MURAL User Guide

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TOC

Introducing MURAL

MURAL provides network operators with near-real-time insight into traffic patterns on their networks. Traffic distribution is analyzed across multiple dimensions, including data centers, radio access types, mobile devices, subscribers, and content types. Each primary dimension has its own screen (referred to as a *tab*) in the user interface, with charts and tables you can use to further analyze the traffic cross-dimensionally.

For details about the traffic dimension, see the indicated topics:

- **Network**—Analysis of traffic distribution across the gateways in your network. See "Analyzing Traffic Distribution Across Network Sites" on page 32.

- **Access Technology**—Analysis of traffic distribution across radio access types (RATs) used by your subscribers. See "Analyzing Traffic Distribution Across Access Technologies" on page 37.

- **Device**—Analysis of traffic distribution across the mobile devices (such as smart phones and tablet computers) that subscribers used to access the network. See "Analyzing Traffic Distribution Across Mobile Devices" on page 41.

- **Top Subscribers**—Analysis of traffic distribution across top subscriber. See "Analyzing Traffic Distribution Across Top Subscribers" on page 45.

- **Content**—Analysis of traffic distribution across types of content, classed by subject matter (such as sports or news), function (filesharing, VOIP), or application (browser, social networking). See "Analyzing Traffic Distribution Across Types of Content" on page 47.

- **Bulkstats**—Summaries of performance statistics for the Cisco ASR. See"Interpreting Performance Statistics for the ASR" on page 87.

- **KPI**—Summaries of key performance indicators (KPIs) for the Cisco ASR. See"Interpreting Performance Statistics for the ASR" on page 87.

- **Reports**—Summaries of traffic analysis for different periods of time (days, weeks, months). See "Scheduling and Interpreting Statistical Reports" on page 64.

- **User Management**—Administration of MURAL user accounts. See "Managing Users" on page 77.

Navigating the Opening Page

After you provide your username and password on the login page, the opening page as illustrated in the following figure is displayed.

The numbered panes are explained as follows:

- **ALERTS** (box **1**)—Use this tab to detect DPI and KPI alerts, create personalized alerts, and act on alert notifications. For more information, see "Identifying and Managing Alerts" on page 11.

- **WORKFLOWS** (box **2**)—Use this tab to view and compare trends, and analyze network traffic distribution across gateways, access technology, content types, devices, top subscribers, and cell sectors. The following work flows are available on this tab:

  - **Trending & Monitoring**— For more information, see "Viewing and Comparing Trends" on page 61.

  - **Network Insights**— For more information, see "Analyzing Traffic Distribution Across Network Sites" on page 32

- **REPORTS** (box **3**)— Use this tab to schedule and interpret reports. For more information, see "Scheduling and Interpreting Statistical Reports" on page 64.

- <user name> (box 4)—Click this to sign out or change password.

- Optional modules (box 5)— Click [⋮⋮⋮] to view optional modules. The available modules are **MURAL**, **Bulkstats/KPIs, User Management**, and **System Monitoring Interface**.

  Click **MURAL** to display information about the application.

  Click **Bulkstats/KPIs** to display performance statistics for a specified Cisco ASR system. For more information, see <cross-ref>.

  Click **User Management** to view all the users in the application. You can create new users, edit the details for existing ones and delete users. For more information, see "Managing Users" on page 77. **Note**: This option is available to admin users, when LDAP integration is not chosen. When LDAP is integrated, permissions and user management is done through the LDAP service.

  Click **System Monitoring Interface** to display a dashboard for monitoring the MURAL system. For more information, see "System Monitoring Interface" on page 80.

- Help (box **6**)—Click this to display the Online Help and information about the application.

Identifying and Managing Alerts

The **ALERTS** tab enables you to view all alerts triggered when the specific thresholds have been surpassed or an alert is detected.

A detection algorithm runs across designated network attributes and compares data over a specified time interval. These values are compared against a baseline to find deviations (alerts) in the data. Detected alerts are assigned a severity rating per severity assigned to the rule.

Use this tab to:

- Review and resolve active notifications

- Create, modify, or delete alert settings

Separated by **Low|Medium|High**, the following image illustrates the **ALERTS** tab containing low confidence alerts, medium confidence alerts, and high confidence alerts.
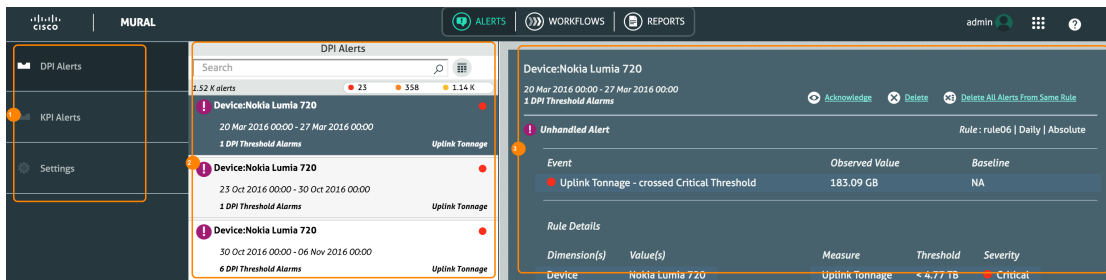
The numbered panes in the preceding image are explained as follows:

1. Alert Navigation pane [box **1**]— This pane displays predefined folders.

   For more information, see "Alert Navigation Pane" on the facing page.

2. Alert List pane [box **2**]— This pane displays a list of alerts corresponding to the selected folders.

   For more information, see "Reviewing Alerts in the Alert List Pane" on the facing page.

3. Alert Details pane [box **3**]— This pane displays the details of a selected

alert from the Alert List pane.

For more information, see "Reviewing the Alert Details Pane" on page 14.

Alert Navigation Pane

When you click the **ALERTS** tab, you can view predefined folders and manage alert rules.

Navigate Folders

The following predefined folders are displayed in the Alert Folder pane.

- **DPI Alerts**— Click this folder to display all the DPI alerts in the adjacent Alert List pane. This is displayed if DPI Alerts application is configured when installing MURAL.

- **KPI Alerts**— Click this folder to display all the KPI in the adjacent Alert List pane. This is displayed if Bulkstats application is configured when installing MURAL. For more information, see "Analyzing KPI Alerts" on page 15.

- **Settings**— Click this to create DPI and KPI alert rules. These rules identify instances which result in a notification after a threshold is crossed. For more information, see "Managing DPI Alerts" on page 18 and "Managing KPI Alerts" on page 22.

You can select any folder to view its content. Upon selection of a folder, it is high-lighted and its details are displayed in the Alert List pane (box **3** in the preceding image). By default, the **DPI Alerts** folder is selected.

Reviewing Alerts in the Alert List Pane

When you click a folder in the Alert Navigation pane, all the corresponding alerts are displayed in the Alert List pane. You can sort the alert list by most recent (default) and least recent alerts. The Alert List pane is populated based on the selected folder, and string in Search criteria. Click an alert to display its details in the Alert Detail pane.

You can view the following details for each alert in the Alert List pane:

- Status of the alert. When a new alert is generated, its status is Unhandled ( ). The other status is Acknowledged ( ).

- Attributes for which the alert was generated. Alerts are grouped by alert rules. The number of times an alert has been triggered is also displayed. The following use cases are addressed with this feature:

  - See only one alert in my inbox when an alert (with the same attributes) is occurring persistently.
  - Know the number of times an alert (with the same attributes) occurred over a certain period.
  - Know the measure types for which alerts where triggered.

- Time range of the alert group, from the beginning of the first alert to the end of the last alert of the group.

- Type of the alert.

- Measure types and confidence level for which anomalies were generated in the group, indicated by the color of the event icon. The Red color ( ) denotes Critical, the Orange color ( ) denotes Major, and the Mango color ( ) denotes Minor.

- Persistence of the alert, indicated by the number of alert.

You can search for specific alerts. For more information, see "Search for Specific Alerts" below

Search for Specific Alerts

You can search for specific alerts in the following ways:

- Use the Search text box to search for specific alerts.

- Use the calendar icon to specify time in the in the past and look at alerts that occurred during that period.

To search for specific alerts by type, dimension, or time:

1. In the Search box that is displayed, specify a criteria. It can be a complete or partial string. Press the **Enter** key.

Click X to remove characters from the string.

To specify a time in the past:

1. Click ⊞ to open a calendar.

2. Select a start date and time.

3. Select an end date and time.

4. Click **Apply**.

All the alerts that occurred during that period are displayed on the **ALERTS** tab.

Reviewing the Alert Details Pane

When you select an alert from the Alert List pane, all the details of the selected alert is displayed in the Alert Details pane. The following section lists the details that are displayed for DPI alert:

- Status of the alert. By default, a new alert is denoted as Unhandled. You can select a different status as required. The available option is **Acknowledge**.

- Attributes for which the alert was generated.

- Time range of the alert group, from the beginning of the first alert to the end of the last alert of the group.

Type of Alert Rule	Granularity	Bucketing	Maximum Number of Alerts
Absolute	Hourly	Daily	24
Absolute	Daily	Weekly	7
Absolute	Monthly	Half-yearly	6
Rate of change	Hourly	Daily	24
Rate of change	Daily	Quarterly	12 to 15
Rate of change	Monthly	Half-yearly	6

- The corresponding alert rule of the alert.

- Frequency of the alert.

- Alert rule type.

- Event type.

- Observed value.

- Baseline.

- Alert rule details and corresponding KPIs.

- Threshold Alarms— All the distinct alerts in the group are displayed. Alerts are sorted based on time, event type, severity (high first), measure, baseline, and then threshold.

Analyzing KPI Alerts

Click the **KPI Alerts** folder to display all the KPI in the adjacent Alert List pane. This is displayed if Bulkstats application is configured when installing MURAL.

Reviewing Alerts in the Alert List Pane

When you click a folder in the Alert Navigation pane, all the corresponding alerts are displayed in the Alert List pane. You can sort the alert list by most recent (default) and least recent alerts. The Alert List pane is populated based on the selected folder, and string in Search criteria. Click an alert to display its details in the Alert Detail pane.

You can view the following details for each alert in the Alert List pane:

- Status of the alert. When a new alert is generated, its status is Unhandled ( ). The other status is Acknowledged ( ).

- Attributes for which the alert was generated. Alerts are grouped by alert rules. The number of times an alert has been triggered is also displayed. The following use cases are addressed with this feature:

  - See only one alert in my inbox when an alert (with the same attributes) is occurring persistently.

- Know the number of times an alert (with the same attributes) occurred over a certain period.
  - Know the measure types for which alerts where triggered.

- Time range of the alert group, from the beginning of the first alert to the end of the last alert of the group.

- Type of the alert.

- Measure types and confidence level for which anomalies were generated in the group, indicated by the color of the event icon. The Red color (●) denotes Critical, the Orange color (●) denotes Major, the Mango color (●) denotes Minor, and the Yellow color (●) denotes Warning.

- Persistence of the alert, indicated by the number of alert.

You can search for specific alerts. For more information, see "Search for Specific Alerts" below.

Search for Specific Alerts

You can search for specific alerts in the following ways:

- Use the Search text box to search for specific alerts.

- Use the calendar icon to specify time in the in the past and look at alerts that occurred during that period.

To search for specific alerts by type, dimension, or time:

1. In the Search box that is displayed, specify a criteria. It can be a complete or partial string. Press the **Enter** key.

   Click X to remove characters from the string.

To specify a time in the past:

1. Click ⊞ to open a calendar.

2. Select a start date and time.

3. Select an end date and time.

4. Click **Apply**.

All the alerts that occurred during that period are displayed on the **ALERTS** tab.

Reviewing the Alert Details Pane

When you select an alert from the Alert List pane, all the details of the selected alert is displayed in the Alert Details pane. The following section lists the details that are displayed for KPI alert:

- Status of the alert. By default, a new alert is denoted as Unhandled. You can select a different status as required. The available option is **Acknowledge**.

- Attributes for which the alert was generated.

- Time range of the alert group, from the beginning of the first alert to the end of the last alert of the group.

Type of Alert Rule	Granularity	Bucketing	Maximum Number of Alerts
Absolute	5 minutes	2 hours	24
Absolute	10 minutes	4 hours	24
Absolute	15 minutes	6 hours	24
Absolute	30 minutes	12 hours	24

- The corresponding alert rule of the alert.

- Frequency of the alert.

- Alert rule type.

- Event type.

- Observed value.

- Baseline.

- Alert rule details and corresponding KPIs.

- Threshold Alarms— All the distinct alerts in the group are displayed. Alerts are sorted based on time, event type, severity (high first), measure, baseline, and then threshold.

Managing DPI Alerts

Alert detection is based on finding variances between a measured value and an expected value (baseline). This section explains the rules and values that define the baseline.

Note: The maximum number of active rules that can be in the system at any given time is 25.

To manage DPI alert rules:

1. Click **Settings** in the Alert Folder pane.

   Under **DPI Alert Rules**, the existing rules are displayed along with options to edit and remove these on the tab.

2. Perform one of the following tasks:

   - "Viewing DPI Rules" below

   - "Adding a DPI Rule" on the next page

Viewing DPI Rules

The table lists all active rules and their values, such as:

- **DPI Alert Rule Name**— Designated name for the DPI alert rule.

- **Frequency**— Granularity based on which an alert is raised.

- **Dimension**— Parameters defining parts of the network which should be checked against this rule.

- **Measure**— The type of data which should be checked against this alert rule.

- **Minor**— Threshold value for which a minor alert is raised.

- **Major**— Threshold value for which a major alert is raised

- **Critical**— Threshold value for which a critical alert is raised

- **Range**—Time range which is checked for crossing the threshold.

- **Status**—Indicates the status of the alert. The statuses are **Expired** or **Active**.

  Note: By default, the maximum number of alerts that can be detected by the system for a rule is 10. You can customize this limit as per your requirement. Contact Technical Support.

- **Edit/Delete**—Two icons for actions that can be performed on this alert rule: edit and delete.

Adding a DPI Rule

To add a new rule:

1. Click next to **Add New Rule**.

   The following image illustrates the **Add DPI Alert Rule** dialog box that is displayed.

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Before setting the Threshold, Threshold Granularity, or Threshold Value, review the next two sections:

- "Understanding Thresholds" on the next page

- "Setting Threshold Granularity" on the next page

2. Perform the following steps in the **Add DPI Alert Rule** dialog box that is displayed:

   a. In the **Rule Name** box, enter a unique name for the rule.

   b. From the **Measure** drop-down list, select a measure. The available options are: Uplink Tonnage, Hits, Total Tonnage, Downlink Tonnage, and Unique Subscribers.

   c. From the **Type** drop-down list, select a type. The available options are: **Absolute** and **Rate of Change**.

   d. From the **Granularity** drop-down list, select a granularity in minutes at which the KPI is to be calculated. The available options are: **Hourly**, **Daily**, and **Monthly**.

   e. To set threshold for a selected severity, perform the following steps:

      a. Select a check box adjacent to the severity type. The available options are: **Warning**, **Minor**, **Major**, and **Critical**.

      b. From the **Comparator** drop-down list, select a comparator. Based on the rule type, the options are displayed.

         If you selected **Absolute**, the available options are **=** (Equal to), **>** (Greater than), and **<** (Lesser than).

         If you selected **Rate of Change**, the available options are **Any change over**, **Increasing over**, and **Decreasing over**.

         Note: You must specify a unique threshold for each severity. For example, you cannot select the same comparator and enter the same value for two different severities.

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     c. In the blank field, enter an absolute signed double value against which each KPI value for the defined granularity will be compared against.

        The alarm is raised if the value is more or is less than the threshold value (as configured).

   f. In the **Start Time** and **End Time** fields, set the time range.

   g. Set the dimensions:

     a. From the **APN** drop-down list, select an APN.

     b. From the **Value** drop-down list, select a value.

     c. Click ⊕ to add a gateway.

     d. Repeat the above step to add protocol, radio access type, and SGSN.

   h. Click **Create** to apply your changes or **Cancel** to discard them.

Understanding Thresholds

The baseline is a threshold defined by the user for each rule. There are two methods of defining the baseline:

- **Static value**—A non-variant number.
- **Temporal Moving Average**—A variant number, determined by averaging the last N (three) values for the specified interval being analyzed.

