# Simulate Quality of Service (QoS)

Quality of Service (QoS) is a means of ensuring high-quality performance for critical applications. The concept is that because requirements of some users and services are more critical than others, some traffic requires preferential treatment.

Using Cisco Crosswork Planning QoS features, you can ensure that service levels are met without reactively expanding or over-provisioning the network. QoS features are available for undifferentiated traffic, for service classes, and for interface queues.

- Undifferentiated traffic—Aggregate traffic on an interface.
- Service class—A user-defined classification of traffic that is not discovered by Cisco Crosswork Planning. Examples include voice, video, and data. Service classes apply to the entire network.
- Queue—In live networks, traffic waits in conceptual lines (queues) and then is forwarded over an interface on a per-queue basis according to QoS parameters. Similarly in Cisco Crosswork Planning, each queue has a set of user-defined QoS parameters (interface queue properties) that specify how these queues are prioritized and what percentage of traffic they carry. An interface contains zero or more queues that are discoverable by Cisco Crosswork Planning. You can also manually create and configure them. The traffic per queue is also discovered.

This section contains the following topics:



# QoS requirements

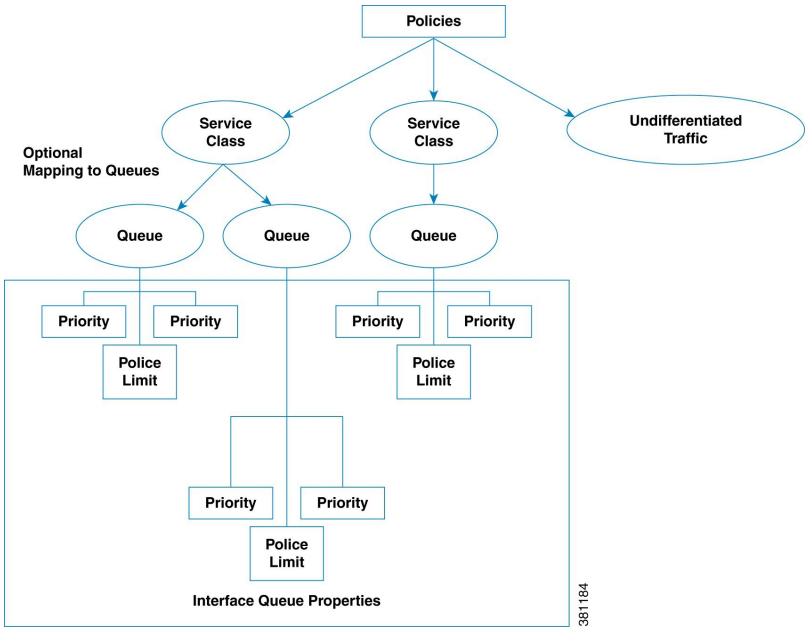
In Cisco Crosswork Planning, QoS requirements are defined by policies and interface queue properties.

- Policy—Maximum percentage of traffic capacity that can be utilized by either a service class or by undifferentiated traffic. There are two policies: one for normal operation and one for worst-case scenarios.

Policies set on service classes do not affect QoS requirements of any other service class. Nor would this parameter have any effect on live network behavior.

- Interface queue properties—Configured parameters that would affect routing behavior in a live network. In Cisco Crosswork Planning, the interface queue properties are priority, weight, and police limit. To set these properties, see Edit interface queue properties, on page 10.
  - The **Priority** identifies the precedence of the queue. For example, traffic in a priority 1 queue is routed before traffic in a priority 2 queue. Queues with the same priority evenly share the capacity based on weighted-round robin (WRR) calculations. You can change this behavior using the weight and police limit parameters. There are unlimited number of priorities, though most networks only use no more than three. By default, queues do not have priorities.
  - The **Weight** is the percentage of preference given to queues of an equal priority level, which enables the network to fairly distribute the load among available resources. For example, if 10 Gbps were passing through a 10GbE interface on two priority 1 queues, by default 5 Gbps would pass through each queue. However, if you set the weight of one queue to 75% and the other to 25%, the distribution would be 7 Gbps and 2.5 Gbps, respectively. By default, all queues have a weight of 100%.
  - The **Police limit** is the maximum percentage of available capacity permitted through a queue of a given priority level, thereby preventing traffic from higher priority queues from starving lower priority queues. For example, if the interface is a 20GbE and a priority 1 queue has a police limit of 40%, then only 8 Gbps of interface traffic can go through this queue. By default, all queues have a police limit of 100%. To see examples of this *starvation*, refer to the examples in Policies and QoS bound calculations, on page 3, where you can see that lower priority queues received zero traffic due to priority settings.

***Figure 1: Policies and interface queue parameters***



# QoS bound and QoS violations

Cisco Crosswork Planning uses the concepts of **QoS bound** and **QoS violation** as a way of identifying whether QoS parameters are being met or surpassed, thus better enabling you to plan for service requirements across the network. Policies and queue properties determine the QoS bound calculation. In turn, this calculation determines whether there is a violation.

- QoS bound—Maximum interface capacity available without violating these QoS requirements. A separate QoS bound is calculated for both policy and interface queue properties.

| QoS bound for... | Calculated based on... |
|---|---|
| Interface queues | Combination of interface queue properties, or in live networks, it is the capacity percentage that is discovered. |
| Service class | Policy |
| Service class mapped to queues | The lower of these two calculations is used:<br>• Policy for service class<br>• Queue properties for queues |
| Undifferentiated traffic | Policy |

  In the Network Summary table, the columns that convey the QoS bound information are: QoS bound meas, QoS bound meas (%), QoS bound sim, and QoS bound sim (%).

