIG_HS20=y

# Enable interface matching in wpa_supplicant
#CONFIG_MATCH_IFACE=y

# Disable roaming in wpa_supplicant
CONFIG_NO_ROAMING=y

# AP mode operations with wpa_supplicant
# This can be used for controlling AP mode operations with wpa_supplicant. It
# should be noted that this is mainly aimed at simple cases like
# WPA2-Personal while more complex configurations like WPA2-Enterprise with an
# external RADIUS server can be supported with hostapd.
CONFIG_AP=y

#
```

P2P (Wi-Fi Direct)  
# This can be used to enable P2P support in wpa\_supplicant. See README-P2P for  
# more information on P2P operations.  
CONFIG\_P2P=y

# Enable TDLS support  
CONFIG\_TDLS=y

# Wi-Fi Direct  
# This can be used to enable Wi-Fi Direct extensions for P2P using an external  
# program to control the additional information exchanges in the messages.  
CONFIG\_WIFI\_DISPLAY=y

# Autoscan  
# This can be used to enable automatic scan support in wpa\_supplicant.  
# See wpa\_supplicant.conf for more information on autoscan usage.  
#  
# Enabling directly a module will enable autoscan support.  
# For exponential module:  
#CONFIG\_AUTOSCAN\_EXPONENTIAL=y  
# For periodic module:  
#CONFIG\_AUTOSCAN\_PERIODIC=y

# Password (and passphrase, etc.) backend for external storage  
# These optional mechanisms can be used to add support for storing passwords  
# and other secrets in external (to wpa\_supplicant) location. This allows, for  
# example, operating system specific key storage to be used  
#  
#  
External password backend for testing purposes (developer use)  
#CONFIG\_EXT\_PASSWORD\_TEST=y

# Enable Fast Session Transfer (FST)  
#CONFIG\_FST=y

# Support Multi Band Operation  
#CONFIG\_MBO=y

# Fast Initial Link Setup (FILS) (IEEE 802.11ai)  
# Note: This is an experimental and not yet complete implementation. This  
# should not be enabled for production use.  
#CONFIG\_FILS=y

# Support RSN on IBSS networks  
# This is needed to be able to use mode=1 network profile with proto=RSN and  
# key\_mgmt=WPA-PSK (i.e., full key management instead of WPA-None).  
#CONFIG\_IBSS\_RSN=y

```
# External PMKSA cache control
# This can be used to enable control interface commands that allow the current
# PMKSA cache entries to be fetched and new entries to be added.
#CONFIG_PMKSA_CACHE_EXTERNAL=y

# Mesh Networking (IEEE 802.11s)
#CONFIG_MESH=y

# Background scanning modules
# These can be used to request wpa_supplicant to perform background scanning
# operations for roaming within an ESS (same SSID). See the bgscan
# parameter in
# the wpa_supplicant.conf file for more details.
# Periodic background scans based on signal strength
#CONFIG_BGSCAN_SIMPLE=y
# Learn channels used by the network and try to avoid bgscans on other
# channels (experimental)
#CONFIG_BGSCAN_LEARN=y

# Opportunistic Wireless Encryption (OWE)
# Experimental implementation of draft-harkins-owe-07.txt
#CONFIG_OWE=y
```

```
include $(wildcard $(LOCAL_PATH)/android_config_*.inc)
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/android.config
No license file was found, but licenses were detected in source scan.
```

```
/*
```

```
* WPA SupPLICANT / Configuration parser and common functions
* Copyright (c) 2003-2015, Jouni Malinen <j@w1.fi>
*
* This software may be distributed under the terms of the BSD license.
* See README for more details.
*/
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/config.c
No license file was found, but licenses were detected in source scan.
```

```
/*
```

```
* WPA SupPLICANT / Example program endpoint
* Copyright (c) 2003-2005, Jouni Malinen <j@w1.fi>
*
* This software may be distributed under the terms of the BSD license.
* See README for more details.
*/
```

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/main\_none.c  
No license file was found, but licenses were detected in source scan.

/\*

\* Wi-Fi Multimedia Admission Control (WMM-AC)  
\* Copyright(c) 2014, Intel Mobile Communication GmbH.  
\* Copyright(c) 2014, Intel Corporation. All rights reserved.  
\*  
\* This software may be distributed under the terms of the BSD license.  
\* See README for more details.  
\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wmm\_ac.c  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wmm\_ac.h  
No license file was found, but licenses were detected in source scan.

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Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/Android.mk  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wpa\_supPLICANT\_conf.sh  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/examples/dpp-qr-code.py  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/eapol\_test.py  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/examples/p2p-nfc.py  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wpa\_supPLICANT\_conf.mk  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/examples/wps-nfc.py  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/utills/log2pcap.py  
No license file was found, but licenses were detected in source scan.

/\*

\* WPA SupPLICANT - Basic mesh peer management  
\* Copyright (c) 2013-2014, cozybit, Inc. All rights reserved.  
\*  
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\* See README for more details.  
\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/mesh\_mpm.h  
\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/mesh\_mpm.c

No license file was found, but licenses were detected in source scan.

```
/*  
* wpa_supplicant - SME  
* Copyright (c) 2009-2010, Jouni Malinen <j@w1.fi>  
*  
* This software may be distributed under the terms of the BSD license.  
* See README for more details.  
*/
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/sme.h  
No license file was found, but licenses were detected in source scan.
```

```
/*  
* WPA SupPLICANT / dbus-based control interface  
* Copyright (c) 2006, Dan Williams <dcbw@redhat.com> and Red Hat, Inc.  
*  
* This software may be distributed under the terms of the BSD license.  
* See README for more details.  
*/
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/dbus/dbus_dict_helpers.c  
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/dbus/dbus_old.h  
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/dbus/dbus_old_handlers.c  
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/dbus/dbus_old.c  
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/dbus/dbus_old_handlers.h  
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/dbus/dbus_dict_helpers.h  
No license file was found, but licenses were detected in source scan.
```