Setting Threshold Granularity

The time series is broken into hourly intervals, making it the smallest increment that can be used to analyze anomalies. The granularity for thresholds within rules are Hourly, Daily, and Monthly.

If using the Temporal Moving Average as the rule threshold, the formula to determine the baseline will be a rolling average of:

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- **Hourly**—Hourly data-points from the same time and day of the last three weeks

- **Daily**—Daily data-points from the same day of the previous three weeks

- **Monthly**—Monthly data-points from the last three months

Note: If using a Temporal Moving Average threshold value, the amount of time defined in these formulas is also the amount of time the system requires to "learn" the rule after it is created. So, if you create a rule that averages the last three months for the baseline, the rule will not identify anomalies until three months after it was created.

Editing a DPI Rule

To edit an existing active rule:

1. Click [pencil icon] in the **Edit** column for the DPI rule that you want to edit.

   Note: You can modify details of only the active rule. The edit icon is disabled for the expired rules.

2. Edit the threshold values as required. All other fields are disabled.

3. Click **Update**.

Managing KPI Alerts

You can configure alarms on key performance indicators that are based on the Bulkstats data received from multiple ASR nodes in a network. You can create an alert on a specific schema and instance of a gateway. When the KPI crosses or misses the threshold that you defined, an alarm is raised and displayed on the **KPI Alerts folder**.

Note: The maximum number of active rules that can be in the system at any given time is 25.

To manage KPI alert rules:

1. Click **Settings** in the Alert Folder pane.

   Under **KPI Alert Rules**, the existing rules are displayed along with options to edit and remove these on the tab.

2. Perform one of the following tasks:

   - "Viewing KPI Rules" below

   - "Adding a KPI Rule" below

Viewing KPI Rules

The table lists all active rules and their values, such as:

- **KPI Alert Rule Name**—Designated name for the DPI alert rule.

- **Schema**—Schema of the gateway.

- **KPI**—KPI on which the alarm is configured.

- **Index**—Index of the KPI.

- **Warning**— Threshold value for which a warning is raised.

- **Minor**—Threshold value for which a minor alert is raised

- **Major**—Threshold value for which a major alert is raised

- **Critical**—Threshold value for which a critical alert is raised

- **Status**—Indicates the status of an alert. The statuses are **Expired** or **Active**.

- **Edit/Delete**—Two icons for actions that can be performed on this alert rule: edit and delete.

Adding a KPI Rule

To add a new rule:

1. Click ➕ next to **Add New Rule**.

   The following image illustrates the **Add KPI Alert Rule** dialog box that is displayed.

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2. Perform the following steps in the **Add KPI Alert Rule** dialog box that is displayed:

   a. In the **Rule Name** box, enter a unique name for the rule.

   b. From the **Gateway** drop-down list, select a gateway.

   c. From the **Schema** drop-down list, select a schema.

      Options in this list are populated based on the gateway that you selected in the step a.

   d. From the **KPI** drop-down list, select a KPI.

      Options in this list are populated based on the schema that you selected in the step b. You can create KPIs for a gateway by using the Bulkstats module. For more information, see "Interpreting Performance Statistics for the ASR" on page 87.

   e. From the **Index** drop-down list, select an index.

      Options in this list are populated based on the KPI that you selected in the step c.

   f. From the **Granularity** drop-down list, select a granularity in minutes at which the KPI is to be calculated. The available options are: 5, 10, 15, and 30.

g. To set threshold for a selected severity, perform the following steps:

a. Select a check box adjacent to the severity type. The available options are: **Warning**, **Minor**, **Major**, and **Critical**.

b. From the **Comparator** drop-down list, select a comparator. The available options are: **>=** (Greater than Equal to) and **<=** (Lesser than Equal to).

c. In the blank field, enter an absolute signed double value against which each KPI value for the defined granularity will be compared against.

   Note: You must specify a unique threshold for each severity. For example, you cannot select the same comparator and enter the same value for two different severities.

   The alarm is raised if the value is more or is less than the threshold value (as configured).

h. Click **Create** to apply your changes or **Cancel** to discard them.

Editing a KPI Rule

To edit an existing active rule:

1. Click ✏ in the **Edit** column for the KPI rule that you want to edit.

   Note: You can modify details of only the active rule. The edit icon is disabled for the expired rules.

2. Edit the threshold values as required. All other fields are disabled.

3. Click **Update**.

Understanding Common Features Across Workflow Screens

This section describes certain common features that are available on each of the workflow screens. As an example, the **MURAL Network Insights** screen is illustrated here.
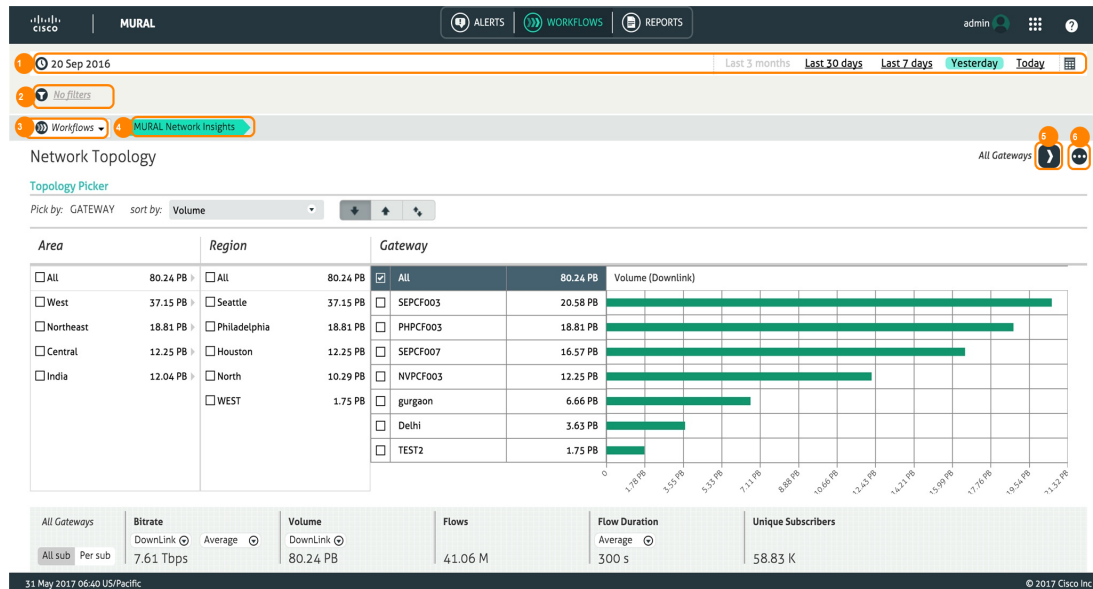
Date and Time

The information displayed on graphs and tables always corresponds to a specific time range. Determining whether the range is set properly, and resetting it as necessary, are the first steps any time you explore data. You can set a required time range to display the relevant data by using the quick links or setting the custom time range from box **1** in the preceding image.

MURAL uses the 24-hour clock to represent times; for example, a 00:00 hours is midnight and 18:00 hours is 6 PM. By default, data for Yesterday is displayed. For the optional modules (Bulkstats and KPI), data for the last 6 hours is displayed by default.

Setting the Time Range to a Standard Duration

To set the time range quickly to a standard duration, click its name in the right portion of the time range selector. The following table lists a few examples of the start and end days (the list can be customized based on your requirements):

Range	Start Day/Time	End Day/Time
Last 3 months	First day of the month 4 months prior to the current month	00:00 hours on first day of the current month
Last 30 Days	00:00 thirty days prior to the date of the latest data in the system	00:00 on the date of the latest data in the system
Last 7 Days	00:00 six days prior to the date of the latest data in the system	Time and date of the latest data in the system
Yesterday	00:00 on a day before the latest data in the system	00:00 on the date of the latest data in the system
Today	00:00 on the date of the latest data in the system	Time and date of the latest data in the system

For the optional modules, Bulkstats and KPI the following quick links are displayed.

Range	Start Day/Time	End Day/Time
6 hours	Six hours prior to the date of the latest data in the system	Time and date of the latest data in the system
12 hours	Twelve hours prior to the date of the latest data in the system	Time and date of the latest data in the system
24 hours	Twenty-four hours prior to the date of the latest data in the system	Time and date of the latest data in the system
Last 7 Days	00:00 six days prior to the date of the latest data in the system	Time and date of the latest data in the system
Last 30 days	00:00 thirty days prior to the date of the latest data in the system	00:00 on the date of the latest data in the system

If you select a quick time range that begins before the time when data was first collected, MURAL displays all available data (that is, data from the entire period between the first collection time and the last hourly interval for which data is available on the current day). The Selected Time Range field specifies the start and end times.

Setting the Time Range to a Custom Duration

Quick time ranges are convenient, but are limited to standard start times, end times, and durations. Using the custom time range selector, you can customize the start and end times.

To access the custom time range interface, click the calendar icon (⊞) at the right end of the time range selector. The custom time range interface opens with a calendar that depicts the time range currently selected for the tab. In the figure, it is yesterday.

Data is fetched from the system's cache and is refreshed at regular intervals. If you select a time range that falls beyond the available data in cache, the system takes relatively more time to fetch and display data on the UI. This is termed as a slow call and it is informed on the UI as illustrated below.

When you select a custom duration for Bulkstats data, time is snapped based on the longest granularity. If the granularity is hourly, time is snapped to the nearest hour. If the granularity is 15-minutes, time is snapped to the nearest 15th minute.

Filters

By default, filters selected on the Network Topology screen are applied to a screen. Click the **Filters** link (box **2**) to restrict the source of data to only entities that match criteria you choose. For more information, "Filtering in MURAL" on page 56.

Workflows

Click the **Workflows** button (box **3**) to select any other workflow. When you click a workflow, you are taken to the corresponding screen.

The following image illustrates the options available in the **Workflows** menu.
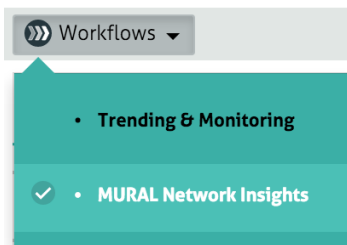
Click to navigate back to the main screen on the **WORKFLOWS** tab.

Breadcrumbs

The Breadcrumb bar (box **4**) is an explore card displaying the dimension route that you follow when exploring the user interface. You can use the breadcrumb bar to navigate back to any previous dimension explored in the chain by clicking the corresponding breadcrumb.

Note: If you selected filters on the starting screen, those filters are carried forward to the next screen. However, if you make any changes to the filters in the subsequent screen and you decide to navigate back to the main screen through the breadcrumb, the filters that were set originally on the main screen are retained.

The current or active screen is highlighted in Turquoise and the other screens in the route are displayed in dark blue color as illustrated in the following breadcrumb bar image.

The minimum and maximum size of the breadcrumb bar can be customized as per your requirements. If breadcrumbs exceed the maximum size, an ellipsis (...) is displayed after the last possible breadcrumb. If a breadcrumb exceeds its

maximum size in length, the extra characters are truncated and a default tooltip is displayed.

Drill-Down

You can select options from this menu (box **5**) to view detailed information about individual , gateways, or network sectors. The format and type of information depend on the option you select. Each workflow has different options displayed in the drill-down menu. The following flow chart illustrates the navigation paths through the **WORKFLOWS** tab.
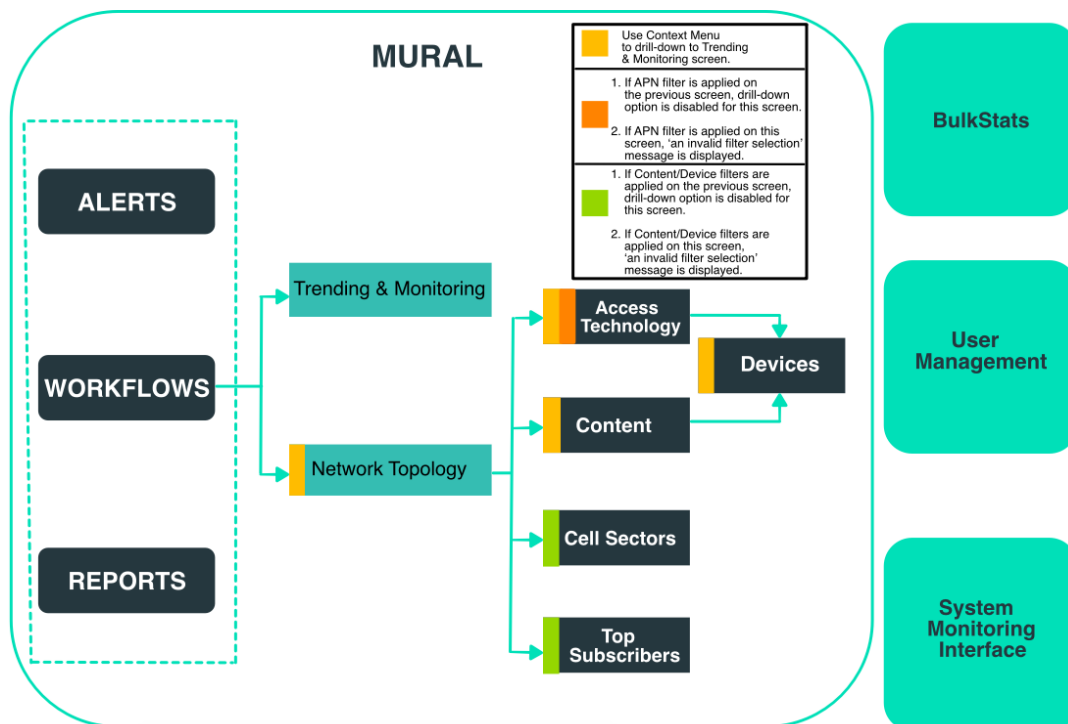
Context Menu

After viewing the information and making the required selections, you can per-form additional tasks by selecting options from the context menu (, box **6**).

Analyzing Traffic Distribution Across Network Sites

The **MURAL Network Insights** workflow in MURAL reports the distribution of network traffic across the sites where your network equipment is physically located (also referred to as *gateways*). By tracking traffic patterns at a gateway over time, you can anticipate demand and provision efficiently to meet customer requirements at minimal cost.

Use the **MURAL Network Insights** workflow to answer questions like the following:

- What is the distribution of traffic across the geographical network?

- What particular usage trends are developing at a gateway?

- How does network usage compare between gateways?

The following image illustrates the Network Topology screen.

The panes in the numbered boxes provide the following functionality:

1. Sort by— Select a measure by which you want to sort data and display in box **1**. The available options are:

- Volume— Volume of traffic that traversed the network, in bytes. By default, downlink traffic (flowing from the network toward mobile users) as indicated by the selected icon (✦) is displayed. Click ✦ to display uplink traffic (flowing from mobile users toward the network). Click ✦ to display the total traffic.

- Bitrate— Number of bits per second (bps) of traffic flowing on the network. By default, downlink traffic (flowing from the network toward mobile users) as indicated by the selected icon (✦) is displayed. Click ✦ to display uplink traffic (flowing from mobile users toward the network). Click ✦ to display the total traffic.

- Flows— Number of active flows.

- Avg Flow Duration— Average duration in seconds for the type of event reported.

- Unique Subscribers—Number of active subscribers.

2. Network Topology (box **2**)— Select a topology to display data. By default, all the areas, regions, and gateways are selected. To select a value, select the required check boxes. Based on selections made in boxes **1** and **2**, horizontal bars representing the data are displayed. Select checkboxes next to the required gateways to view the usage statistics in summary pane (box **3**), compare trends (box **4**), or export data in a CSV file (box **4**). You can also drill-down to view detailed information (box **5**).

3. Summary (box **3**)— Refer to the panel that appear in the lower half of the display area summarizing multiple statistics. For more information, see "Interpreting Usage Statistics in the Summary Table" on page 35.

4. Selected gateway (box **4**)—This is a display-only field. The gateway that you selected in box **2** is displayed.

5. Drill-Down (box **5**)—Provides detailed information about individual , gate-
    ways, or network sectors. The format and type of information depend on
    the option you select by clicking :

    - Access Technology—reports the distribution of network traffic across
      the radio access types that subscribers use to connect to your net-
      work. For more information, "Analyzing Traffic Distribution Across
      Access Technologies" on page 37.

    - Cell Sectors—statistics for network sectors are presented in a table.
      For more information, see "Analyzing Traffic in Mobile Network Sect-
      ors" on page 53.

    - Top Subscribers—reports the distribution of network traffic across
      subscribers, who are grouped into segments by level of usage. For
      more information, see "Analyzing Traffic Distribution Across Top Sub-
      scribers" on page 45.

    - Content—reports the distribution of network traffic across the types
      of content being accessed by your subscribers. For more information,
      see "Analyzing Traffic Distribution Across Types of Content" on
      page 47.

      Note: If you set Content and Device filters, the **Cell Sectors** and
      Top Subscribers options are disabled in the Drill-down menu. If you
      set APN filter, the **Access Technology** option is disabled in the Drill-
      down menu.

6. Context menu (box **6**)—After viewing the information and making the
    required selections, you can perform additional tasks by selecting options
    from the context menu ( ). For example, you can view traffic patterns
    tracked in a time-series line chart for up to three of the categories. For
    more information, see "Viewing and Comparing Trends" on page 61.

    You can also export data in a CSV file by clicking the **Export to CSV** link.

Note: See "Understanding Common Features Across Workflow Screens" on
page 26 to know more about the common features across workflow screens.

Interpreting Usage Statistics in the Summary Table

A summary table summarizing the usage statistics is displayed at the bottom of the screen. The columns are as follows:

- <Gateway>— Signifies the data distribution across the selected gateway. For example, it is **All Gateways** in the preceding figure (box **3**). Select **All Sub** to view usage statistics for all the subscribers in that gateway. Select **Per Sub** to view usage statistics per subscriber.

- **Bitrate**—Number of bits per second (bps). By selecting values from the available drop-down lists, you can view the following:

  - **Avg Downlink Rate**—Average number of bits per second (bps) that traveled from the network toward mobile users.It is calculated by dividing the total number of bytes by the number of seconds in the selected time range, then multiplying by eight to convert bytes to bits.

  - **Avg Uplink Rate**—Average number of bits per second (bps) that traveled from mobile users toward the network. It is calculated in the same way as the downlink rate.

  - **Peak Agg Downlink Rate**—Largest number of bits per second (bps) that traveled from the network toward mobile users.

  - **Peak Agg Uplink Rate**—Largest number of bits per second (bps) that traveled from the network toward mobile users.

- **Volume**—Volume of traffic. By selecting values from the available drop-down lists, you can view the following:

  - **Downlink Volume**—Number of bytes that traveled from the network toward mobile users.

  - **Uplink Volume**—Number of bytes that traveled from mobile users toward the network.

- **Flows**—Number of active flows.

- **Flow Duration**—By selecting values from the available drop-down lists, you can view the following:

    - **Avg Duration**—Average duration in seconds for the type of event reported in the two fields below this field (either flows or hits).

    - **Peak Duration**—Longest duration in seconds for the type of event reported in the two fields below this field (either flows or hits).

- **Unique Subscribers**—Number of active subscribers.

The letter following the numerical value for a statistic indicates the multiple, the meaning of which depends on the type of statistic (traffic rate, traffic volume, or count).

	Rate Statistics	Volume Statistics	Count Statistics
K	kilobits per second (Kbps)	kilobytes	thousands (10^3)
M	megabits per second (Mbps)	megabytes	millions (10^6)
G	gigabits per second (Gbps)	gigabytes	–
B	–	–	billions (10^9)
T	terabits per second (Tbps)	terabytes	trillions (10^{12})
P	petabits per second (Pbps)	petabytes	–
Q	–	–	quadrillions (10^{15})

Analyzing Traffic Distribution Across Access Technologies

The **Access Technology** screen in MURAL reports the distribution of network traffic across the radio access types that subscribers use to connect to your network.

The following figure illustrates the **Access Technology** screen reached through the **MURAL Network Insights** workflow.

The panes in the numbered boxes provide the following functionality:

1. Sort by— Select a measure by which you want to sort data and display in box **1**. The available options are:

    - Volume— Volume of traffic that traversed the network, in bytes. By default, downlink traffic (flowing from the network toward mobile users) as indicated by the selected icon ( ) is displayed. Click to display uplink traffic (flowing from mobile users toward the network). Click to display the total traffic.

    - Bitrate— Number of bits per second (bps) of traffic flowing on the

network. By default, downlink traffic (flowing from the network toward mobile users) as indicated by the selected icon (↓) is displayed. Click ↑ to display uplink traffic (flowing from mobile users toward the network). Click ↕ to display the total traffic.

- Flows— Number of active flows.

- Avg Flow Duration— Average duration in seconds for the type of event reported.

- Unique Subscribers—Number of active subscribers.

2. Traffic distribution (box **2**)—Indicates the proportion of total network traffic that used each radio access type. When you access the Access Technology screen, the data is presented in a doughnut chart. Select the required wedge from the doughnut chart to view the usage statistics in summary pane (box **3**) or export data in a CSV file (box **6**). You can also drill-down to view detailed information (box **5**).

3. Summary (box **3**)— Refer to the panel that appear in the lower half of the display area summarizing multiple statistics. For more information, see "Interpreting Usage Statistics in the Summary Table" on the next page.

4. Selected Access Technology (box **4**)—This is a display-only field. The access technology that you selected in box **2** is displayed here.

5. Drill-Down (box **5**)—Provides detailed information about distribution of network traffic across the mobile devices (such as phones and tablet computers) used by your network subscribers. Click 〉 > **Devices**. For more information, see "Analyzing Traffic Distribution Across Mobile Devices" on page 41.

6. Context menu (box **6**)—After viewing the information and making the required selections, you can perform additional tasks by selecting options from the context menu (⋯). For example, you can view traffic patterns tracked in a time-series line chart for up to three of the categories. For

more information, see "Viewing and Comparing Trends" on page 61.

You can also export data in a CSV file by clicking the **Export to CSV** link.

Note: See "Understanding Common Features Across Workflow Screens" on page 26 to know more about the common features across workflow screens.

Interpreting Usage Statistics in the Summary Table

A summary table summarizing the usage statistics is displayed at the bottom of the screen. The columns are as follows:

- <Access Technology>— Signifies the data distribution across the selected access technology. For example, it is **All Technologies** in the preceding figure (box **3**). Select **All Sub** to view usage statistics for all the subscribers using that access technology. Select **Per Sub** to view usage statistics per subscriber.

- **Bitrate**—Number of bits per second (bps). By selecting values from the available drop-down lists, you can view the following:

  - **Avg Downlink Rate**—Average number of bits per second (bps) that traveled from the network toward mobile users.It is calculated by dividing the total number of bytes by the number of seconds in the selected time range, then multiplying by eight to convert bytes to bits.

  - **Avg Uplink Rate**—Average number of bits per second (bps) that traveled from mobile users toward the network. It is calculated in the same way as the downlink rate.

  - **Peak Agg Downlink Rate**—Largest number of bits per second (bps) that traveled from the network toward mobile users.

  - **Peak Agg Uplink Rate**—Largest number of bits per second (bps) that traveled from the network toward mobile users.

- **Volume**—Volume of traffic. By selecting values from the available drop-down lists, you can view the following:

- **Downlink Volume**—Number of bytes that traveled from the network toward mobile users.

- **Uplink Volume**—Number of bytes that traveled from mobile users toward the network.

- **Flows**—Number of active flows.

- **Flow Duration**—By selecting values from the available drop-down lists, you can view the following:

  - **Avg Duration**—Average duration in seconds for the type of event reported in the two fields below this field (either flows or hits).

  - **Peak Duration**—Longest duration in seconds for the type of event reported in the two fields below this field (either flows or hits).

- **Unique Subscribers**—Number of active subscribers.

The letter following the numerical value for a statistic indicates the multiple, the meaning of which depends on the type of statistic (traffic rate, traffic volume, or count).

	Rate Statistics	**Volume Statistics**	**Count Statistics**
K	kilobits per second (Kbps)	kilobytes	thousands (10^3)
M	megabits per second (Mbps)	megabytes	millions (10^6)
G	gigabits per second (Gbps)	gigabytes	–
B	–	–	billions (10^9)
T	terabits per second (Tbps)	terabytes	trillions (10^{12})
P	petabits per second (Pbps)	petabytes	–
Q	–	–	quadrillions (10^{15})

Analyzing Traffic Distribution Across Mobile Devices

The Devices screen in MURAL reports the distribution of network traffic across the mobile devices (such as phones and tablet computers) used by your network subscribers. By tracking traffic patterns, you can determine how best to optimize content delivery for different devices.

Use the **Device** screen to answer questions like the following:

- Which devices do subscribers use most?

- Is one type of device generating the most traffic?

- Are the most popular categories of web content different on particular device models or types?

- What mobile apps are the most popular on a device?

- Where in my network are specific device models generating the most traffic?

- Is there a correlation between the amount of traffic that subscribers generate and the type of device they use?

The following figure illustrates the **Devices** screen reached through the **MURAL Network Insights** > **Access Technology** workflow.
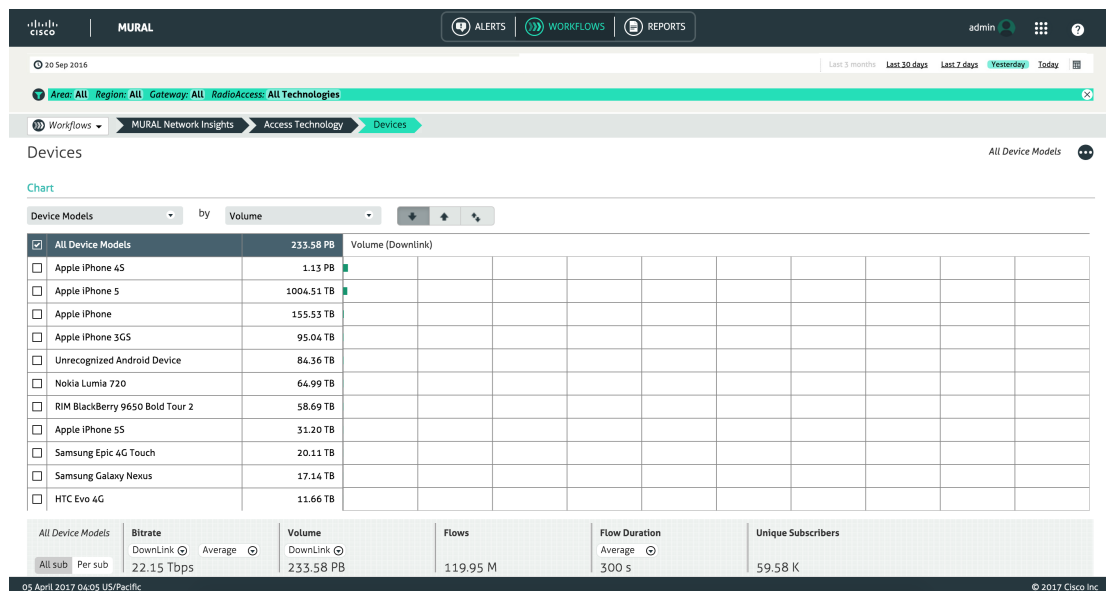
The panes in the numbered boxes provide the following functionality:

1. Sort by (box **1**)— Select a measure by which you want to sort data and display distribution of data in box 2. The available options are:

   - Models—models of mobile devices

   - OS—operating systems that are supported by mobile devices

   - Manufacturer—manufacturer of mobile devices (brands)

2. Traffic distribution (box **2**)—Indicates the proportion of total network traffic that was generated by mobile devices. Select checkboxes next to the required models to view the usage statistics in summary pane (box **3**) or export data in a CSV file (box **5**).

3. Summary (box **3**)— Refer to the panel that appear in the lower half of the display area summarizing multiple statistics. For more information, see "Interpreting Usage Statistics in the Summary Table" below.

4. Selected device (box **4**)—This is a display-only field. The device that you selected in box **2** is displayed.

5. Context menu (box **5**)—After viewing the information and making the required selections, you can perform additional tasks by selecting options from the context menu ( ). For example, you can view traffic patterns tracked in a time-series line chart for up to three of the categories. For more information, see "Viewing and Comparing Trends" on page 61.

   You can also export data in a CSV file by clicking the **Export to CSV** link.

Note: See "Understanding Common Features Across Workflow Screens" on page 26 to know more about the common features across workflow screens.

Interpreting Usage Statistics in the Summary Table

A summary table summarizing the usage statistics is displayed at the bottom of the screen. The columns are as follows:

- <Model>— Signifies the data distribution across the selected gateway. For example, it is **All Models** in the preceding figure (box **3**). Select **All Sub** to view usage statistics for all the subscribers using that device model. Select **Per Sub** to view usage statistics per subscriber.

- **Bitrate**—Number of bits per second (bps). By selecting values from the available drop-down lists, you can view the following:

  - **Avg Downlink Rate**—Average number of bits per second (bps) that traveled from the network toward mobile users.It is calculated by dividing the total number of bytes by the number of seconds in the selected time range, then multiplying by eight to convert bytes to bits.

  - **Avg Uplink Rate**—Average number of bits per second (bps) that traveled from mobile users toward the network. It is calculated in the same way as the downlink rate.

  - **Peak Agg Downlink Rate**—Largest number of bits per second (bps) that traveled from the network toward mobile users.

  - **Peak Agg Uplink Rate**—Largest number of bits per second (bps) that traveled from the network toward mobile users.

- **Volume**—Volume of traffic. By selecting values from the available drop-down lists, you can view the following:

  - **Downlink Volume**—Number of bytes that traveled from the network toward mobile users.

  - **Uplink Volume**—Number of bytes that traveled from mobile users toward the network.

- **Flows**—Number of active flows.

- **Flow Duration**—By selecting values from the available drop-down lists, you can view the following:

- **Avg Duration**—Average duration in seconds for the type of event reported in the two fields below this field (either flows or hits).

- **Peak Duration**—Longest duration in seconds for the type of event reported in the two fields below this field (either flows or hits).

- **Unique Subscribers**—Number of active subscribers.

The letter following the numerical value for a statistic indicates the multiple, the meaning of which depends on the type of statistic (traffic rate, traffic volume, or count).

	Rate Statistics	Volume Statistics	Count Statistics
K	kilobits per second (Kbps)	kilobytes	thousands (10^3)
M	megabits per second (Mbps)	megabytes	millions (10^6)
G	gigabits per second (Gbps)	gigabytes	–
B	–	–	billions (10^9)
T	terabits per second (Tbps)	terabytes	trillions (10^{12})
P	petabits per second (Pbps)	petabytes	–
Q	–	–	quadrillions (10^{15})

Analyzing Traffic Distribution Across Top Subscribers

The **Top Subscribers** screen in MURAL reports the distribution of network traffic across top subscribers. By tracking traffic patterns, you can determine how best to optimize content delivery to top subscribers.

Use the Top Subscribers screen to answer questions like the following:

- Which subscriber is generating the most traffic?

- Where in my network are certain subscribers generating the most traffic?

The following figure illustrates the **Top Subscribers** screen reached through the **MURAL Network Insights** workflow.

Note: See "Understanding Common Features Across Workflow Screens" on page 26 to know more about the common features across workflow screens.

In the **Top #** field, you can enter the number of subscribers for which you want to display the traffic distribution. By default, data is displayed for 1000 subscribers. Click ⬤ > **Export table data** to export data in a CSV file.

The columns of the table report the following information:

- **Subscriber ID**—Unique identifier of the subscriber.

- **Bitrate (Uplink)**—Average number of bits per second (bps) that traveled from mobile users toward the network. It is calculated in the same way as

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the downlink rate.

- **Bitrate (Downlink) (bps)**—Average number of bits per second (bps) that traveled from the network toward mobile users.It is calculated by dividing the total number of bytes by the number of seconds in the selected time range, then multiplying by eight to convert bytes to bits.

- **Volume (Uplink)**—Number of bytes that traveled from mobile users toward the network.

- **Volume (Downlink)**—Number of bytes that traveled from the network toward mobile users.

- **Flows**—Total number of distinct flows in both directions, where a flow is defined as a group of packets that have the same source and destination IP addresses, source and destination port numbers, and transport protocol.

Changing the Sort Order in the Top Subscribers Table

When you access the Top Subscribers screen for the first time during a MURAL session, the rows are sorted according to the value in the **Subscriber ID** column, largest to smallest.