```
/*  
* wpa_gui - ScanResults class  
* Copyright (c) 2005-2006, Jouni Malinen <j@w1.fi>  
*  
* This software may be distributed under the terms of the BSD license.  
* See README for more details.  
*/
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/wpa_gui-qt4/scanresults.h  
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/wpa_gui-qt4/scanresults.cpp
```

No license file was found, but licenses were detected in source scan.

/\*

- \* WPA Supplicant / dbus-based control interface
  - \* Copyright (c) 2006, Dan Williams <dcbw@redhat.com> and Red Hat, Inc.
  - \* Copyright (c) 2009-2010, Witold Sowa <witold.sowa@gmail.com>
  - \* Copyright (c) 2009, Jouni Malinen <j@w1.fi>
  - \*
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  - \* See README for more details.
- \*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supplicant-1-tar-gz/wpa\_supplicant/dbus/dbus\_new.c

No license file was found, but licenses were detected in source scan.

/\*

- \* wpa\_supplicant D-Bus control interface - common functionality
  - \* Copyright (c) 2006, Dan Williams <dcbw@redhat.com> and Red Hat, Inc.
  - \* Copyright (c) 2009, Witold Sowa <witold.sowa@gmail.com>
  - \* Copyright (c) 2009, Jouni Malinen <j@w1.fi>
  - \*
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  - \* See README for more details.
- \*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supplicant-1-tar-gz/wpa\_supplicant/dbus/dbus\_common.c

No license file was found, but licenses were detected in source scan.

/\*

- \* WPA Supplicant / Configuration backend: text file
  - \* Copyright (c) 2003-2012, Jouni Malinen <j@w1.fi>
  - \*
  - \* This software may be distributed under the terms of the BSD license.
  - \* See README for more details.
  - \*
  - \* This file implements a configuration backend for text files. All the
  - \* configuration information is stored in a text file that uses a format
  - \* described in the sample configuration file, wpa\_supplicant.conf.
- \*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supplicant-1-tar-gz/wpa\_supplicant/config\_file.c

No license file was found, but licenses were detected in source scan.

/\*



\* IEEE 802.11v WNM related functions and structures  
\* Copyright (c) 2011-2012, Qualcomm Atheros, Inc.  
\*  
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\* See README for more details.  
\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wnm\_sta.h  
No license file was found, but licenses were detected in source scan.

/\*

\* wpa\_supPLICANT - Internal definitions  
\* Copyright (c) 2003-2014, Jouni Malinen <j@w1.fi>  
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\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wpa\_supPLICANT\_i.h  
No license file was found, but licenses were detected in source scan.

/\*

\* wpa\_supPLICANT / WPS integration  
\* Copyright (c) 2008-2012, Jouni Malinen <j@w1.fi>  
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\* See README for more details.  
\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wps\_supPLICANT.h  
No license file was found, but licenses were detected in source scan.

/\*

\* WPA SupPLICANT / dbus-based control interface for p2p  
\* Copyright (c) 2011-2012, Intel Corporation  
\*  
\* This software may be distributed under the terms of the BSD license.  
\* See README for more details.  
\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/dbus/dbus\_new\_handlers\_p2p.h

No license file was found, but licenses were detected in source scan.

```
/*
 * WPA Supplicant / dbus-based control interface
 * Copyright (c) 2006, Dan Williams <dcbw@redhat.com> and Red Hat, Inc.
 * Copyright (c) 2009, Witold Sowa <witold.sowa@gmail.com>
 *
 * This software may be distributed under the terms of the BSD license.
 * See README for more details.
 */
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/dbus/dbus_new_helpers.c
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/dbus/dbus_new_helpers.h
```

No license file was found, but licenses were detected in source scan.

```
/*
 * Operating classes
 * Copyright(c) 2015 Intel Deutschland GmbH
 * Contact Information:
 * Intel Linux Wireless <ilw@linux.intel.com>
 * Intel Corporation, 5200 N.E. Elam Young Parkway, Hillsboro, OR 97124-6497
 *
 * This software may be distributed under the terms of the BSD license.
 * See README for more details.
 */
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/op_classes.c
```

No license file was found, but licenses were detected in source scan.

```
/*
 * wpa_gui - WpaGui class
 * Copyright (c) 2005-2011, Jouni Malinen <j@w1.fi>
 *
 * This software may be distributed under the terms of the BSD license.
 * See README for more details.
 */
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/wpa_gui-qt4/wpagui.cpp
```

No license file was found, but licenses were detected in source scan.

wpa\_supplicant for Windows

=====

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advertisement clause removed).

wpa\_supplicant has support for being used as a WPA/WPA2/IEEE 802.1X  
Supplicant on Windows. The current port requires that WinPcap  
(<http://winpcap.polito.it/>) is installed for accessing packets and the  
driver interface. Both release versions 3.0 and 3.1 are supported.

The current port is still somewhat experimental. It has been tested  
mainly on Windows XP (SP2) with limited set of NDIS drivers. In  
addition, the current version has been reported to work with Windows  
2000.

All security modes have been verified to work (at least complete  
authentication and successfully ping a wired host):

- plaintext
- static WEP / open system authentication
- static WEP / shared key authentication
- IEEE 802.1X with dynamic WEP keys
- WPA-PSK, TKIP, CCMP, TKIP+CCMP
- WPA-EAP, TKIP, CCMP, TKIP+CCMP
- WPA2-PSK, TKIP, CCMP, TKIP+CCMP
- WPA2-EAP, TKIP, CCMP, TKIP+CCMP

Building wpa\_supplicant with mingw  
-----

The default build setup for wpa\_supplicant is to use MinGW and  
cross-compiling from Linux to MinGW/Windows. It should also be  
possible to build this under Windows using the MinGW tools, but that  
is not tested nor supported and is likely to require some changes to  
the Makefile unless cygwin is used.

Building wpa\_supplicant with MSVC  
-----

wpa\_supplicant can be built with Microsoft Visual C++ compiler. This  
has been tested with Microsoft Visual C++ Toolkit 2003 and Visual  
Studio 2005 using the included nmake.mak as a Makefile for nmake. IDE  
can also be used by creating a project that includes the files and

defines mentioned in nmake.mak. Example VS2005 solution and project files are included in vs2005 subdirectory. This can be used as a starting point for building the programs with VS2005 IDE. Visual Studio 2008 Express Edition is also able to use these project files.

WinPcap development package is needed for the build and this can be downloaded from [http://www.winpcap.org/install/bin/WpdPack\\_4\\_0\\_2.zip](http://www.winpcap.org/install/bin/WpdPack_4_0_2.zip). The default nmake.mak expects this to be unpacked into C:\dev\WpdPack so that Include and Lib directories are in this directory. The files can be stored elsewhere as long as the WINPCAPDIR in nmake.mak is updated to match with the selected directory. In case a project file in the IDE is used, these Include and Lib directories need to be added to project properties as additional include/library directories.

OpenSSL source package can be downloaded from <http://www.openssl.org/source/openssl-0.9.8i.tar.gz> and built and installed following instructions in INSTALL.W32. Note that if EAP-FAST support will be included in the wpa\_supplicant, OpenSSL needs to be patched to support it [openssl-0.9.8i-tls-extensions.patch](#).

The example nmake.mak file expects OpenSSL to be installed into C:\dev\openssl, but this directory can be modified by changing OPENSLLDIR variable in nmake.mak.

If you do not need EAP-FAST support, you may also be able to use Win32 binary installation package of OpenSSL from <http://www.slproweb.com/products/Win32OpenSSL.html> instead of building the library yourself. In this case, you will need to copy Include and Lib directories in suitable directory, e.g., C:\dev\openssl for the default nmake.mak. Copy {Win32OpenSSLRoot}\include into C:\dev\openssl\include and make C:\dev\openssl\lib subdirectory with files from {Win32OpenSSLRoot}\VC (i.e., libeay\*.lib and ssleay\*.lib). This will end up using dynamically linked OpenSSL (i.e., .dll files are needed) for it. Alternative, you can copy files from {Win32OpenSSLRoot}\VC\static to create a static build (no OpenSSL .dll files needed).

Building wpa\_supplicant for cygwin

-----

wpa\_supplicant can be built for cygwin by installing the needed development packages for cygwin. This includes things like compiler, make, openssl development package, etc. In addition, developer's pack for WinPcap (Wpdpack.zip) from <http://winpcap.polito.it/install/default.htm> is needed.

.config file should enable only one driver interface, CONFIG\_DRIVER\_NDIS. In addition, include directories may need to be added to match the system. An example configuration is available in defconfig. The library and include files for WinPcap will either need to be installed in compiler/linker default directories or their location will need to be adding to .config when building wpa\_supplicant.

Other than this, the build should be more or less identical to Linux version, i.e., just run make after having created .config file. An additional tool, win\_if\_list.exe, can be built by running "make win\_if\_list".

#### Building wpa\_gui

-----

wpa\_gui uses Qt application framework from Trolltech. It can be built with the open source version of Qt4 and MinGW. Following commands can be used to build the binary in the Qt 4 Command Prompt:

```
# go to the root directory of wpa_supplicant source code
cd wpa_gui-qt4
qmake -o Makefile wpa_gui.pro
make
# the wpa_gui.exe binary is created into 'release' subdirectory
```

#### Using wpa\_supplicant for Windows

-----

wpa\_supplicant, wpa\_cli, and wpa\_gui behave more or less identically to Linux version, so instructions in README and example wpa\_supplicant.conf should be applicable for most parts. In addition, there is another version of wpa\_supplicant, wpa\_svc.exe, which can be used as a Windows service and which reads its configuration from registry instead of text file.

When using access points in "hidden SSID" mode, ap\_scan=2 mode need to be used (see wpa\_supplicant.conf for more information).

Windows NDIS/WinPcap uses quite long interface names, so some care will be needed when starting wpa\_supplicant. Alternatively, the adapter description can be used as the interface name which may be easier since it is usually in more human-readable

format. win\_if\_list.exe can be used to find out the proper interface name.

Example steps in starting up wpa\_supplicant:

```
# win_if_list.exe
ifname: \Device\NPF_GenericNdisWanAdapter
description: Generic NdisWan adapter

ifname: \Device\NPF_{769E012B-FD17-4935-A5E3-8090C38E25D2}
description: Atheros Wireless Network Adapter (Microsoft's Packet Scheduler)

ifname: \Device\NPF_{732546E7-E26C-48E3-9871-7537B020A211}
description: Intel 8255x-based Integrated Fast Ethernet (Microsoft's Packet Scheduler)
```

Since the example configuration used Atheros WLAN card, the middle one is the correct interface in this case. The interface name for -i command line option is the full string following "ifname:" (the "\Device\NPF\_" prefix can be removed). In other words, wpa\_supplicant would be started with the following command:

```
# wpa_supplicant.exe -i{769E012B-FD17-4935-A5E3-8090C38E25D2}' -c wpa_supplicant.conf -d
-d
optional enables some more debugging (use -dd for even more, if needed). It can be left out if debugging information is not needed.
```

With the alternative mechanism for selecting the interface, this command has identical results in this case:

```
# wpa_supplicant.exe -iAtheros -c wpa_supplicant.conf -d
```

Simple configuration example for WPA-PSK:

```
#ap_scan=2
ctrl_interface=
network={
  ssid="test"
  key_mgmt=WPA-PSK
  proto=WPA
  pairwise=TKIP
  psk="secret passphrase"
}
```

(remove '#' from the comment out ap\_scan line to enable mode in which wpa\_supplicant tries to associate with the SSID without doing

scanning; this allows APs with hidden SSIDs to be used)

wpa\_cli.exe and wpa\_gui.exe can be used to interact with the wpa\_supplicant.exe program in the same way as with Linux. Note that ctrl\_interface is using UNIX domain sockets when built for cygwin, but the native build for Windows uses named pipes and the contents of the ctrl\_interface configuration item is used to control access to the interface.

Anyway, this variable has to be included in the configuration to enable the control interface.

Example SDDL string formats:

(local admins group has permission, but nobody else):

```
ctrl_interface=SDDL=D:(A;;GA;;;BA)
```

("A" == "access allowed", "GA" == GENERIC\_ALL == all permissions, and "BA" == "builtin administrators" == the local admins. The empty fields are for flags and object GUIDs, none of which should be required in this case.)

(local admins and the local "power users" group have permissions, but nobody else):

```
ctrl_interface=SDDL=D:(A;;GA;;;BA)(A;;GA;;;PU)
```

(One ACCESS\_ALLOWED ACE for GENERIC\_ALL for builtin administrators, and one ACCESS\_ALLOWED ACE for GENERIC\_ALL for power users.)

(close to wide open, but you have to be a valid user on the machine):

```
ctrl_interface=SDDL=D:(A;;GA;;;AU)
```

(One ACCESS\_ALLOWED ACE for GENERIC\_ALL for the "authenticated users" group.)

This one would allow absolutely everyone (including anonymous users) -- this is *\*not\** recommended, since named pipes can be attached to from anywhere on the network (i.e. there's no "this machine only" like there is with 127.0.0.1 sockets):