You can sort based on the values in any of the remaining columns. To change columns, click in the column's header bar. The sort icon (▼ or ▲) moves to the new column and the rows are resorted. The increasing-order sort icon (▲) indicates the sort order is smallest to largest, and the decreasing-order sort icon (▼) largest to smallest.
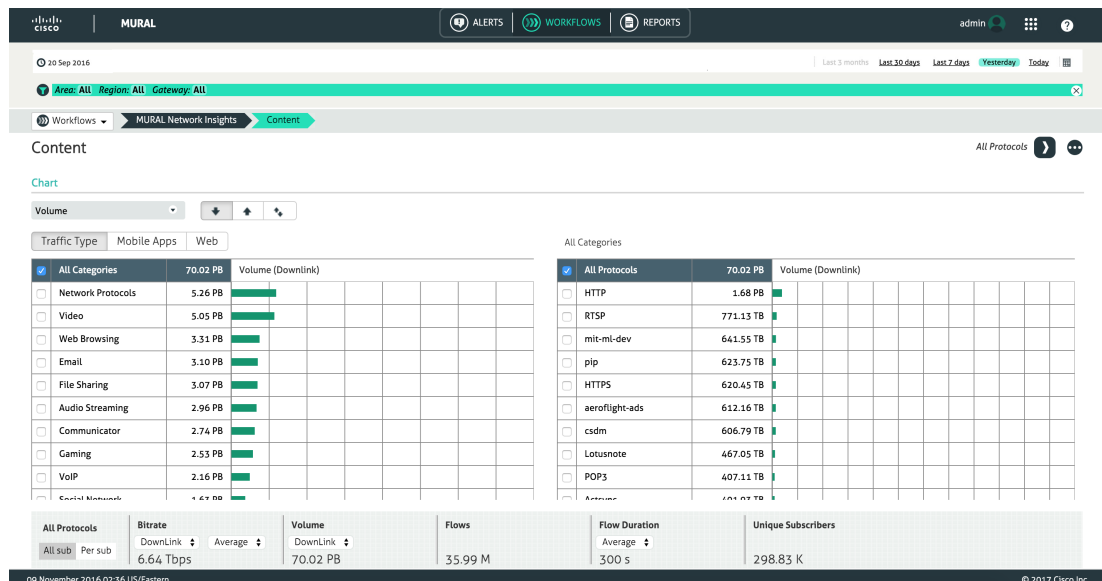

Analyzing Traffic Distribution Across Types of Content

The **Content** screen in MURAL reports the distribution of network traffic across the types of content being accessed by your subscribers. By tracking traffic patterns for types of content over time, you can identify which web applications, web domains, and non-web content are most popular. This enables you to make informed decisions about new product and service introductions, marketing campaigns, resource allocation, and network provisioning across multiple geographies.

Use the **Content** screen to answer questions like the following:

- Which service providers are contributing the most in traffic?

- Which mobile applications are the most popular?

- Which domains are the most popular within a given category?

- How are traffic patterns changing for a particular service provider of mobile application?

- Where in my network is a particular type of content generating the most usage?

The following figure illustrates the **Content** screen reached through the **MURAL Network Insights** workflow.

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The panes in the numbered boxes provide the following functionality:

1. Sort by— Select a measure by which you want to sort data and display in box **1**. The available options are:

   - Volume— Volume of traffic that traversed the network, in bytes. By default, downlink traffic (flowing from the network toward mobile users) as indicated by the selected icon (▼) is displayed. Click ▲ to display uplink traffic (flowing from mobile users toward the network). Click ⁘ to display the total traffic.

   - Bitrate— Number of bits per second (bps) of traffic flowing on the net-work. By default, downlink traffic (flowing from the network toward mobile users) as indicated by the selected icon (▼) is displayed. Click ▲ to display uplink traffic (flowing from mobile users toward the network). Click ⁘ to display the total traffic.

   - Flows— Number of active flows.

   - Avg Flow Duration— Average duration in seconds for the type of event reported.

   - Unique Subscribers—Number of active subscribers.

2. Content categories table (box **2**)—Categorizes traffic according to the icon selected above the table:

   - **Traffic Type**—Traffic is categorized by transport protocol, such as **VOIP** (voice over IP) or **Web**, referring to Hypertext Transfer Protocol (HTTP). For more information, see "Categorizing Traffic by Type and Protocol" on the next page.

   - **Mobile Apps**—Traffic is categorized by type of application used to request and deliver the content, such as **Browser** or **Social Networking**. For more information, see "Categorizing Traffic by Application Type" on page 50.

   - **Web**—Traffic is categorized by subject matter (type of content), such

as **Sports** or **Entertainment**. For more information, see "Categorizing Traffic by Type of Content" on the facing page.

3. Summary (box **3**)— Refer to the panel that appear in the lower half of the display area summarizing multiple statistics. For more information, see "Interpreting Usage Statistics in the Summary Table" on page 51.

4. Selected category (box **4**)— This is a display-only field. The category that you selected in box **2** is displayed.

5. Drill-Down (box **5**)— Click 〉 and select **Devices** to open tne Device screen. The **Device** screen reports the distribution of network traffic across the mobile devices (such as phones and tablet computers) used by your net-work subscribers. For more information, see "Analyzing Traffic Distribution Across Mobile Devices" on page 41.

6. Context menu (box **6**)—After viewing the information and making the required selections, you can perform additional tasks by selecting options from the context menu (⬤). For example, you can view traffic patterns tracked in a time-series line chart for up to three of the categories. For more information, see "Viewing and Comparing Trends" on page 61.

You can also export data in a CSV file by clicking the **Export to CSV** link.

Note: See "Understanding Common Features Across Workflow Screens" on page 26 to know more about the common features across workflow screens.

Categorizing Traffic by Type and Protocol

The table in the main pane of the **Content** screen reports statistics about the traffic in your network during the selected time range.

The following figure illustrates what the tables looks like when you first access the Content screen through the MURAL Network Insights workflow. The **Traffic Type** is selected, and the table displays values for all the categories and protocol type of the packets that constitute the traffic in separate tables. Categories and Protocols are sorted in order of decreasing traffic volume in the **Volume** (Down-link) column. You can perform the following tasks:

- Sort data by selecting required options from box 1.

- Select a category and view data for the corresponding protocols.

- Select required categories, protocols, and click **❯** > **Devices** to display the **Device** screen.

Categorizing Traffic by Application Type

To categorize traffic by the type of application used to request and download data, click the **Mobile Apps** subtab above the table. In this mode, MURAL assigns traffic to categories according to the type of application used to request content from the network. The categories include the following.

Browser	Social Networking
Business	Weather
Productivity	Standard

Categorizing Traffic by Type of Content

To categorize traffic by type of content, click the **Web** subtab above the table. The tables display values for all the service providers (left quadrant) and their cor-responding web protocols (right quadrant). In the table displaying values for web protocols, traffic is categorized by security protocols, that is **HTTP** and **HTTPS**, HTTPS is added to show the encrypted data.

You can alter the placement of tables by selecting options from the drop-down menu at the upper right quadrant. The available options are **Service Provider** > **Web Protocol** and **Web Protocol** > **Service Provider**.

Interpreting Usage Statistics in the Summary Table

A summary table summarizing the usage statistics is displayed at the bottom of the screen. The columns are as follows:

- <Category>— Signifies the data distribution across the selected category. For example, it is **All Protocols** in the preceding figure (box **3**). Select **All Sub** to view usage statistics for all the subscribers in that category. Select **Per Sub** to view usage statistics per subscriber.

- **Bitrate**—Number of bits per second (bps). By selecting values from the available drop-down lists, you can view the following:

  - **Avg Downlink Rate**—Average number of bits per second (bps) that traveled from the network toward mobile users.It is calculated by dividing the total number of bytes by the number of seconds in the selected time range, then multiplying by eight to convert bytes to bits.

  - **Avg Uplink Rate**—Average number of bits per second (bps) that traveled from mobile users toward the network. It is calculated in the same way as the downlink rate.

  - **Peak Agg Downlink Rate**—Largest number of bits per second (bps) that traveled from the network toward mobile users.

  - **Peak Agg Uplink Rate**—Largest number of bits per second (bps) that traveled from the network toward mobile users.

- **Volume**—Volume of traffic. By selecting values from the available drop-down lists, you can view the following:

  - **Downlink Volume**—Number of bytes that traveled from the network toward mobile users.

  - **Uplink Volume**—Number of bytes that traveled from mobile users toward the network.

- **Flows**—Number of active flows.

- **Flow Duration**—By selecting values from the available drop-down lists, you can view the following:

  - **Avg Duration**—Average duration in seconds for the type of event reported in the two fields below this field (either flows or hits).

  - **Peak Duration**—Longest duration in seconds for the type of event reported in the two fields below this field (either flows or hits).

- **Unique Subscribers**—Number of active subscribers.

The letter following the numerical value for a statistic indicates the multiple, the meaning of which depends on the type of statistic (traffic rate, traffic volume, or count).

	Rate Statistics	Volume Statistics	Count Statistics
K	kilobits per second (Kbps)	kilobytes	thousands (10^3)
M	megabits per second (Mbps)	megabytes	millions (10^6)
G	gigabits per second (Gbps)	gigabytes	–
B	–	–	billions (10^9)
T	terabits per second (Tbps)	terabytes	trillions (10^{12})
P	petabits per second (Pbps)	petabytes	–
Q	–	–	quadrillions (10^{15})

Analyzing Traffic in Mobile Network Sectors

The **Cell Sectors** screen reports traffic statistics for sectors. A *sector* is a sub-division of a mobile network cell that is served by a specific pair of nodes, which have two different defined functions in the network architecture.

The following figure illustrates the **Cell Sectors** screen reached through the **MURAL Network Insights** workflow.

To specify the set of sectors to display, click the **GGSN List** and **SGSN List** drop-down menus above the table and select a node from each of them. The list of sectors is determined only by the two nodes.

The **GGSN List** drop-down menu lists the Gateway GPRS support nodes in General Packet Radio Service (GPRS). The **SGSN List** drop-down menu lists the Serving GPRS support nodes in GPRS.

The columns of the table report the following information:

- **Cell ID**—Sector identifier, comprised of the mobile country code (MCC), mobile network code (MNC), location area code (LAC) and cell identifier (CI).

- **Bitrate (Uplink)**—Average number of bits per second (bps) that traveled from mobile users toward the network. It is calculated in the same way as the downlink rate.

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- **Bitrate (Downlink) (bps)**—Average number of bits per second (bps) that traveled from the network toward mobile users. It is calculated by dividing the total number of bytes by the number of seconds in the selected time range, then multiplying by eight to convert bytes to bits.

- **Volume (Uplink)**—Number of bytes that traveled from mobile users toward the network.

- **Volume (Downlink)**—Number of bytes that traveled from the network toward mobile users.

- **Flows**—Total number of distinct flows in both directions, where a flow is defined as a group of packets that have the same source and destination IP addresses, source and destination port numbers, and transport protocol.

For numerical values, the letter following the digits indicates the multiple, the meaning of which depends on the type of unit of measure (traffic rate, traffic volume, or count).

	Rate Statistics	Volume Statistics	Count Statistics
K	kilobits per second (Kbps)	kilobytes	thousands (10^3)
M	megabits per second (Mbps)	megabytes	millions (10^6)
G	gigabits per second (Gbps)	gigabytes	–
B	–	–	billions (10^9)
T	terabits per second (Tbps)	terabytes	trillions (10^{12})
P	petabits per second (Pbps)	petabytes	–
Q	–	–	quadrillions (10^{15})

Changing the Sort Order in the Cell Sectors Table

When you access the **Cell Sectors** screen for the first time during a MURAL session, the rows are sorted according to the value in the **Cell ID** column, largest to smallest.

You can sort based on the values in any of the remaining columns. To change columns, click in the column's header bar. The sort icon (▼ or ▲) moves to the

new column and the rows are resorted. The increasing-order sort icon (▲) indic-

ates the sort order is smallest to largest, and the decreasing-order sort icon (▼)

largest to smallest.

Filtering in MURAL

By default, the network traffic in MURAL include all data collected during the selected time range. Filters enable you to restrict the source of data to only entities that match criteria you choose.

Accessing Filtering Toolbar

You can see and edit filters from each workflow on the **WORKFLOWS** tab. Each screen has the **Filter** link ( ). Click   to display the Filters dialog box.

Filters include any geographical area or physical elements that constitute the network hierarchy, devices information, content categories, and technology. Filters typically work in a hierarchical manner from left to right. You can select the filter values in this order to ensure that the lower-order fields (to the right) are correlated with the proper higher-order fields (to the left). This is signified in UI by connecting arrows ( ) and its absence between attributes signifies that this hierarchical relationship is not applicable. You can also select a child filter directly, without selecting the parent element first.

Filters are grouped into the following categories:

- Network Topology

- APN/RAT

- Device

- Content

Applying Filter Settings

Perform the following steps:

1. Click   , and perform the following steps in the Filters dialog box:

    a. Click the **Network Topology** link, if not clicked already.

    b. Click   next to **Area**, **Region**, or **Gateway** to display the

corresponding submenu. Your system administrator defined the criteria in them during initial MURAL configuration. In the usual configuration, they correspond to geographic areas where network equipment is located. For a network in the United States, for example, the choices in the Area category might be regions like Northeast and South, the choices for Region the states in which network equipment is located, and the choices for Gateway cities.

The criteria you select in either or both Area and Region categories determine which criteria are available in the categories below it. For example, if you select the single criterion California in the Region category, then the available criteria in the Gateway category are limited to locations that your system administrator has defined as belonging to the California region.

2. To select and apply filters from the APN or radio type category, perform the following steps:

   a. Click the **APN/RAT** link.

   b. Select the **Filter Enabled** check box to enable selection of filters.

   c. Click the **APN** or **Radio Type** radio button to select criteria from that category. The lists of criteria are configured by your system administrator during initial MURAL configuration:

      - APN—Access point names

      Note: The **Access Technology** option is not displayed in the Drill-down menu of the Network Topology screen, if the APN filter is set.

      - Radio Type—Mobile technologies such as GSM (Global System for Mobile Communications) and CDMA (Code Division Multiple Access)

3. To select and apply filters from the devices category, perform the following steps:

a. Click the **Device** link.

b. Select the **Filter Enabled** check box to enable selection of filters

c. Click ⌄ next to **Device Group**, **Device OS**, **Device Manufacturer**, or **Device Models** to display the corresponding sub-menu. Your system administrator defined the criteria in them during initial MURAL configuration.

Note: The **Cell Sectors**, and **Top Subscribers** options are not displayed in the Drill-down menu of the Network Topology screen, if the Device filter is set.

4. To select and apply filters from the content category, perform the following steps:

a. Click the **Content** link.

b. Select the **Filter Enabled** check box to enable selection of filters.

c. Perform one of the following tasks:

- To set filters for the traffic type category:

a. Select the **Traffic Type Category** option.

b. From the drop-down menu that is displayed, select a cat-egory.

c. From the **Traffic Type Applications** drop-down menu in the right pane, select the required value.

- To set filters for the mobile application category:

a. Select the **Mobile Apps Category** option.

b. From the drop-down menu that is displayed, select a cat-egory.

        c. From the **Mobile Applications** drop-down menu in the
            right pane, select the required value.

- To set filters for the web category:

        a. Select the **Web** option.

        b. From the **Web Protocol** drop-down menu in the right
            pane, select a value.

        c. From the **Service Provider** table, select a service pro-
            vider.

Note: The **Cell Sectors**, and **Top Subscribers** options are
not displayed in the Drill-down menu of the Network Topology
screen, if the Content filter is set.

5. Click **Apply** to apply the changes.

## Selecting Filter Criteria from a Drop-Down Menu

Click the open-menu icon (⊟) to display the list of criteria for a selected cat-
egory.

When the menu drops down, all values are checked. Perform the following steps:

- To exclude a value from the filter, click its check box to remove the check.

- To remove the check from all boxes, click the check box next to Select All.
  (If there are a large number of values and you want to include only a few of
  them in the filter, it is most efficient to deselect all of them this way and
  then check your selections.)

- To select values in the filter, click check boxes next to the required values.

- To add the selected values to the filter and close the drop-down menu, click
  outside the drop-down menu. The selected values appear as a comma-sep-
  arated list in the white box.

Removing Filter Settings

Applied filters are displayed in a bar on the main screen as illustrated below.
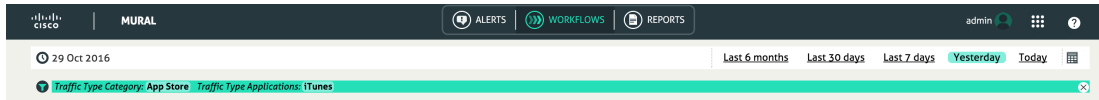

Filters can be removed in one of the following ways:

- On the main screen, click X to remove all the applied filters.

- Click the filters bar, the Filters dialog box is displayed. Clear the check boxes next to values that you want to remove. Individually removing filters is generally preferred when you only want to make a few modifications to the current settings.

- Click the filters bar, the Filters dialog box is displayed. Click **Clear All** to remove all the filters.

Viewing and Comparing Trends

Use the **Trending & Monitoring** workflow to gain holistic view of service provider's network business activities for massive volume of data.

The following image illustrates the Trending & Monitoring screen.
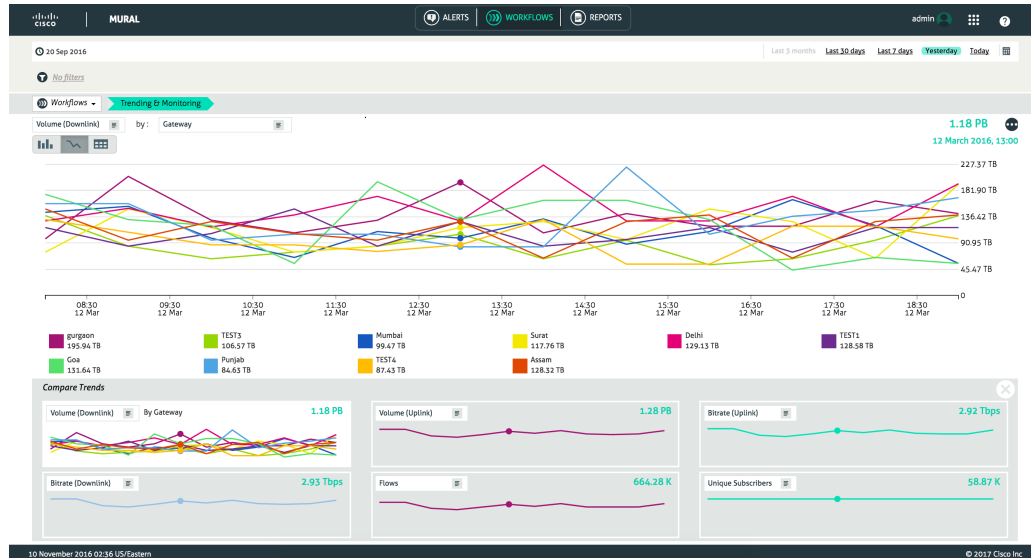
The panes in the numbered boxes provide the following functionality:

- View by (box **1**)— Click this drop-down list to select any one of the following options:

    - **Volume (Downlink)**— Number of bytes that traveled from the network toward mobile users.

    - **Volume (Uplink)**— Number of bytes that traveled from mobile users toward the network.

    - **Volume (Total)**— Total number of bytes.

    - **Bitrate (Downlink)**— Number of bits per second (bps) that traveled from the network toward mobile users.

    - **Bitrate (Uplink)**— Number of bits per second (bps) that traveled from mobile users toward the network.

    - **Avg Uplink Rate**— Total number of bits per second (bps).

- **Flows**— Number of active flows.

- **Unique Subscribers**— Number of active subscribers.

- **Avg Flow Duration**— Average duration of flows in the network.

- Dimension (box **2**)— Click this drop-down menu to select a category for which you want to compare trends.

- Chart type (box **3**)— Click one of the icons to display a corresponding chart. You can view data represented in a bar graph, line chart, or a table. For more information, see "Analyze Data in Charts" below.

- Chart details (box **4**)— Based on the selections made in boxes **1** through **3**, a bar graph, line chart or table containing data for an event is displayed. For more information, see "Analyze Data in Charts" below.

- Compare Trends (box **5**)— Displays trends for all the measures: volume, bitrate, flows, subscribers. The first chart displayed in this box depends on the measure type selected from the drop-down list in box **1**. You can click one of the following graphs to display its details in box **4**.

- Context menu (box **6**)— After viewing the information and making the required selections, you can export data in a CSV file.

Analyze Data in Charts

By default, a time series line chart displaying time and downlink volume is displayed. You can make selections in the screen (boxes **1** through **3** in the preceding image) to display a required chart.

The preceding image illustrates the line chart when the data is broken down by gateway. To view the downlink volume for each device manufacturer in the time bins, click the device manufacturer name. The values are highlighted in the line chart. To remove a category from the chart, click its legend at the bottom of the chart. The crossed eye () indicates its removal from the representation.

Note: If you select a time bin and choose to toggle between the chart types changing visual representations (line chart, bar graph, or table), the selected time bin remains as is.

Graph

Click ![bar chart icon] to represent data in a bar chart.

When you hover over a bar in the graph, the row and corresponding values (in the top-right corner) are highlighted. The corresponding bars in other bar graphs (Compare Trends) are also highlighted.

Note: A maximum of 30 bars can be displayed in the graph. If there are more based on your selection, the view is switched to a line chart.

Table

Click ![table icon] to represent data in a table.

When you hover over a row in the table, the row and corresponding values (in the top-right corner) are highlighted. The corresponding bars in other bar graphs (Compare Trends) are also highlighted.

Scheduling and Interpreting Statistical Reports

The **REPORTS** tab in MURAL is an interface for reviewing and scheduling stat-istical reports.

The following figure illustrates the functional areas in the orange boxes.

Click the refresh icon ( ) to refresh data on the **REPORTS** tab.

You can perform the following tasks:

- "Reviewing Completed Reports" below

- "Administering Scheduled Reports" on the next page

- "Scheduling and Interpreting Statistical Reports" above

Reviewing Completed Reports

When you first access the **REPORTS** tab during a MURAL session, the **Completed subtab** is open and lists all the completed reports in a table. The table provides the following information about each report:

- **ID**—Unique numerical identifier assigned to each report by the system.

- **Name**—Report name, assigned in the **Report Name** field on the **Review and Submit** screen of the **Generate Report** wizard when the report was scheduled (see "Step 4 —Reviewing and Submitting the Report Request" on page 74).

- **Type**—Report type, as set on the **Choose Report type** screen of the **Generate Report** wizard when the report was scheduled (see "Step 1 —

Selecting the Report Type" on page 67).

- **Delivered on**—Date the report was generated and added to the list of completed reports.

- **Period**—Range of dates covered by the report, as set on the
  Choose Report Period screen of the **Generate Report** wizard when the report was scheduled (see "Step 2 —Specifying the Covered Period of Time" on page 68).

- **Requested by**— User ID of the user who scheduled the report.

- **Filters**—Click to display information about the report. The reported set of filter criteria was defined on the **Choose Filters** screen of the **Generate Report** window when the report was scheduled "Step 3 —Selecting and Applying Filters" on page 71).

- **Download**—Click for saving the report as a PDF (**.pdf**) file, or viewing the PDF report immediately.

- **Delete**—Icon for removing a report from the reports database. Click the trash can icon ( ).

Administering Scheduled Reports

By default, the table lists all the pending reports. The table provides the following information about each report:

- **Id**—Unique numerical identifier assigned by MURAL.

- **Name**—Report name, assigned in the **Report Name** field on the
  Review & Submit screen of the **Generate Report** wizard when the report was scheduled (see "Step 4 —Reviewing and Submitting the Report Request" on page 74).

- **Type**—Report type, as set on the **Choose Report Category** screen of the
  Generate Report wizard when the report was scheduled ("Step 1 —Selecting the Report Type" on page 67).

- **Expected Delivery Date**—Date the report will be generated and added to the

list of available reports.

- **Requested On**—Date the report was scheduled.

- **Period**—Range of dates covered by the report, as set on the **Choose Report Period** screen of the **Generate Report** wizard when the report was scheduled (see "Step 2 —Specifying the Covered Period of Time" on page 68).

- **Status**—Report status:

    - **Cancelled**—Reported was canceled before being generated (see the **Delete** item in this list)

    - **Failed**—Report was not generated

    - **Pending**—Report has not yet been generated

- **Requested By**—User ID of the user who scheduled the report.

- **Filters**—Click ⓘ to display filters that are set for the report.

- **Delete**—For Pending reports, click ⊗ to cancel the report. For Completed or Failed reports, click 🗑 to delete the report.

Scheduling Reports

The **Generate Repor**t wizard is an interface for scheduling generation of MURAL reports. To access the window, click the **New Report** icon (⊕) in the navigation bar on the right side of the screen.

The **Generate Report** wizard guides you through the report-scheduling process by presenting a screen for each step:

- "Step 1 —Selecting the Report Type" on the next page

- "Step 2 —Specifying the Covered Period of Time" on page 68

- "Step 3 —Selecting and Applying Filters" on page 71

- "Step 4 —Reviewing and Submitting the Report Request" on page 74

After providing the required information on each of the first three screens, click the **Next Step** button in the lower right corner to continue to the next step (on the final screen the button says **Submit** instead).

Until you submit the finalized report request, you can change the selections on any of the screens by clicking the **Back** icon to go back one screen at a time. You can also click the **Start Over** button to return to the initial **Choose Report Type** screen, clearing your selections on all screens. To navigate back to the main Reports screen, click **Cancel** or ▨.

Step 1 —Selecting the Report Type

On the **Choose Report Type** screen, click the radio button for the report to create, then click the **Next Step** button.

Reports include multiple statistics (for example, volume and rate of traffic, subscriber count, flow count, and so on) for the indicated types of network entities:

- Gateway Traffic—This report provides traffic analysis for the selected gateways.

- Subscriber Segment Activity—This report provides traffic analysis subscriber segments.

- Device Usage—This report provides traffic analysis for the top mobile devices based on usage.

- Tonnage Distribution based on Subscriber Percent —This report summarizes the trend of subscribers, grouped into percentiles based on their level of activity, who account for specified percentages of total traffic. This trend can be based on Gateway(s), RAT Type(s) or APN(s).

- Content Type Analysis—This report summarizes generic types of content (such as text, video, application, and images) that account for the greatest amount of HTTP traffic.

- Top Domains—This report summarizes content provider websites that

served the greatest amount of content.

- Top Apps—This report summarizes specific mobile applications (such as browsers, streaming video sites, and social media portals) that account for the greatest amount of traffic.

- Tethering Usage—This report provides an analysis of tethered and untethered traffic generated by smart devices.

- Top Subscriber Activity—This report provides traffic analysis of top N subscribers.

Step 2 —Specifying the Covered Period of Time

On the **Choose Report Period** screen, you choose an option to specify the period—months, weeks, or days—for which to include data in the report:

- "Scheduling a One-Time Report" below

- "Scheduling a Recurring Report" on the next page

- "Scheduling an Hourly Report" on the next page

- "Scheduling a Report for a Standard Duration" on page 70

Scheduling a One-Time Report

Perform the following steps to generate a one-time report:

1. Select the **One time report** option on the left side of the screen.

2. Click the calendar icon (⊞) in the **Start Time** field to select a start date and time.

3. Click the calendar icon (⊞) in the **End Time** field to select an end date and time.

   The report delivery time as calculated by the system is displayed in the Expected Delivery date field.

4. Click **Next Step** to proceed.

Scheduling a Recurring Report

To schedule generation of multiple instances of a report at a specified frequency (daily, weekly, or monthly), perform the following steps:

1. Select the **Recurring report** option on the left side of the screen.

2. Click the calendar icon (⊞) in the **Start Time** field to select a start date and time.

3. From the **Frequency** drop-down list, select **Daily**, **Monthly**, or **Weekly** as required.

4. Set the number of reports to create, either by typing in the **Number of Instances** box. The minimum value is 1 and the maximum is 50. The table to the right updates to list all reports to be generated.

5. To schedule an hourly report at the set frequency, select the **Hourly Report** check box.

6. In the **No. of Hours** field, enter the number of hours to define the duration of the report. The table at the bottom updates to list all reports to be generated.

7. Click **Next Step** to proceed.

Scheduling an Hourly Report

Perform the following steps to generate an hourly report:

1. Select the **Hourly report** option on the left side of the screen.

2. Click the calendar icon (⊞) in the **Start Time** field to select a start date and time.

3. In the **No. of Hours** field, enter the number of hours to define the duration of the report.

   The report delivery time as calculated by the system is displayed in the **Expected Delivery** date field.

4. Click **Next Step** to proceed.

Scheduling a Report for a Standard Duration

You can set the time range quickly to a predefined duration.

The start and end times for the selected range are reported in the right pane of the screen on selection of one of the available quick link. Time ranges that include the current day end with the last hourly interval for which statistics have been calculated.

Perform the following steps to schedule a report to a standard duration:

1. Select one of the available options in the left pane **Yesterday**, **Last week**, **Last 15 days**, and **Last 30 days**.

   The start time, end time, and expected delivery date are displayed in the right pane. All quick time ranges start and end at 00:00 hours. The following table summarizes the start and end days.

Range	Start Day	End Day
Yesterday	One day before current day	Current day
Last Week	Sunday of previous week	Sunday of current week
Last 15 days	Sunday of two weeks before	First day of current month
Last 30 days	First day of previous month	First day of current month

   Note: The **Last 15 days** option is not available for the **Tethering Usage** report.

   If you are scheduling the **Tonnage Distribution based on Subscriber Percent** report, the following quick links are displayed in the Choose Report Period screen:

Range	Start Day	End Day
Last 1 week	Sunday of previous week	Sunday of current week
Last 2 week	Sunday of two weeks before	Sunday of current week
Last 3 week	Sunday of three weeks before	Sunday of current week
Last 4 week	Sunday of four weeks before	Sunday of current week

2. Click **Next Step** to proceed.

Step 3 —Selecting and Applying Filters

You can restrict the source of data to only entities that match criteria that you choose in the **Choose Filters** screen. The categories that are displayed in the **Choose Filters** screen depends on the report type selected in the **Choose Report Type screen** of Step 1. The following procedure describes each category irrespective of the report type.

Perform the following steps:

1. To select and apply filters from the network topology category, perform the following steps:

    a. Click the **Network Topology** link, if not clicked already.

    b. Click ▼ next to **Area**, **Region**, or **Gateway** to display the corresponding submenu. Your system administrator defined the criteria in them during initial MURAL configuration. In the usual configuration, they correspond to geographic areas where network equipment is located. For a network in the United States, for example, the choices in the Area category might be regions like Northeast and South, the choices for Region the states in which network equipment is located, and the choices for Gateway cities.

    The criteria you select in either or both Area and Region categories determine which criteria are available in the categories below it. For example, if you select the single criterion California in the Region category, then the available criteria in the Gateway category are limited to locations that your system administrator has defined as belonging to the California region.

    c. If you are scheduling the **Tonnage Distribution based on Subscriber Percent** report, select **Gateway**, **APN**, or **Radio Type** as the basis to generate the report.

2. To select and apply filters from the APN or radio type category, perform the following steps:

---

a. Click the **APN/RAT** link.

b. Select the **Filter Enabled** check box to enable selection of filters.

c. Click the **APN** or **Radio Type** radio button to select criteria from that category. The lists of criteria are configured by your system administrator during initial MURAL configuration:

- APN—Access point names

- Radio Type—Mobile technologies such as GSM (Global System for Mobile Communications) and CDMA (Code Division Multiple Access)

d. If you are scheduling the **Tonnage Distribution based on Subscriber Percent** report, select **Gateway**, **APN**, or **Radio Type** as the basis to generate the report.

3. To select and apply filters from the top subscribers category, perform the following steps:

a. Click the **Top N Subscribers** link.

b. Select the **Filter Enabled** check box to enable selection of filters.

c. In the box, enter the number (1 through N) of the most active subscribers to include in the report. To compile the list of most active subscribers, MURAL tracks subscribers over a period of several weeks and ranks their activity level with an algorithm that considers both the volume of traffic and the number of hits and flows each one generates. The subscribers in the list are not necessarily active at the time the filter is applied.

4. To select and apply filters from the top devices category, perform the following steps:

a. Click the **Top N Devices** link.

b. Select the **Filter Enabled** check box to enable selection of filters

c. In the box, enter the number (1 through N) of the most active devices to include in the report. To compile the list of most active devices, MURAL tracks subscribers over a period of several weeks and ranks their activity level with an algorithm that considers both the volume of traffic and the number of hits and flows each one generates. The devices in the list are not necessarily active at the time the filter is applied.