```
ctrl_interface=SDDL=D:(A;;GA;;;BU)(A;;GA;;;AN)
```

(BU == "builtin users", "AN" == "anonymous")

See also [1] for the format of ACEs, and [2] for the possible strings that can be used for principal names.

[1]

[http://msdn.microsoft.com/library/default.asp?url=/library/en-us/secauthz/security/ace\\_strings.asp](http://msdn.microsoft.com/library/default.asp?url=/library/en-us/secauthz/security/ace_strings.asp)

[2]

[http://msdn.microsoft.com/library/default.asp?url=/library/en-us/secauthz/security/sid\\_strings.asp](http://msdn.microsoft.com/library/default.asp?url=/library/en-us/secauthz/security/sid_strings.asp)

Starting wpa\_supplicant as a Windows service (wpa\_supplicant.exe)

-----

wpa\_supplicant can be started as a Windows service by using wpa\_supplicant.exe program that is alternative build of wpa\_supplicant.exe. Most of the core functionality of wpa\_supplicant.exe is identical to wpa\_supplicant.exe, but it is using Windows registry for configuration information instead of a text file and command line parameters. In addition, it can be registered as a service that can be started automatically or manually like any other Windows service.

The root of wpa\_supplicant configuration in registry is HKEY\_LOCAL\_MACHINE\SOFTWARE\wpa\_supplicant. This level includes global parameters and a 'interfaces' subkey with all the interface configuration (adapter to confname mapping). Each such mapping is a subkey that has 'adapter', 'config', and 'ctrl\_interface' values.

This program can be run either as a normal command line application, e.g., for debugging, with 'wpa\_supplicant.exe app' or as a Windows service. Service need to be registered with 'wpa\_supplicant.exe reg <full path to wpa\_supplicant.exe>'. Alternatively, 'wpa\_supplicant.exe reg' can be used to register the service with the current location of wpa\_supplicant.exe. After this, wpa\_supplicant can be started like any other Windows service (e.g., 'net start wpa\_supplicant') or it can be configured to start automatically through the Services tool in administrative tasks. The service can be unregistered with 'wpa\_supplicant.exe unreg'.

If the service is set to start during system bootup to make the network connection available before any user has logged in, there may be a long (half a minute or so) delay in starting up wpa\_supplicant due to WinPcap needing a driver called "Network Monitor Driver" which is started by default on demand.

To speed up wpa\_supplicant start during system bootup, "Network Monitor Driver" can be configured to be started sooner by setting its



startup type to System instead of the default Demand. To do this, open up Device Manager, select Show Hidden Devices, expand the "Non Plug-and-Play devices" branch, double click "Network Monitor Driver", go to the Driver tab, and change the Demand setting to System instead.

Configuration data is in HKEY\_LOCAL\_MACHINE\SOFTWARE\wpa\_supplicant\configs key. Each configuration profile has its own key under this. In terms of text files, each profile would map to a separate text file with possibly multiple networks. Under each profile, there is a networks key that lists all networks as a subkey. Each network has set of values in the same way as network block in the configuration file. In addition, blobs subkey has possible blobs as values.

```
HKEY_LOCAL_MACHINE\SOFTWARE\wpa_supplicant\configs\test\networks\0000
  ssid="example"
  key_mgmt=WPA-PSK
```

See win\_example.reg for an example on how to setup wpasvc.exe parameters in registry. It can also be imported to registry as a starting point for the configuration.

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/README-Windows.txt
```

No license file was found, but licenses were detected in source scan.

```
/*
```

```
* WPA SupPLICANT / dbus-based control interface
* Copyright (c) 2006, Dan Williams <dcbw@redhat.com> and Red Hat, Inc.
* Copyright (c) 2009-2010, Witold Sowa <witold.sowa@gmail.com>
* Copyright (c) 2009-2015, Jouni Malinen <j@w1.fi>
*
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*/
```

Found in path(s):

```
* /opt/cola/permits/1832084929_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa_supplicant/dbus/dbus_new_handlers.c
```

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```
/*
```

```
* WPA SupPLICANT - binder interface for wpa_supplicant daemon
* Copyright (c) 2004-2016, Jouni Malinen <j@w1.fi>
* Copyright (c) 2004-2016, Roshan Pius <rpius@google.com>
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```

\* See README for more details.

\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/binder/fi/w1/wpa\_supPLICANT/ISupPLICANT.aidl

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/\*

\* WPA SupPLICANT / UNIX domain socket -based control interface

\* Copyright (c) 2004-2014, Jouni Malinen <j@w1.fi>

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Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/ctrl\_iface\_unix.c

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/\*

\* binder interface for wpa\_supPLICANT daemon

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\*/

package fi.w1.wpa\_supPLICANT;

/\*\*

\* Interface exposed by wpa\_supPLICANT for each network interface it controls.

\*/

interface Iiface {

}

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/binder/fi/w1/wpa\_supPLICANT/Iiface.aidl

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\* WPA SupPLICANT / Windows Named Pipe -based control interface

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\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/ctrl\_iface\_named\_pipe.c

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/\*

- \* Generic advertisement service (GAS) query
- \* Copyright (c) 2009, Atheros Communications
- \* Copyright (c) 2011-2014, Qualcomm Atheros, Inc.
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Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/gas\_query.c

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- \* WPA SupPLICANT - Scanning
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Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/scan.h

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/scan.c

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- \* WPA SupPLICANT - Glue code to setup EAPOL and RSN modules
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Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wpas\_glue.c

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- \* wpa\_gui - WpaGui class

\* Copyright (c) 2005-2006, Jouni Malinen <j@w1.fi>  
\*  
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\* See README for more details.  
\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wpa\_gui-qt4/wpagui.h

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/\*

\* WPA SupPLICANT - test code for pre-authentication  
\* Copyright (c) 2003-2007, Jouni Malinen <j@w1.fi>  
\*  
\* This software may be distributed under the terms of the BSD license.  
\* See README for more details.  
\*  
\* IEEE 802.1X SupPLICANT test code (to be used in place of wpa\_supPLICANT.c).  
\* Not used in production version.  
\*/

Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/preauth\_test.c

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/\*

\* wpa\_supPLICANT - IBSS RSN  
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Found in path(s):

\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/ibss\_rsn.c

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wpa\_gui icon files

To convert the svg icons to other formats, make sure inkscape and imagemagick are installed and use `make` to create various sized png and xpm icons.

wpa\_gui.svg

-----

Copyright (c) 2008 Bernard Gray <bernard.gray@gmail.com>

The wpa\_gui icon is licensed under the GPL version 2. Alternatively, the icon may be distributed under the terms of BSD license.

ap.svg

-----

mystica\_Wireless\_Router.svg

<http://openclipart.org/media/files/mystica/8390>

Wireless Router

by: mystica

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laptop.svg

-----

metalmarius\_Laptop.svg

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Laptop

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group.svg

-----

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[http://www.openclipart.org/people/Anonymous/Anonymous\\_Network.svg](http://www.openclipart.org/people/Anonymous/Anonymous_Network.svg)

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2009-04-29 04:07:37

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A network icon by Andrew Fitzsimon. Etiquette Icon set.

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invitation.svg

-----

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[http://www.openclipart.org/people/jean\\_victor\\_balin/jean\\_victor\\_balin\\_unknown\\_green.svg](http://www.openclipart.org/people/jean_victor_balin/jean_victor_balin_unknown_green.svg)

Uploader:

jean\_victor\_balin

Drawn by:

jean\_victor\_balin

Created:

2006-10-27 02:12:13

Description:

Public Domain

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\* /opt/cola/permits/1832084929\_1698262264.028356/0/wpa-supPLICANT-1-tar-gz/wpa\_supPLICANT/wpa\_gui-qt4/icons/README

# 1.56 openssl 1.0.1k

## 1.56.1 Available under license :

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```
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```

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```
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 * rijndael-alg-fst.c
 *
 * @version 3.0 (December 2000)
 *
 * Optimised ANSI C code for the Rijndael cipher (now AES)
 *
 * @author Vincent Rijmen <vincent.rijmen@esat.kuleuven.ac.be>
 * @author Antoon Bosselaers <antoon.bosselaers@esat.kuleuven.ac.be>
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```
*/opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/aes/rijndael.c
```

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```
/**
 * rijndael-alg-fst.h
 *
 * @version 3.0 (December 2000)
 *
 * Optimised ANSI C code for the Rijndael cipher (now AES)
 *
 * @author Vincent Rijmen <vincent.rijmen@esat.kuleuven.ac.be>
 * @author Antoon Bosselaers <antoon.bosselaers@esat.kuleuven.ac.be>
 * @author Paulo Barreto <paulo.barreto@terra.com.br>
 *
 */
```