Selecting Filter Criteria from a Drop-Down Menu

Click the open-menu icon ( ) to display the list of criteria for a selected category.

The following figure shows an example for the Network Topology category.
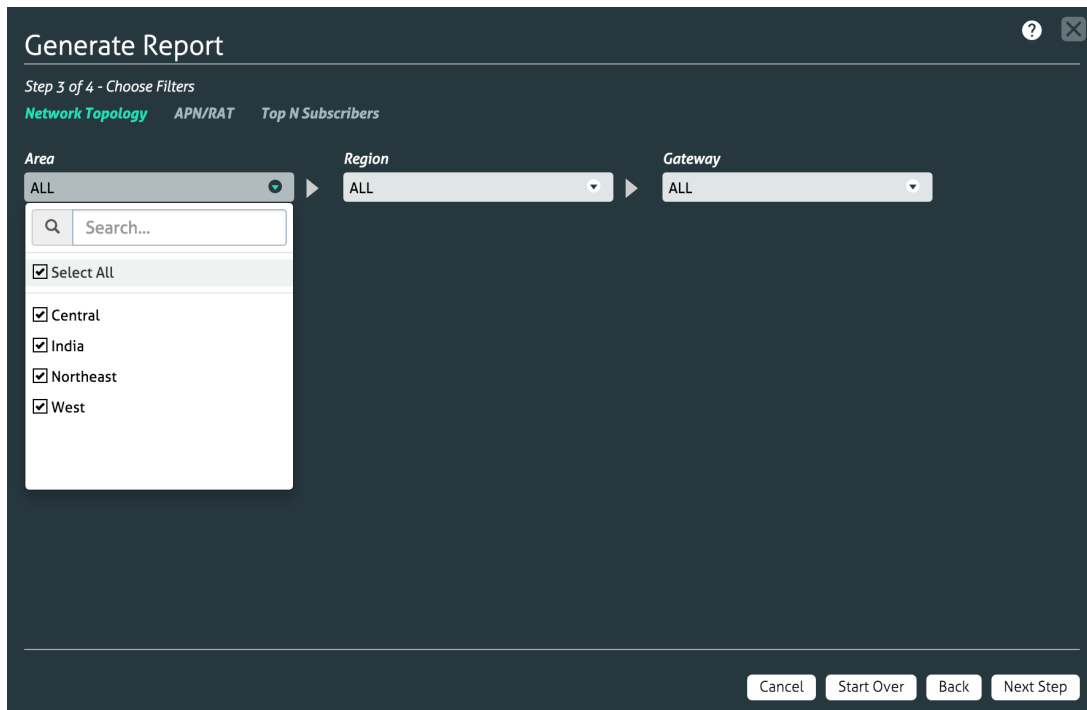
When the menu drops down, all values are checked. Perform the following steps:

- To exclude a value from the filter, click its check box to remove the check.

- To remove the check from all boxes, click the check box next to Select All. (If there are a large number of values and you want to include only a few of

them in the filter, it is most efficient to deselect all of them this way and then check your selections.)

- To select values in the filter, click check boxes next to the required values.

- To add the selected values to the filter and close the drop-down menu, click outside the drop-down menu. The selected values appear as a comma-separated list in the white box.

Step 4 —Reviewing and Submitting the Report Request

The **Review & Submit** screen summarizes the selections you made on the previous three screens. This report is about the traffic on 30th March (Yesterday) at the gateway in Delhi.

You can still change settings in the three fields by clicking the **Back** button to go back one screen at a time. You can also click the **Start Over** button to return to the initial **Choose Report Type** screen, clearing your selections on all screens. In the other fields, you can define additional characteristics of the report.

- To require the reader of the report to provide a password, click the Make Password Protected check box and type the password in the boxes.

- To add up to five additional recipients to the email list, click the Add Additional Email Ids check box and type the email addresses in the box. Separate them with commas but not spaces.

When you complete your review, click the **Submit** button to schedule the report.

Administering Scheduled Reports

By default, the table lists all the pending reports. The table provides the following information about each report:

- **Id**—Unique numerical identifier assigned by MURAL.

- **Name**—Report name, assigned in the **Report Name** field on the **Review & Submit** screen of the **Generate Report** wizard when the report was scheduled (see "Step 4 —Reviewing and Submitting the Report Request" on the previous page).

- **Type**—Report type, as set on the **Choose Report Category** screen of the **Generate Report** wizard when the report was scheduled ("Step 1 —Selecting the Report Type" on page 67).

- **Expected Delivery Date**—Date the report will be generated and added to the list of available reports.

- **Requested On**—Date the report was scheduled.

- **Period**—Range of dates covered by the report, as set on the **Choose Report Period** screen of the **Generate Report** wizard when the report was scheduled (see "Step 2 —Specifying the Covered Period of Time" on page 68).

- **Status**—Report status:

    - **Cancelled**—Reported was canceled before being generated (see the **Delete** item in this list)

    - **Failed**—Report was not generated

    - **Pending**—Report has not yet been generated

- **Requested By**—User ID of the user who scheduled the report.

- **Filters**—Click 🛈 to display filters that are set for the report.

- **Delete**—For Pending reports, click ⊗ to cancel the report. For Completed or Failed reports, click 🗑 to delete the report.

Managing Users

To access Manage Users screen, click [⠿] in the top-right corner of the screen. From the optional modules that are displayed, click **User Management**.

The Manage Users screen is displayed in a separate window listing the current system users and the following properties associated with each account:

- **User Name**

- **Name**

- **Email**

- **User Role**

- **Privileges**

- **Status**

- **Actions** (Edit and delete buttons)

Search for Specific Users

To search for specific users, type a complete or partial string in the Search box.

All the users matching the criteria are listed in the table. Click X to clear the search criteria.

Create Users

To create a new user, Click [+]. The New User dialog box is displayed. For more information, see "Creating a New User" on the facing page.

Modify User

To create a new user, Click [✎]. The Edit User dialog box is displayed. For more information, see "Modifying User Details" on page 79.
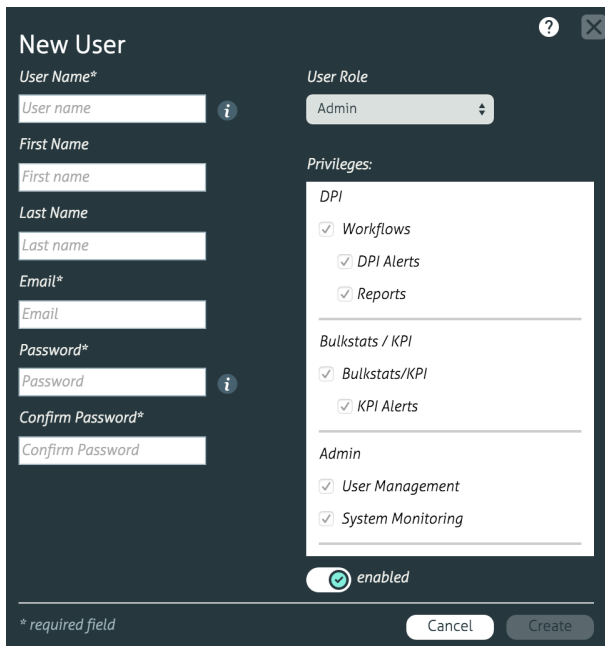
Delete Users

Delete a user by clicking delete icon (🗑) in the **Actions** column.

Creating a New User

To create a new user:

1. Click ➕. The New User dialog box is displayed.

2. Specify values in each field:

   - User Name— Unique name for the user. Click ⓘ to display the spe-
     cifications for the user name.

   - First name— First name of the user.

   - Last name— Last name of the user.

   - Email— Email address of the user.

   - Password— Password for the user to log into the application. Click

ℹ️ to display the specifications for the password.

- Confirm Password— Password as entered in the **Password** field.

- User Role— **Admin** or **Application**. If you select **Admin**, the user has access to all the applications.

  If you select **Application**, the **Privileges** pane is enabled. Select the checkbox next to the required privilege to provide access to the user.

- enabled— click this button to enable the user in the system.

  Note: * indicates a mandatory field.

3. Click **Create**.

Modifying User Details

To modify user details:

1. Click the edit button for the user account you want to change. The Edit User pop-up box is displayed.

2. Apply necessary changes. You can also update your password by clicking the **Update Password** link.

3. Click **Update** to apply your changes or **Cancel** to discard them.

System Monitoring Interface

After you log into the MURAL UI, click [⊞] on the top right of the screen to view other MURAL applications. By default, the screen displays the content associated with MURAL application.

Click **System Monitoring Interface** as shown in the image below, to open System Monitoring Interface.
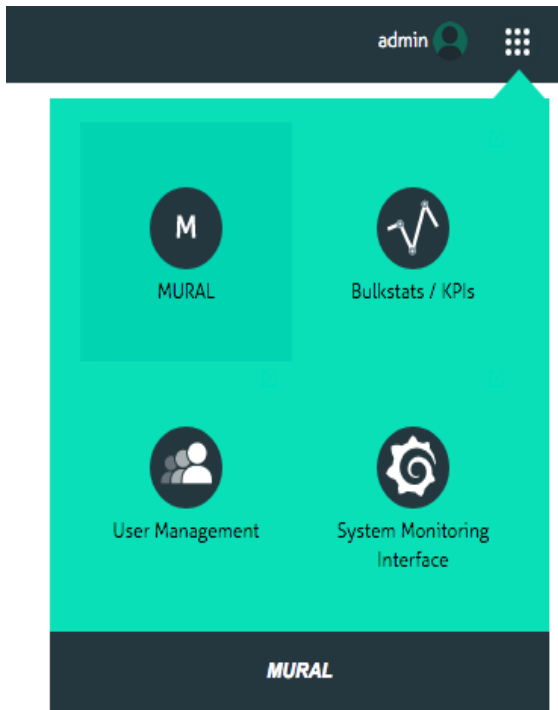
Note: In case the HDFS is down, a warning sign is displayed on the System Monitoring Interface option ([⚙️⚠]).

MURAL provides System Monitoring Interface (SMI) for a user to monitor the health of the system. The SMI interface provides information about various key performance indicators (KPIs), such as collector status, job lag, Hadoop status, disks usage status, and memory usage. This makes it easier for the administrator to monitor overall health of the system without requiring to log into individual nodes.

Note: System Monitoring Interface (SMI) is available only for users with administrator role in MURAL UI.
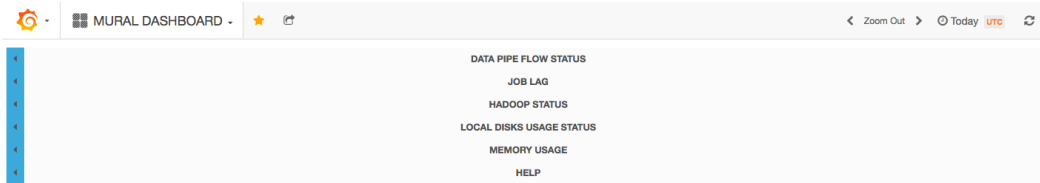
The image shows the landing page when you log into **System Monitoring Interface** after providing your username and password on the login page, the page features the following tabs:

- "Monitoring Collector Status" below

- "Monitoring Job Lag" on the facing page

- "Monitoring HDFS Cluster Status" on page 83

- "Monitoring Local Disk Usage" on page 85

- "Monitoring Memory Usage " on page 86

Note: These tabs are collapsed when you open the SMI interface. You can click the title of the tab to expand it.

Monitoring Collector Status

The **DATA PIPE FLOW STATUS** tab on the MURAL DASHBOARD reports the status of the data flow across collectors. You can open the tab by clicking its title, or the arrow icon on the left side of the tab.

A time-series graph displays Collector data for different time range, as shown in the following image.
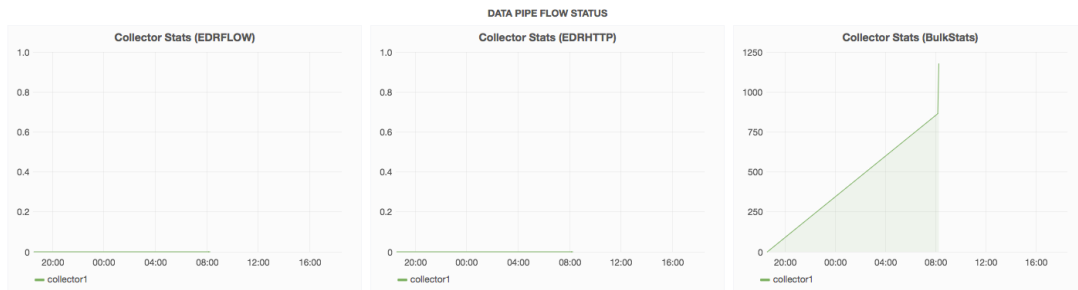
The X-axis on the graph shows different date and time periods, and the Y-axis depicts number of records for a data feed. There are separate graphs to represent records for different data feeds such as, EDR Flow, EDR HTTP and BulkStats. You can hover over the graph to monitor the collector data for a specific time period (UTC time zone).

To view a graph in detail:

1. Click the title of the graph, such as **Collector Stats (EDRFLOW)**.
2. Click **View** on the pop-up menu.

This displays the zoomed-out view of the graph as shown below. You can use it to view minute details on the graph.
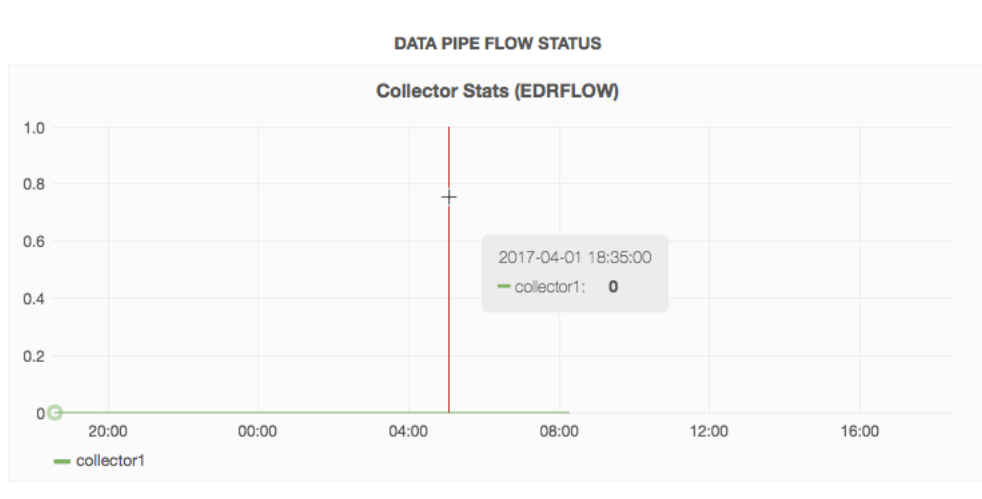
Monitoring Job Lag

The **JOB LAG** tab on the MURAL DASHBOARD reports the status for main jobs for each application, such as CoreJob, CubeExporter and EDR for DPI job, and so on.

There are separate tabs for each job type as shown in the following image.

The lag is calculated by subtracting timestamp of current instance of job from the system time. You can monitor the status of the jobs by using the following color code:

- **Green**- denotes that the jobs are in healthy state, and there is no job lag.
- **Orange**- denotes that there is a major lag in the job, and the lag needs to be monitored before entering into critical lag condition.
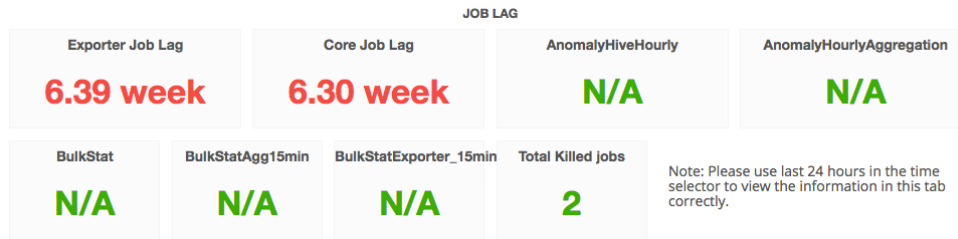- **Red**- denotes critical job lag, and requires immediate monitoring of the system.

The following table provides information about threshold values of main jobs for DPI application. For additional applications, other than **MURAL**, contact technical support for defining the threshold values.

Job Name	Lower Threshold Value (Orange)	Upper Threshold Value (Red)
CoreJob	120	180
EDR	150	210
CubeExporter	150	210

On the **JOB LAG** tab, you can also monitor the number of jobs killed for a specific time period. By default, it displays the number of jobs killed in the last 24 hours.

Monitoring HDFS Cluster Status

The **HADOOP STATUS** tab reports the status of HDFS health in the system. You can view Hadoop status of various parameters as shown in the following image.

You can monitor HDFS health for defined KPIs by using the following color codes:

- **Green**- denotes HDFS is healthy, and is functioning properly in the system.
- **Red**- denotes that you must take an appropriate action for the KPI, and contact technical support for further details.

On the **HADOOP STATUS** tab, you can monitor the following parameters:

- **HDFS Total** - indicates the total space available for HDFS in Tebibyte (TiB).
- **HDFS Used**- indicates the total memory used by HDFS in percentage.

  The following table lists the color codes for the threshold memory usage:

Memory Usage	Color
Less than or Equal to 75%	Green
More than 75%	Orange
Equal to or More than 85%	Red

- **Hadoop Live Nodes**- shows the number of live data nodes in HDFS system for a specific time period.
- **Hadoop Dead Nodes**- shows the number of dead data nodes in HDFS system for a specific time period.
- **Hadoop Missing Blocks**- shows the number of corrupt blocks in the system. The value of this field must be **zero** for HDFS to be in healthy (green) state. If the number of missing blocks is one or more than one, the count is displayed in red, indicating that the jobs will not run successfully.
- **FS Image last updated**- indicates the latest time stamp when the FS image was updated. The FS image must be updated every day to be in healthy state, if the FS image is not updated in the last 24 hours, capture the information and contact technical support.

Monitoring Local Disk Usage

The **LOCAL DISKS USAGE STATUS** tab on the MURAL DASHBOARD provides information about the utilization of the disk space in percentage. You can open the tab by clicking its title, or the arrow icon on the left side of the tab.

A time-series graph displays disk space utilization for different time range as shown in the following image.
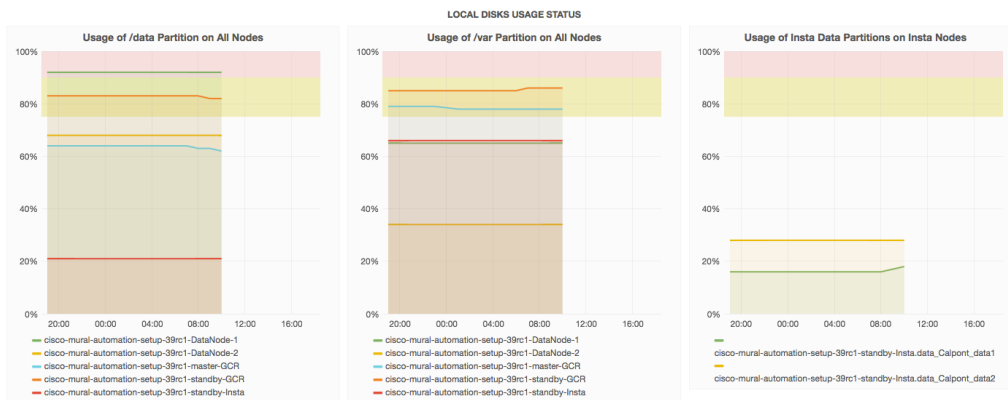
The X-axis on the graph shows different time periods, and the Y-axis depicts the percentage utilization of disk space.

There are separate graphs to represent disk usage for /data partition for all nodes, /var partition for all nodes, and iNSTA data partition for iNSTA nodes. You can hover over the graph to monitor the disk space utilization of top 10 processes for specific time zone.

Note: If disk utilization of any node is more than 85% for any partitions, contact technical support with the required information.

To view a graph in detail:

1. Click the title of the graph.
2. Click **View** on the pop-up menu.

This displays the zoomed-out view of the graph, you can use it to view minute details on the graph.

Monitoring Memory Usage

The **MEMORY USAGE** tab on the MURAL DASHBOARD provides information about the total memory utilization of the system. You can open the tab by clicking its title, or the arrow icon on the left side of the tab.

A time-series graph displays memory usage for different time range, as shown in the image below.
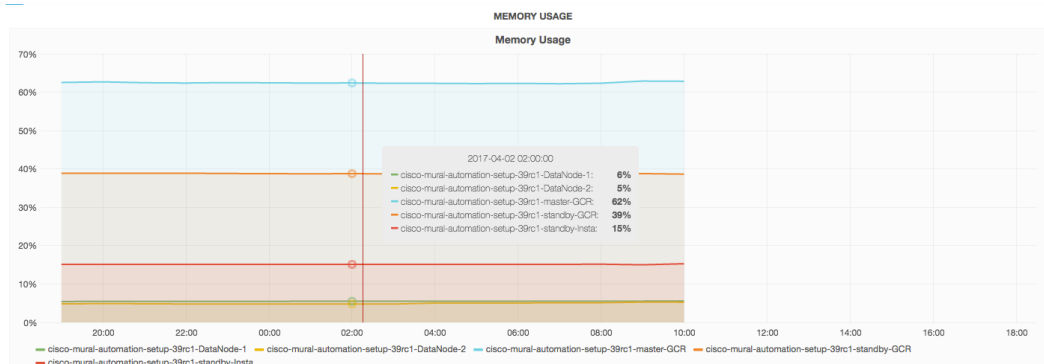
The X-axis on the graph shows different time periods, and the Y-axis depicts the percentage utilization of memory. The graph displays memory usage of each node in percentage.

Note: If memory utilization of any node is more than 85% of the total RAM, contact technical support with the required information.

Interpreting Performance Statistics for the ASR

Click ⬚ > **Bulkstats/KPIs** to display performance statistics for a specified Cisco ASR system.

MURAL refers to the statistics as *counters* and groups them functionally into collections called *schemata*. For example, the **card** schema collects together statistics about the line cards in the ASR chassis and the **gprs** schema collects together statistics about General Packet Radio Service. This topic does not explain the meaning of the counters; see the *Cisco ASR 5000 Series Statistics and Counters Reference*.

The panes in the numbered boxes provide the following functionality:

1. Date and time— Select a date and time to display data for the selected duration. For more information, see "Date and Time" on page 26

2. Filters— Click 🔽 to filter data based on your requirement. You can set the following:

   - ASR for which counters are displayed

   - Schema from which counters are displayed and lists the counter names in alphabetical order. You can optionally display a subset of the counters from the schema

   For more information, see "Selecting the Gateway" on page 91.

   Mouse-over the filters statement to display complete list of available counters for the selected gateway and schema. Names that start with a numeral are listed first, followed by names in alphabetical order.

3. Display pane—In the upper half of the pane, reports values for counters from the selected gateway and schema. You can export data to a CSV file by clicking ⚫ > **Export to CSV**. In the lower half, provides an interface for comparing hourly values for two counters. See the following sections:

- "Interpreting the Bulkstats Display" below

- "Comparing Two Counters" on page 90

Interpreting the Bulkstats Display

The upper half of the main display pane on the **BULKSTAS** tab reports values for counters from the currently selected schema on the currently selected gateway (individual ASR system). If values are not available for a schema, the words No Data appear in both halves of the pane.

The following example is for the **DC1** gateway and **aal2** schema. The **downlink_ bytes_drop_rab_not_in_conn_state** counter is selected and its aggregated value for **DC1** is 8820. The right half of the pane reports the value of 1avg_cpubusy for the two entities in **DC1** to which the **card** schema applies (51.455 for **ser- vname1-vpnname1** and 54.081 for **servname1-vpnname1**).

The lower half of the pane is an interface for visually comparing the hourly values of two counters as they change over the course of the selected time range. For instructions on using the interface, see "Comparing Two Counters" on page 90.

The numbered panes are described as follows:

- Counters <Search counter name> (box **1**)— Displays only counters whose names include (in any position) the string of characters you type in the box.

Names each counter displayed in the left half of the pane and specifies its value. To limit the list of counters in the left half of the upper pane to only those that have a certain character string in their names (in any position), type the characters in the **Counters** search box above the list. The list is updated immediately as you type each character. If no counters match the search string, the list disappears completely. You can also use this interface to search for particular counter names.

- Indices <counter name> (box **2**)— Specifies the counter being displayed in the right half of the pane for each entity to which the schema applies. If the schema has no entity, this header reads and the words No Data appear in the pane below it. Names each entity displayed in the right half of the pane and specifies the value for it of the counter named in the header.

- Compare (box **3**)— Names and sets the two counters or entities for which hourly values appear in the lower half of the pane. See "Comparing Two Counters" on the facing page.

Comparing Two Counters

In the lower half of the main display pane, you can visually compare hourly values for two counters as they change over the course of the selected time range. In the following example, activity is compared for two CPUs: the **15avg_cpubusy** counter appears in magenta and the **15peak_cpubusy** counter in turquoise.
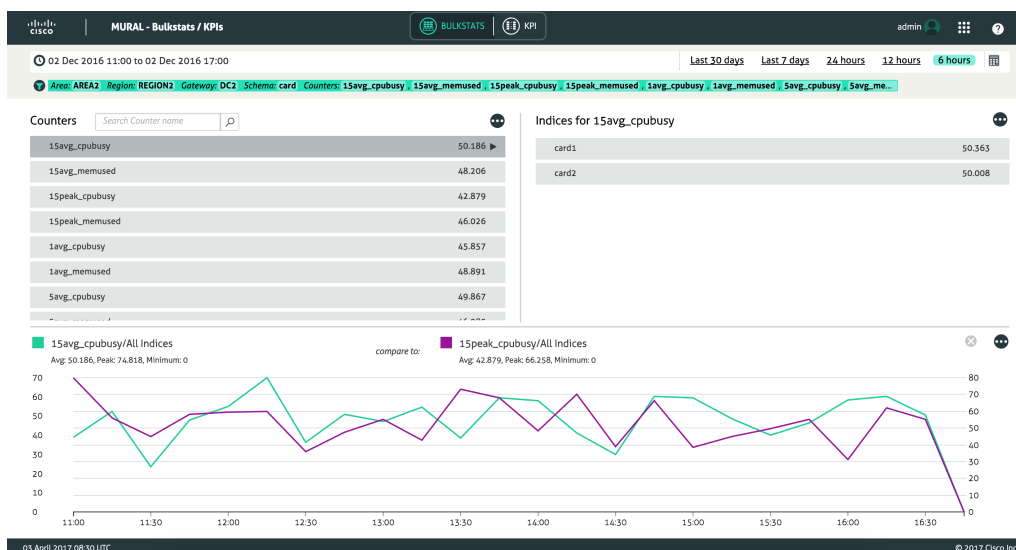
The names of the counters appear in two locations:

- In the counters list in the upper left part of the pane, enclosed in boxes colored to match the lines in the chart. The boxed counters are not necessarily always visible, for example if you scroll to a different part of the counters list.

- In the legend above the line chart, which also reports the average, peak (highest), and minimum (lowest) hourly values that occurred during the selected time range. The words **All Indices** following the counter name indicate that the values in the chart are aggregates for all entities to which the schema applies (in the example, **card1** and **card2**).

You can compare any two counters from the left and right halves of the pane (the left-hand values being aggregates and the right-hand values being individual entities to which the schema applies). In the following example, the aggregated value of the **1avg_cpubusy** counter (selected in the left column and displayed in magenta) is compared to the counter's value for **card1** (selected in the right column and displayed in turquoise).

You can export the data in a CSV file by clicking ⬤ > **Export to CSV**. A CSV file is generated for each counter that is dragged for a comparison.

To specify the two counters to compare, perform the following steps.

1. Navigate to the first counter, using the search box and scroll bar as necessary to make it easier to locate.

2. Click and hold down the mouse button on the counter as you drag it into the box in the lower left pane labeled **Drag Here** with the turquoise square (■) in the lower left pane. When you reach the box and the icon changes to the green-cross icon, release the mouse button.

3. Repeat Steps 1 and 2 for the second counter, dragging it into the box labeled **Drag Here** with the magenta square (■) in the lower right pane.

Selecting the Gateway

Click 🔻 to display the Select Gateway/Schema/Counter dialog box. You can set the following:

- ASR for which counters are displayed

- Schema from which counters are displayed and lists the counter names in alphabetical order. You can optionally display a subset of the counters from the schema

  For more information, see "Selecting the Schema" on the facing page.

The choices available on the **Area**, **Region**, and **Gateway** panes are defined by your system administrator during initial MURAL configuration. In the usual configuration, they correspond to geographic areas where network equipment is located. For a network in the United States, for example, the choices for **Area** might be regions like **EAST** and **SOUTH**, the choices for **Region** the states in which network equipment is located, and the choices for **Gateway** individual ASR 5000 systems.

Note: Although the field names **Area** and **Region** are also used in the **Network Topology** category of the filter interface on the **WORKFLOWS** tab, and the available values might be the same, the two interfaces do not function the same way. In the filter interface, you can specify multiple values in multiple fields. In the **Select Gateway** window, you are specifying a single gateway and the choices available in the **Gateway** field depend on the settings in the two fields above it. If the desired gateway is not listed, you must change the value in one or both **Area** and **Region** fields to the value that applies to the gateway.

To change to the new gateway, click the **Apply** button. To close the **Select Gateway** window without changing the current gateway, click the **Next** button to select schema and counters.

Selecting the Schema

To select the schema from which counters are reported, and optionally display only a subset of counters:

1. Several dozen schemata are usually available; to navigate to the one you want; you can type a letter or string in the **Search Schema name** field to jump down to the first schema whose name begins. In the following example, the **gprs** schema is being selected.
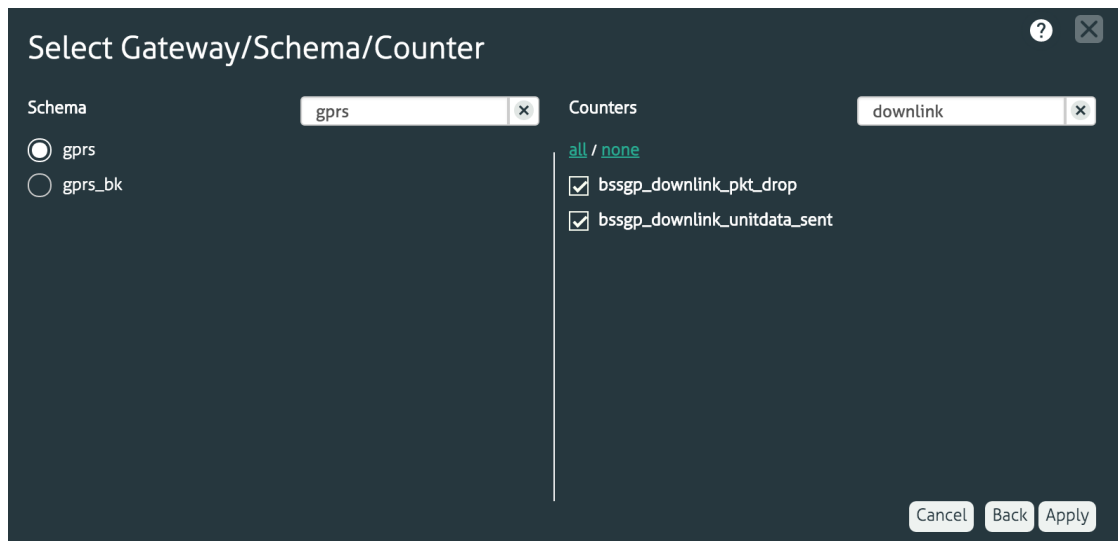
2. After selecting the new schema, select check boxes next to the required counters. You can also type a letter or string in the **Search Counter name** field. In the preceding figure, the **downlink** is being entered.

   To remove the check from all boxes, click **none**. (If there are a large number of counters and you want to display only a few of them, it is most efficient to deselect all of them this way and then check your selections.)

   To include all counters, click **all**.

3. Click **Apply**.

Interpreting Key Performance Indicators from the ASR

The **KPI** tab in MURAL reports key performance indicators (KPIs) from the Cisco ASR.