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/\* debug.c -- debug utilities

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```
/* dtls -- a very basic DTLS implementation
```

```
*
```

```
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```

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*
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*/
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```
* /opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/hmac.c
```

```
* /opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/hmac.h
```

```
* /opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/ccm.h
```

```
* /opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/global.h
```

```
* /opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/dtls.c
```

```
* /opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/ccm.c
```

```
* /opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/crypto.h
```

```
* /opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/crypto.c
```

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```
/*
```

```
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```

```
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```

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/\* debug.h -- debug utilities

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```
/*
* FILE: sha2.h
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*
* $Id: sha2.h,v 1.1 2001/11/08 00:02:01 adg Exp adg $
*/
```

Found in path(s):

```
*/opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/sha2/sha2.h
```

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\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/doc/html/dtls-  
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\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/doc/html/index.html

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/\*

\* FILE: sha2prog.c

\* AUTHOR: Aaron D. Gifford - <http://www.aarongifford.com/>

\*

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\*

\* \$Id: sha2prog.c,v 1.1 2001/11/08 00:02:11 adg Exp adg \$

\*/

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\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/sha2/sha2prog.c

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/\* dtls -- a very basic DTLS implementation

\*

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\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/dtls\_time.h

\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/state.h

\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/peer.c  
\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/dtls\_time.c  
\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/peer.h  
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\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/utlist.h  
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/\* t\_list -- tinydtls lists

\*

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\*  
\* This file is part of the Contiki operating system.  
\*  
\* Author: Adam Dunkels <adam@sics.se>  
\*

\* \$ Id: list.h,v 1.5 2010/09/13 13:31:00 adamdunkels Exp \$

\*/

Found in path(s):

\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/t\_list.h

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#### VERSION:

This is version 1.0 RELEASE

While this is my "release" version, due to lack of additional official test vectors against which to verify this implementation's correctness, beware that there may be implementation bugs. Also, it has not yet been tested on very many other architectures, big-endian machines in particular.

#### LICENSE:

This implementation is released freely under an open-source BSD license which appears at the top of each source code file.

#### WHAT IT IS:

The files sha2.h and sha2.c implement the SHA-256, SHA-384, and SHA-512 hash algorithms as described in the PDF document found at the following web address:

<http://csrc.nist.gov/cryptval/shs/sha256-384-512.pdf>

The interface is similar to the interface to SHA-1 found in the OpenSSL library.

The file sha2prog.c is a simple program that accepts input from either STDIN or reads one or more files specified on the command line, and then generates the specified hash (either SHA-256, SHA-384, SHA-512, or any combination thereof, including all three at once).

#### LIMITATIONS:

This implementation has several limitations:

\* Input data is only accepted in octet-length increments. No sub-byte data is handled. The NIST document describes how to handle sub-byte

input data, but for ease of implementation this version will only accept message data in multiples of bytes.

- \* This implementation utilizes 64-bit integer data types. If your system and compiler does not have a 64-bit integer data type, this implementation will not work.
- \* Because of the use of 64-bit operations, many 32-bit architectures that do have 64-bit data types but do operations most efficiently on 32-bit words, this implementation may be slower than an implementation designed to use only 32-bit words (emulating the 64-bit operations).
- \* On platforms with 128-bit integer data types, the SHA-384 and SHA-512 bit counters used by this implementation might be better off using the 128-bit type instead of simulating it with two 64-bit integers.
- \* This implementation was written in C in hopes of portability and for the fun of it during my spare time. It is probably not the most efficient or fastest C implementation. I welcome suggestions, however, that suggest ways to speed things up without breaking portability. I also welcome suggestions to improve portability.
- \* As mentioned above, this code has NOT been thoroughly tested. This is perhaps the most severe limitation.

#### BEFORE YOU COMPILE (OPTIONS):

Each of the options described below may either be defined in the sha2.h header file (or in the sha2.c file in some cases), or on the command line at compile time if your compiler supports such things. For example:

```
#define SHA2_USE_INTTYPES_H  
#define SHA2_UNROLL_TRANSFORM
```

Or:

```
cc -c -DSHA2_UNROLL_TRANSFORM sha2.c  
cc -c -DBYTE_ORDER=4321 -DBIG_ENDIAN=4321 sha2.c
```

Here are the available options.

Read on below for a description of each one:

```
SHA2_USE_INTTYPES_H  
SHA2_USE_MEMSET_MEMCPY/SHA2_USE_BZERO_BCOPY  
SHA2_UNROLL_TRANSFORM  
BYTE_ORDER (LITTLE_ENDIAN/BIG_ENDIAN)
```

- \* SHA2\_USE\_INTTYPES\_H option:

By default, this code uses `u_intXX_t` data types for 8 bit, 32 bit, and 64 bit unsigned integer type definitions. Most BSD systems define these, as does Linux. However, some (like Compaq's Tru64 Unix) may instead use `uintXX_t` data types as defined by recent ANSI C standards and as included in the `inttypes.h` header file. Those wanting to use `inttypes.h` need to define this either in `sha.h` or at compile time.

On those systems where NEITHER definitions are available, you will need to edit both `sha2.h` and `sha2.c` and define things by hand in the appropriate sections.

**\* BYTE\_ORDER definitions:**

This code assumes that `BYTE_ORDER` will be defined by the system during compile to either equal `LITTLE_ENDIAN` or `BIG_ENDIAN`. If your system does not define these, you may need to define them by hand in the `sha.c` file according to the byte ordering conventions of your system.

**\* SHA2\_USE\_MEMSET\_MEMCPY or SHA2\_USE\_BZERO\_BCOPY**

The code in `sha2.c` can use either `memset()/memcpy()` for memory block operations, or `bzero()/mcopy()`. If you define neither of these, the code will default to `memset()/memcpy()`. You can define either at the command line or in `sha2.h` or in `sha2.c`.

**\* SHA2\_UNROLL\_TRANSFORM**

By defining this either on the command line or in `sha2.h` or `sha2.c`, the code will use macros to partially "unroll" the SHA transform function. This usually generates bigger executables. It CAN (but not necessarily WILL) generate faster code when you tell your compiler to optimize things. For example, on the FreeBSD and Linux x86 systems I tested things on (using `gcc`), when I optimized with just `-O2` and unrolled the transform, the hash transform was faster by 15-30%. On these same systems, if I did NO optimization, the unrolled transform was SLOWER, much slower (I'm guessing because the code was breaking the cache, but I'm not sure). Your mileage may vary.

**PORTABILITY:**

The code in `sha2.c` and `sha2.h` is intended to be portable. It may require that you do a few `#definitions` in the `.h` file. I've successfully compiled and tested the `sha2.c` and `sha2.h` code on Apple's OS X (on a PPC), FreeBSD 4.1.1 on Intel, Linux on Intel, FreeBSD on the Alpha, and even under Windows98SE using Metrowerks C. The utility/example programs (`sha2prog.c`, `sha2test.c`, and `sha2speed.c`) will very likely have more trouble in portability since they do I/O.

To get sha2.c/sha2.h working under Windows, I had to define SHA2\_USE\_INTTYPES\_H, BYTE\_ORDER, LITTLE\_ENDIAN, and had to comment out the include of <sys/types.h> in sha2.h. With a bit more work I got the test program to run and verified that all the test cases passed.

#### SUGGESTIONS/BUG FIXES:

If you make changes to get it working on other architectures, if you fix any bugs, or if you make changes that improve this implementation's efficiency that would be relatively portable and you're willing to release your changes under the same license, please send them to me for possible inclusion in future versions.

If you know where I can find some additional test vectors, please let me know.

#### CHANGE HISTORY:

0.8 to 0.9 - Fixed spelling errors, changed to u\_intXX\_t type usage, removed names from prototypes, added prototypes to sha2.c, and a few things I can't recall.

0.9 to 0.9.5 - Add a new define in sha2.c that permits one to compile it to either use memcpy()/memset() or bcopy()/bzero() for memory block copying and zeroing. Added support for unrolled SHA-256/384/512 transform loops. Just compile with SHA2\_UNROLL\_TRANSFORM to enable. It takes longer to compile, but I hope it is a bit faster. I need to do some test to see whether or not it is. Oh, in sha2.c, you either need to define SHA2\_USE\_BZERO\_BCOPY or SHA2\_USE\_MEMSET\_MEMCPY to choose which way you want to compile. \*Whew\*

It's amazing how quickly something simple starts to grow more complex even in the span of just a few hours. I didn't really intend to do this much.

0.9.5 to 0.9.6 - Added a test program (sha2test) which tests against several known test vectors. WARNING: Some of the test output hashes are NOT from NIST's documentation and are the output of this implementation and so may be incorrect.

0.9.6 to 0.9.7 - Fixed a bug that could cause invalid output in certain cases and added an assumed scenario where zero-length data is hashed. Also changed the rotation macros to use a temporary variable as this reduces the number of operations. When data is fed in blocks of the right length, copying of

data is reduced in this version. Added SHAYXZ\_Data() functions for ease of hashing a set of data. Added another file sha2speed.c for doing speed testing. Added another test vector with a larger data size (16KB). Fixed u\_intXX\_t and uintXX\_t handling by adding a define for SHA2\_USE\_INTTYPES\_H as well as made a few other minor changes to get rid of warnings when compiling on Compaq's Tru64 Unix.

0.9.7 to 0.9.8 - The bug fix in 0.9.7 was incomplete and in some cases made things worse. I believe that 0.9.8 fixes the bug completely so that output is correct. I cannot verify this, however, because of the lack of test vectors against which to do such verification. All versions correctly matched the very few NIST-provided vectors, but unfortunately the bug only appeared in longer message data sets.

0.9.8 to 0.9.9 - Fixed some really bad typos and mistakes on my part that only affected big-endian systems. I didn't have direct access for testing before this version. Thanks to Lucas Marshall for giving me access to his OS X system.

0.9.9 to 1.0.0b1 Added a few more test samples and made a few changes to make things easier compiling on several other platforms. Also I experimented with alternate macro definitions in the SHA2\_UNROLL\_TRANSFORM version (see sha2.slower.c) and eliminated the T1 temporary variable (the compiler would of course still use internal temporary storage during expression evaluation, but I'd hoped the compiler would be more efficient), but unfortunately under FreeBSD 4.1.1-STABLE on an x86 platform, the change slowed things down.

1.0.0b1 to 1.0 RELEASE Fixed an off-by-one implementation bug that affected SHA-256 when hashed data length  $L = 55 + 64 * X$  where X is either zero or a positive integer, and another (basically the same bug) bug in SHA-384 and SHA-512 that showed up when hashed data lengths  $L = 111 + 128 * X$ . Thanks to Rogier van de Pol for sending me test data that revealed the bug. The fix was very simple (just two tiny changes). Also, I finally put the files into RCS so future changes will be easier to manage. The sha2prog.c file was rewritten to be more useful to me, and I got rid of the old C testing program and now use a perl script with a subdirectory full of test data. It's a more flexible test system.

LATEST VERSION:

The latest version and documentation (if any :) should always be available

on the web at:

<http://www.aarongifford.com/computers/sha.html>

#### CONTACT ME:

I can be reached via email at:

Aaron Gifford <[me@aarongifford.com](mailto:me@aarongifford.com)>

Please don't send support questions. I don't have the time to answer and they'll probably be ignored. Bug fixes, or patches that add something useful will be gratefully accepted, however.

If you use this implementation, I would enjoy getting a brief email message letting me know who you are and what use to which it is being put. There is no requirement to do so. I just think it would be fun.

#### EXAMPLES:

Here's an example of compiling and using the sha2 program (in this example I build it using the unrolled transform version with -O2 optimizations), and then running the perl testing script:

```
cc -O2 -DSHA2_UNROLL_TRANSFORM -Wall -o sha2 sha2prog.c sha2.c
% ./sha2test.pl
```

[most of the perl script output deleted for brevity]

===== RESULTS (18 VECTOR DATA FILES HASHED) =====

HASH TYPE	NO. OF TESTS	PASSED	FAILED
SHA-256	18	18	0
SHA-384	18	18	0
SHA-512	18	18	0
-----			
TOTAL:	54	54	0

NO ERRORS! ALL TESTS WERE SUCCESSFUL!

ALL TEST VECTORS PASSED!

That's all folks! Have fun!

Aaron out.

Found in path(s):

\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/sha2/README

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\* FILE: sha2speed.c

\* AUTHOR: Aaron D. Gifford - <http://www.aarongifford.com/>

\*

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\* \$Id: sha2speed.c,v 1.1 2001/11/08 00:02:23 adg Exp adg \$

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\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/sha2/sha2speed.c

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/\* alert.h -- DTLS alert protocol

\*



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/\* dtls -- a very basic DTLS implementation

\*

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\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/tests/ccm-testdata.c  
\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/numeric.h

No license file was found, but licenses were detected in source scan.