KPIs are formulas that operate on the statistics generated by the ASR (which are reported individually on the **Bulkstats** tab as described in "Interpreting Performance Statistics for the ASR" on page 87). MURAL refers to the statistics as *counters* and groups them functionally into collections called *schemata*. For example, the **apn** schema collects together statistics about access point names (APNs) and the **port** schema collects together statistics about ports on line cards. This topic does not explain the meaning of the counters; see the *Cisco ASR 5000 Series Statistics and Counters Reference*.

The **KPI** tab is divided functionally into several panes, numbered **1** through **4** in the following figure.
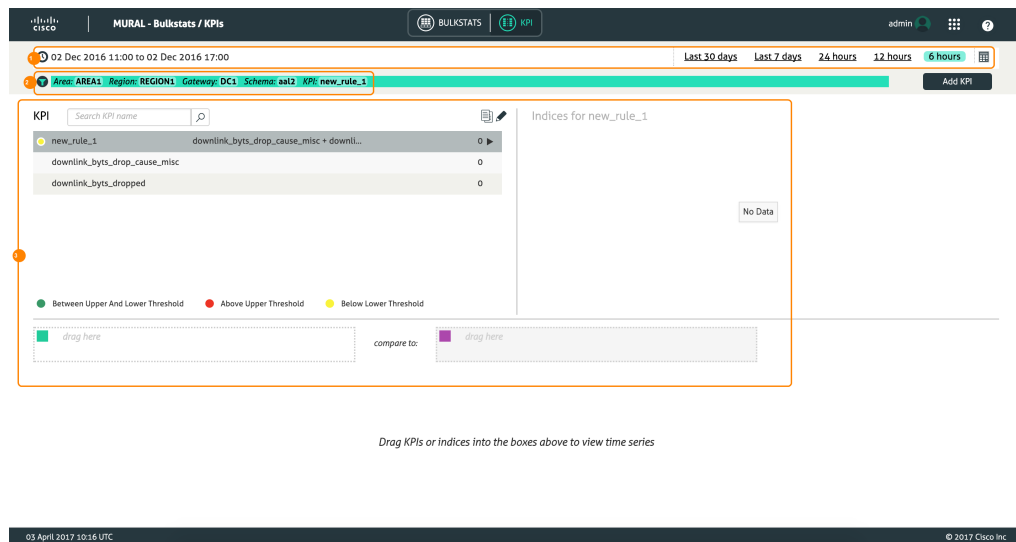
The numbered panes are described as follows:

1. Date and time— Select a date and time to display data for the selected duration. For more information, see "Date and Time" on page 26

2. Filters— Click 🔽 to filter data based on your requirement. You can set the following:

- ASR for which counters are displayed

- Schema from which KPIs are displayed and lists the KPI names in
  alphabetical order. You can optionally display a subset of the KPIs
  from the schema.

For more information, see "Selecting the Gateway" on page 103.

Mouse-over the filters statement to display complete list of available KPIs
for the selected gateway and schema. Names that start with a numeral are
listed first, followed by names in alphabetical order.

3. Display pane—In the upper half of the pane, reports values for KPIs from
   the selected gateway and schema. In the lower half, provides an interface
   for comparing hourly values for two KPIs. See the following sections:

   - "Interpreting the KPI Display" below

   - "Interpreting Key Performance Indicators from the ASR" on the pre-
     vious page

   - "Interpreting Key Performance Indicators from the ASR" on the pre-
     vious page

Interpreting the KPI Display

The upper half of the main display pane on the **KPI** tab reports values for KPIs and
their component counters from the currently selected schema on the currently
selected gateway (individual ASR system). If values are not available for a
schema, the words No Data appear in both halves of the pane.

The following example is for the **Delhi** gateway and **ecs** schema.

The lower half of the pane is an interface for visually comparing the values of two KPIs or counters on an hourly basis as they change over the course of the selected time range. For instructions on its use, see "Comparing Hourly Values for Two KPIs or Counters" on page 98.
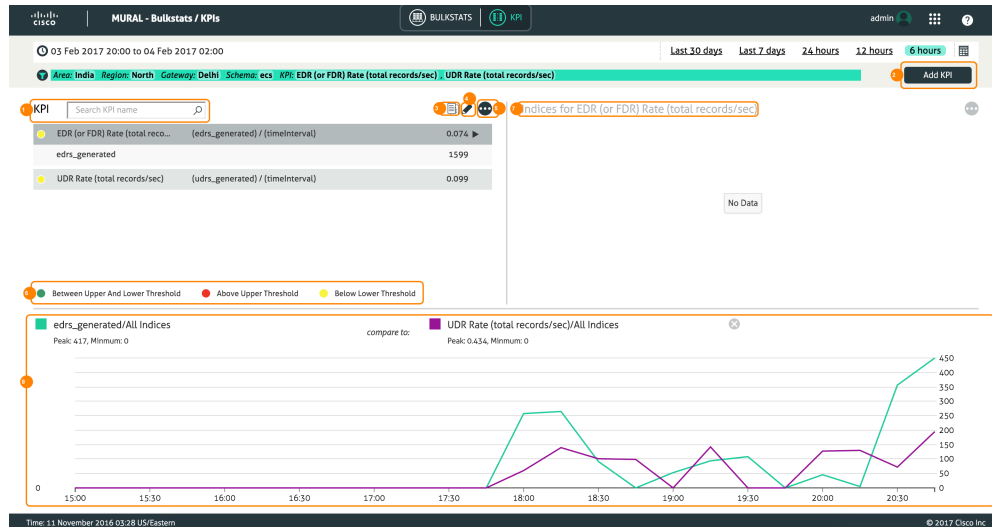
The following table describes the elements in the pane.

- KPI <Search counter name> (box **1**)— Displays only KPIs whose names include (in any position) the string of characters you type in the box. Names each KPI displayed in the left half of the pane and specifies its value. To limit the list of KPIs in the left half of the upper pane to only those that have a certain character string in their names (in any position), type the characters in the **Search KPI name** box above the list. The list is updated immediately as you type each character. If no KPIs match the search string, the list disappears completely. You can also use this interface to search for particular KPI names.

- Add KPI (box **2**)— Click this button to add anew KPI. For more information, see "Defining New KPIs" on page 99.

- Clone KPI (box **3**)— Click this icon to clone an existing KPI. For more information, see "Defining New KPIs" on page 99.

- Edit KPI (box **4**)— Click this icon to modify details of an existing KPI. For

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more information, see "Defining New KPIs" on page 99.

- Context menu (box **5**)— Click this icon to export data in a CSV file.

- Threshold legend (box **6**)— These legends are displayed next to KPIs based on their threshold value. Following legends are used:

    - Between Upper and Lower Threshold (🟢)— When the value is greater than the lower threshold but less than the upper threshold.

    - Above Upper Threshold (🔴)— When the value of the KPI is greater than the upper threshold.

    - Below Lower Threshold (🟡)— When the value of the KPI is less than the lower threshold.

- Indices <KPI name> (box **7**)— Specifies the KPI being displayed in the right half of the pane for each entity to which the schema applies. If the schema has no entity, this header reads and the words No Data appear in the pane below it. Names each entity displayed in the right half of the pane and specifies the value for it of the KPI named in the header.

- Compare (box **8**)— Names and sets the two KPIs or entities for which hourly values appear in the lower half of the pane. See "Comparing Hourly Values for Two KPIs or Counters" on the facing page.

Note: Some KPI names are too long to appear in full in the list of KPIs. You can also mouse over the name in the list to display the full value.

Similarly, formulas are usually too long to appear in full in the list of KPIs. To display the full formula for a KPI, mouse over its name in the list, as shown in the following figure for the **2G Subscriber PDP De-act Success Rate (%)** KPI. For information about the notation used in formulas, see "Defining New KPIs" on the next page.

Comparing Hourly Values for Two KPIs or Counters

In the lower half of the main display pane, you can visually compare values on an hourly basis for two KPIs or counters as they change over the course of the selected time range. In the following example, activity is compared for the KPIs called **2G Inter SGSN RAU Rate per RA (%)**, which appears in magenta, and **2G Intra SGSN RAU Rate per RA (%)**, which appears in turquoise. The names of the KPIs appear in two locations:

- In the KPIs list in the upper left quadrant of the pane, enclosed in boxes colored to match the lines in the chart. The boxed counters are not necessarily always visible, for example if you scroll to a different part of the KPIs list.

- In the legend above the line chart, which also reports the peak (highest) and minimum (lowest) hourly values that occurred during the selected time range.

You can compare any two KPIs or counters from the left and right halves of the pane. To specify the two entities to compare, perform the following steps.

1. Navigate to the first KPI, using the search box and scroll bar as necessary to make it easier to locate.

2. Click and hold down the mouse button on the KPI as you drag it into the box in the lower left pane labeled **Drag Here** with the turquoise square (■) in the lower left pane. When you reach the box and the icon changes to the green-cross icon, release the mouse button.

3. Repeat Steps 1 and 2 for the second KPI, dragging it into the box labeled **Drag Here** with the magenta square (█) in the lower right pane.

Defining New KPIs

You can define new KPIs in existing schemata. Perform the following steps:

1. Click the **Add KPI** button to the top-right of the screen.

   The **Add KPI** dialog box is displayed, with the **Schema** field set to the schema currently selected on the Filters screen, and the **Counters** box populated with the counters from that schema (in the figure, the schema is **ecs**).

2. Type values in the text fields:

   - **Name**—The name of the new KPI, unique within the schema. It can contain upper- and lowercase letters, numbers, and spaces.

   - **Description**—(Optional) A phrase that describes the KPI. It can be up to 255 characters in length.

- **Lower threshold**—A numerical value. When the value of the KPI is less than this number, the yellow threshold indicator appears in front of its name in the KPIs list. When the value is greater than this number but less than the upper threshold, the indicator is green.

- **Upper threshold**—A numerical value. When the value of the KPI is greater than this number, the red threshold indicator appears in front of its name in the KPIs list. When the value is less than this number but greater than the lower threshold, the indicator is green.

3. If the schema in which you want to add the KPI does not currently appear in the **Schema** field, click on the drop-down menu button and then on your choice in the menu. The list of counters in the **Counters** box is updated.

4. Define the formula. It can be helpful to write out the formula before you start to define it. Formulas obey the standard mathematical order of operations and use the following notation:

   - Addition—Plus sign (**+**)

   - Subtraction—Hyphen (**-**)

   - Multiplication—Asterisk (*****)

   - Division—Forward slash (*/*)

Use parentheses (**( )**) to enclose operations that need to be performed out of standard order. In the following formula for the **3G Authentication Success Rate (%)** KPI, for example, the parentheses around the four counters in the denominator (`3G_auth_cipher_response` through `3G_auth_unacceptable`) mean they are summed first. The parentheses around the numerator (`3G_auth_cipher_response`) and summed denominator mean the division operation is performed before the result is multiplied by 100. To make the following formula easier to read, the terms are spread across several lines and there are extra spaces around the symbols.

```
(3G_auth_cipher_response /
   ( 3G_auth_cipher_response + 3G_auth_cipher_mac_fail
      + 3G_auth_cipher_syn_fail + 3G_auth_unacceptable )
 ) * 100
```

To enter counter names in the formula, you can either type them directly into the **Formula** box, or perform the following steps to select them from the **Counters** box:

    a. Use the scroll bar to navigate to the counter. You can shorten the list of counters to only those that have a certain character string in their names (in any position) by typing the characters in the **Counters** search box.

    b. Double-click the counter to add it to the **Formula** box at the position of the cursor (the pipe symbol [**|**]).

5. To create the new KPI, click the **Add** button. To close the **Add KPI** window without adding the new KPI, click the **Cancel** button or the close-window icon in the window's title bar.

Cloning KPIs

You can clone KPIs. *Cloning* refers to creating a copy of a KPI and saving it with a different name, presumably after modifying it. The source KPI for the clone is not changed.

1. Select the KPI you want to clone by clicking its row in the KPIs list.

2. Click the clone icon ( ). The **KPI (Save as)** window pops up.

3. Make the desired changes (the only field you cannot change is **Schema**). For instructions on searching the list of counters, constructing a formula, and changing the lower and upper thresholds, see "Defining New KPIs" on page 99.

4. To create the new KPI, click the **Update** button. To close the **KPI (Save as)** window without adding the new KPI, click the **Cancel** button or the close-window icon in the window's title bar.

Editing KPIs

To modify a KPI, perform the following steps.

1. Select the KPI you want to edit by clicking its row in the KPIs list.

2. Click the edit icon ( ). The **Edit KPI** window pops up.

3. Make the desired changes (the only fields you cannot change are **Name** and **Schema**). For instructions on searching the list of counters, constructing a formula, and changing the lower and upper thresholds, see "Defining New KPIs" on page 99.

4. To save your changes, click the **Update** button. To close the **Edit KPI** window without saving changes, click the **Cancel** button or the close-window icon in the window's title bar.

Selecting the Gateway

Click 🔻 to display the Select Gateway/Schema/KPI dialog box. You can set the following:

- ASR for which KPIs are displayed

- Schema from which KPIs are displayed and lists the KPI names in alphabetical order. You can optionally display a subset of the KPIs from the schema

  For more information, see "Selecting the Schema" on page 92.

The choices available on the **Area**, **Region**, and **Gateway** panes are defined by your system administrator during initial MURAL configuration. In the usual configuration, they correspond to geographic areas where network equipment is located. For a network in the United States, for example, the choices for **Area** might be regions like **EAST** and **SOUTH**, the choices for **Region** the states in which network equipment is located, and the choices for **Gateway** individual ASR 5000 systems.

Note: Although the field names **Area** and **Region** are also used in the **Network Topology** category of the filter interface on the **WORKFLOWS** tab, and the available values might be the same, the two interfaces do not function the same way. In the filter interface, you can specify multiple values in multiple fields. In the **Select Gateway** window, you are specifying a single gateway and the choices available in the **Gateway** field depend on the settings in the two fields above it. If the desired gateway is not listed, you must change the value in one or both **Area** and **Region** fields to the value that applies to the gateway.

To change to the new gateway, click the **Apply** button. To close the **Select Gateway** window without changing the current gateway, click the **Next** button to select schema and KPIs.

Selecting the Schema

To select the schema from which counters are reported, and optionally display only a subset of counters:

1. Several dozen schemata are usually available; to navigate to the one you want; you can type a letter or string in the **Search Schema name** field to jump down to the first schema whose name begins. In the following example, the **ecs** schema is being selected.
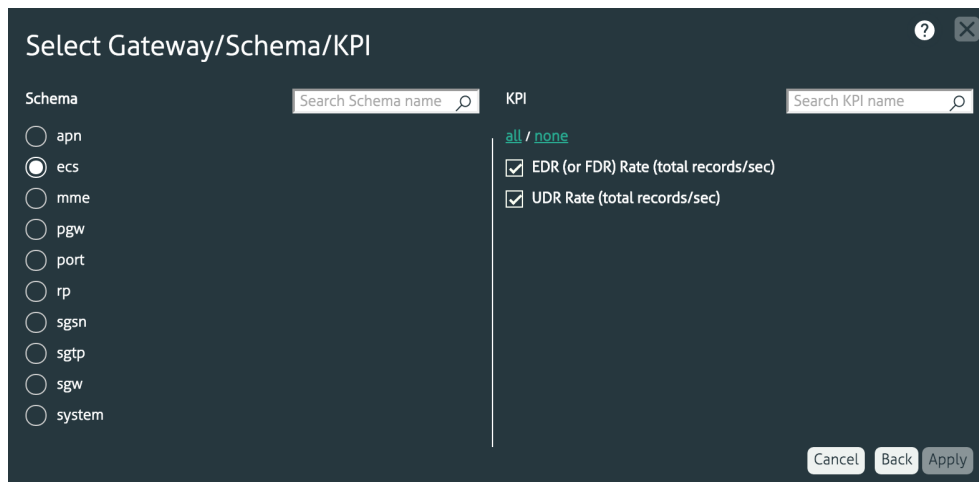
2. After selecting the new schema, select check boxes next to the required KPIs. You can also type a letter or string in the **Search KPI name** field.

   To remove the check from all boxes, click **none**. (If there are a large number of KPIs and you want to display only a few of them, it is most efficient to deselect all of them this way and then check your selections.)

   To include all KPIs, click **all**.

3. Click **Apply**.