```
<div class="line"><a name="l00005"></a><span class="lineno"> 5</span>&#160;<span class="comment"> *  
Permission is hereby granted, free of charge, to any person</span></div>  
<div class="line"><a name="l00011"></a><span class="lineno"> 11</span>&#160;<span class="comment"> *  
furnished to do so, subject to the following conditions:</span></div>  
<div class="line"><a name="l00013"></a><span class="lineno"> 13</span>&#160;<span class="comment"> *  
The above copyright notice and this permission notice shall be</span></div>  
<div class="line"><a name="l00014"></a><span class="lineno"> 14</span>&#160;<span class="comment"> *  
included in all copies or substantial portions of the Software.</span></div>
```

Found in path(s):

\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-  
0.4.0/doc/html/crypto\_8h\_source.html  
\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-  
0.4.0/doc/html/debug\_8c\_source.html  
\*  
/opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-  
0.4.0/doc/html/dtls\_8c\_source.html  
\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-  
0.4.0/doc/html/global\_8h\_source.html  
\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-  
0.4.0/doc/html/state\_8h\_source.html  
\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-  
0.4.0/doc/html/peer\_8h\_source.html  
\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-  
0.4.0/doc/html/dtls\_8h\_source.html  
\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-  
0.4.0/doc/html/numeric\_8h\_source.html  
\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-  
0.4.0/doc/html/peer\_8c\_source.html  
\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-  
0.4.0/doc/html/alert\_8h\_source.html  
\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-  
0.4.0/doc/html/dtls\_\_time\_8h\_source.html  
\*  
/opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-  
0.4.0/doc/html/crypto\_8c\_source.html

```
* /opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/doc/html/hmac_8c_source.html
* /opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/doc/html/ccm_8h_source.html
* /opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/doc/html/ccm_8c_source.html
* /opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/doc/html/dtls__time_8c_source.html
* /opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/doc/html/hmac_8h_source.html
* /opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/doc/html/debug_8h_source.html
```

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```
#                                     -*- Autoconf -*-
# Process this file with autoconf to produce a configure script.
#
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```

```
AC_PREREQ([2.65])
AC_INIT([tinydtls], [0.4.0])
AC_CONFIG_SRCDIR([dtls.c])
dnl AC_CONFIG_HEADERS([config.h])
```

```
# First check for Contiki build to quit configure before any other test
AC_ARG_WITH(contiki,
  [AS_HELP_STRING([--with-contiki],[build libtinydtls for the Contiki OS]),
```

```

[cp -p Makefile.contiki Makefile
cp -p config.h.contiki config.h
AC_MSG_NOTICE([Contiki build prepared])
exit 0],
[]

# Checks for programs.
AC_PROG_MAKE_SET
AC_PROG_CC
AC_PROG_RANLIB
AC_PATH_PROG(DOXYGEN, doxygen, [:])
AC_PATH_PROG(ETAGS, etags, [/bin/false])

AC_C_BIGENDIAN

# Checks for libraries.
AC_SEARCH_LIBS([gethostbyname], [nsl])
AC_SEARCH_LIBS([socket], [socket])
dnl AC_CHECK_LIB([dl],
[dlopen])

AC_ARG_WITH(debug,
[AS_HELP_STRING([--without-debug],[disable all debug output and assertions]),
[CPPFLAGS="{CPPFLAGS} -DNDEBUG"],
[])

CPPFLAGS="{CPPFLAGS} -DDTLSv12 -DWITH_SHA256"
OPT_OBJS="{OPT_OBJS} sha2/sha2.o"

AC_SUBST(OPT_OBJS)

# Checks for header files.
AC_CHECK_HEADERS([assert.h arpa/inet.h fcntl.h inttypes.h netdb.h netinet/in.h stddef.h stdint.h stdlib.h string.h
strings.h sys/param.h sys/socket.h sys/time.h time.h unistd.h])

# Checks for typedefs, structures, and compiler characteristics.
AC_C_INLINE
AC_TYPE_SIZE_T
dnl AC_TYPE_UINT8_T
dnl AC_TYPE_UINT16_T
dnl AC_TYPE_UINT32_T
dnl AC_TYPE_UINT64_T

AC_CHECK_MEMBER([struct sockaddr_in6.sin6_len],
[AC_DEFINE(HAVE_SOCKADDR_IN6_SIN6_LEN, [1],
[Define to 1 if struct sockaddr_in6 has a member sin6_len.])], [],
[#include <netinet/in.h>])

```

```
# Checks for library functions.
AC_FUNC_MALLOC
AC_CHECK_FUNCS([memset select socket strdup strerror strlen fls])
```

```
AC_CONFIG_HEADERS([config.h])
```

```
AC_CONFIG_FILES([Makefile
                 doc/Makefile
                 doc/Doxyfile
                 tests/Makefile
                 sha2/Makefile
                 aes/Makefile])
AC_OUTPUT
```

Found in path(s):

```
* /opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/configure.in
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```

```
<div class="line"><a name="l00003"></a><span class="lineno"> 3</span>&#160;<span class="comment">All
rights reserved.</span></div>
```

```
<div class="line"><a name="l00005"></a><span class="lineno"> 5</span>&#160;<span
class="comment">Redistribution and use in source and binary forms, with or without</span></div>
```

```
<div class="line"><a name="l00006"></a><span class="lineno"> 6</span>&#160;<span
class="comment">modification, are permitted provided that the following conditions are met:</span></div>
```

```
<div class="line"><a name="l00008"></a><span class="lineno"> 8</span>&#160;<span class="comment"> *
Redistributions of source code must retain the above copyright</span></div>
```

```
<div class="line"><a name="l00009"></a><span class="lineno"> 9</span>&#160;<span class="comment">
notice, this list of conditions and the following disclaimer.</span></div>
```

Found in path(s):

```
* /opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-
0.4.0/doc/html/utlist_8h_source.html
```

```
*
```

```
/opt/cola/permits/1846797585_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-
0.4.0/doc/html/uthash_8h_source.html
```

No license file was found, but licenses were detected in source scan.

```
/* dtls -- a very basic DTLS implementation
```

```
*
```

```
* Copyright (C) 2011--2013 Olaf Bergmann <bergmann@tzi.org>
```

```
*
```

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 \*/  
 /\*\*  
 \* @mainpage  
 \*  
 \* @author Olaf Bergmann, TZI Uni Bremen  
 \*  
 \* This library provides a very simple datagram server with DTLS  
 \* support. It is designed to support session multiplexing in  
 \* single-threaded applications and thus targets specifically on  
 \* embedded systems.  
 \*  
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 \*  
 \* This software is under the <a  
 \* href="http://www.opensource.org/licenses/mit-license.php">MIT License</a>.  
 \*  
 \* @subsection uthash UTHash  
 \*  
 \* This library uses <a href="http://uthash.sourceforge.net/">uthash</a> to manage  
 \* its peers (not used for Contiki). @b uthash uses the <b>BSD revised license</b>, see  
 \* <a href="http://uthash.sourceforge.net/license.html">http://uthash.sourceforge.net/license.html</a>.  
 \*  
 \* @subsection sha256 Aaron D. Gifford's SHA256 Implementation  
 \*  
 \* tinyDTLS provides HMAC-SHA256 with BSD-licensed code from Aaron D. Gifford,  
 \* see <a href="http://www.aarongifford.com/">www.aarongifford.com</a>.  
 \*  
 \* @subsection aes Rijndael Implementation From OpenBSD  
 \*  
 \* The AES implementation is taken from rijndael.{c,h} contained in the crypto  
 \* sub-system of the OpenBSD operating system. It is copyright by Vincent Rijmen, \*  
 \* Antoon Bosselaers and Paulo Barreto. See <a  
 \* href="http://www.openbsd.org/cgi-bin/cvsweb/src/sys/crypto/rijndael.c">rijndael.c</a>  
 \* for License info.  
 \*

\* @section download Getting the Files

\*

\* You can get the sources either from the <a

\* href="http://sourceforge.net/projects/tinydtls/files">downloads</a> section or

\* through git from the <a

\* href="http://sourceforge.net/projects/tinydtls/develop">project develop page</a>.

\*

\* @section config Configuration

\*

\* Use @c configure to set up everything for a successful build. For

Contiki, use the

\* option @c --with-contiki.

\*

\* @section build Building

\*

\* After configuration, just type

\* @code

make

\* @endcode

\* optionally followed by

\* @code

make install

\* @endcode

\* The Contiki version is integrated with the Contiki build system, hence you do not

\* need to invoke @c make explicitly. Just add @c tinydtls to the variable @c APPS

\* in your @c Makefile.

\*

\* @addtogroup dtls\_usage DTLS Usage

\*

\* @section dtls\_server\_example DTLS Server Example

\*

\* This section shows how to use the DTLS library functions to setup a

\* simple secure UDP echo server. The application is responsible for the

\* entire network communication and thus will look like a usual UDP

\* server with socket creation and binding and a typical select-loop as

\* shown below. The minimum configuration required for DTLS is the

\* creation of the dtls\_context\_t using dtls\_new\_context(), and a callback

\* for sending data. Received packets are read by the application and

\* passed to

dtls\_handle\_message() as shown in @ref dtls\_read\_cb.

\* For any useful communication to happen, read and write call backs

\* and a key management function should be registered as well.

\*

\* @code

dtls\_context\_t \*the\_context = NULL;

int fd, result;

static dtls\_handler\_t cb = {

```

.write = send_to_peer,
.read = read_from_peer,
.event = NULL,
.get_key = get_key
};

fd = socket(...);
if (fd < 0 || bind(fd, ...) < 0)
    exit(-1);

the_context = dtls_new_context(&fd);
dtls_set_handler(the_context, &cb);

while (1) {
    ...initialize fd_set rfd and timeout ...
    result = select(fd+1, &rfd, NULL, 0, NULL);

    if (FD_ISSET(fd, &rfd))
        dtls_handle_read(the_context);
}

dtls_free_context(the_context);
* @endcode
*
* @subsection dtls_read_cb The Read Callback
*
* The DTLS library expects received raw data to be passed to
* dtls_handle_message(). The application is responsible for
* filling a session_t structure with the address data of the
* remote
peer as illustrated by the following example:
*
* @code
int dtls_handle_read(struct dtls_context_t *ctx) {
    int *fd;
    session_t session;
    static uint8 buf[DTLS_MAX_BUF];
    int len;

    fd = dtls_get_app_data(ctx);

    assert(fd);

    session.size = sizeof(session.addr);
    len = recvfrom(*fd, buf, sizeof(buf), 0, &session.addr.sa, &session.size);

    return len < 0 ? len : dtls_handle_message(ctx, &session, buf, len);
}

```



```

* @endcode
*
* Once a new DTLS session was established and DTLS ApplicationData has been
* received, the DTLS server invokes the read callback with the MAC-verified
* cleartext data as its argument. A read callback for a simple echo server
* could look like this:
* @code
int read_from_peer(struct dtls_context_t *ctx, session_t *session, uint8 *data, size_t len) {
    return dtls_write(ctx, session, data, len);
}
* @endcode
*
* @subsection dtls_send_cb The Send Callback
*
* The callback function send_to_peer() is called whenever data must be
* sent over the network. Here, the sendto() system call is used to
* transmit data within the given session. The socket descriptor required
* by sendto() has been registered as application data when the DTLS context
* was created with dtls_new_context().
* Note that it is on the application to buffer the data when it cannot be
* sent at the time this callback is invoked. The following example thus
* is incomplete as it would have to deal with EAGAIN somehow.
* @code
int send_to_peer(struct dtls_context_t *ctx, session_t *session, uint8 *data, size_t len) {
    int fd = *(int *)dtls_get_app_data(ctx);
    return sendto(fd, data, len, MSG_DONTWAIT, &session->addr.sa, session->size);
}
* @endcode
*
* @subsection dtls_get_key The Key Storage
*
* When a new DTLS session is created, the library must ask the application
* for keying material. To do so, it invokes the registered call-back function
* get_key() with the current context and session information as parameter.
* When the function
* is called with the @p id parameter set, the result must
* point to a dtls_key_t structure for the given identity. When @p id is
* @c NULL, the function must pick a suitable identity and return a pointer to
* the corresponding dtls_key_t structure. The following example shows a
* simple key storage for a pre-shared key for @c Client_identity:
*
* @code
int get_key(struct dtls_context_t *ctx,
            const session_t *session,
            const unsigned char *id, size_t id_len,
            const dtls_key_t **result) {

```

```

static const dtls_key_t psk = {
    .type = DTLS_KEY_PSK,
    .key.psk.id = (unsigned char *)"my identity",
    .key.psk.id_length = 11,
    .key.psk.key = (unsigned char *)"secret",
    .key.psk.key_length = 6
};

*result = &psk;
return 0;
}
* @endcode
*
* @subsection dtls_events The Event Notifier
*
* Applications that want to be notified whenever the status of a DTLS session
* has changed can register an event handling function with the field @c event
* in the
dtls_handler_t structure (see \ref dtls_server_example). The call-back
* function is called for alert messages and internal state changes. For alert
* messages, the argument @p level will be set to a value greater than zero, and
* @p code will indicate the notification code. For internal events, @p level
* is @c 0, and @p code a value greater than @c 255.
*
* Currently, the only defined internal event is @c DTLS_EVENT_CONNECTED. It
* indicates successful establishment of a new DTLS channel.
*
* @code
int handle_event(struct dtls_context_t *ctx, session_t *session,
                dtls_alert_level_t level, unsigned short code) {
    ... do something with event ...
    return 0;
}
* @endcode
*
* @section dtls_client_example DTLS Client Example
*
* A DTLS client is constructed like a server but needs to actively setup
* a new session by calling dtls_connect() at some point. As this function
* usually returns before the new DTLS channel is established, the application
* must
register an event handler and wait for @c DTLS_EVENT_CONNECT before
* it can send data over the DTLS channel.
*
*/

```

Found in path(s):

\* /opt/cola/permits/1846797585\_1700034770.4897707/0/tinydtls-0-4-0-tar-gz/tinydtls-0.4.0/dtls.h

# 1.64 sg3-utils 1.48

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