  QoS bound calculations are a set of decisions being made to determine how to raise traffic on the queues until that traffic cannot be raised any further. This capacity, or the reason the traffic cannot be raised further, is defined both by the QoS parameters and the amount of traffic. For example, when traffic arrives at Queue X, Cisco Crosswork Planning fixes the traffic on all other queues and then determines how it can raise the traffic on Queue X until some other traffic blocks it.

  For those queues that do not reach full capacity, unused queue capacity is made available for other queues.

- QoS violation—Total traffic minus the capacity permitted for the queue (QoS bound). A violation occurs if the maximum QoS capacity allotted through policies and interface queue properties is exceeded. If the number appearing in the **QoS violation** column is positive, the allotted capacity has been surpassed. If the number is negative, the allotted capacity has not been reached.

## Policies and QoS bound calculations

If no other QoS parameters are set via the Interface queue properties of Priority, Weight, and Police limit, the QoS bound is equivalent to the policy set.

*Table 1: Example policies and QoS bound calculations*

| Example configuration | QoS bound | QoS violation (Positive # = Violation) |
|---|---|---|
| Interface capacity = 10,000 Mbps<br>Undifferentiated traffic = 5000 Mbps<br>Normal operation policy = 60% | 6000 Mbps (60%) | –1000 Mbps (–10%)<br>Because this number is negative, there is no capacity violation. |
| Interface capacity = 10,000 Mbps<br>Undifferentiated traffic = 8000 Mbps<br>Normal operation policy = 60% | 6000 Mbps (60%) | 2000 Mbps (20%)<br>Because this number is positive, there is a capacity violation. |
| Interface capacity = 10,000 Mbps<br>Voice traffic = 6000 Mbps<br>Video traffic = 2000 Mbps<br>Voice normal operation policy = 90%<br>Video normal operation policy = 60% | Voice = 9000 Mbps (90%)<br>Video = 6000 Mbps (60%) | Voice = –3000 Mbps (30%)<br>Video = –4000 Mbps (40%) |

# Interface queue properties and QoS bound calculations

Cisco Crosswork Planning simultaneously calculates QoS bound for each queue in the interface. In doing so, Cisco Crosswork Planning uses the Interface queue parameters (Priority, Weight, and Police limit) and the traffic measured or simulated for all queues in the interface. Priority is always considered first. If there are queues of equal Priority, then Weight is applied next.

- Queues with priority 1 share all available interface capacity. Their weight and police limits further refine how much each priority 1 queue can use (their QoS bound). Each priority 1 queue can borrow available capacity from other priority 1 queues up to the limit of their QoS bound.
- The available capacity for priority 2 queues is the total interface capacity minus all capacity consumed by priority 1 queues. The process then begins again for all priority 2 queues. Their weight and police limits determine their QoS bound, and priority 2 queues can borrow capacity from each other up to the limits set by the QoS bound.
- This process continues for each successive priority level. Traffic that is outside any QoS bound is dropped to the lowest priority of all traffic on the interface.

For discovered networks with measured traffic, if no Cisco Crosswork Planning QoS parameters are set, the QoS bound is based on whatever capacity percentages the live network has for each queue.

## Priority

Provided policies are not set that further affect the QoS bound, a queue's QoS bound is calculated as follows:

- Priority 1 QoS bound = 100% of the interface capacity.
- Priority 2 QoS bound = Total interface capacity – amount of traffic consumed by priority 1 queues.
- Priority 3 QoS bound = Total interface capacity – amount of traffic consumed by (priority 1 + priority 2 queues).
- QoS bound for each succeeding priority follows this same pattern where the traffic consumed by all higher priority queues is subtracted from the total interface capacity.

*Table 2: Examples of priority QoS bound calculations*

| Example configuration | QoS bound | QoS violation (Positive # = Violation) | QoS bound calculations |
|---|---|---|---|
| Interface capacity = 20,000 Mbps<br>EF traffic = 6000 Mbps; priority = 1<br>BE traffic = 3000 Mbps; no priority set | EF = 20,000 Mbps<br>BE = 14,000 Mbps | EF = –14,000 Mbps<br>BE = –11,000 Mbps | EF = Total interface capacity because it is the only priority 1 queue<br>BE = 20,000 (interface capacity) – 6000 (consumed by higher priority queues) |
| Interface capacity = 10,000 Mbps<br>EF Traffic = 6000 Mbps; priority = 1<br>BE Traffic = 5000 Mbps; priority = 2 | EF = 10,000 Mbps<br>BE = 4000 Mbps | EF = –4000 Mbps<br>BE = 1000 Mbps | EF = Total interface capacity because it is the only priority 1 queue<br>BE = 10,000 (interface capacity) – 6000 (consumed by higher priority queues |

## Weight

The weight identifies the forwarding precedence for queues of equal priority. If weights for queues of the same priority do not add up to 100%, weights are converted proportionally so they do add up to 100%.

*Table 3: Examples of weight QoS bound calculations*

| Example configuration | QoS bound | QoS violation (Positive # = Violation) | QoS bound calculations |
|---|---|---|---|
| Interface capacity = 10,000 Mbps<br>AF1 traffic = 3000 Mbps; priority = 1; weight = 100%<br>AF2 traffic = 6000 Mbps; priority = 1; weight = 100% | AF1 = 5000 Mbps<br>AF2 = 7000 Mbps | AF1 = –2000 Mbps<br>AF2 = –1000 Mbps | AF1 = Half of capacity for priority 1 queues because both queues have equal weights<br>AF2 = 5000 (half of capacity) + 2000 (unused AF1 capacity) |

| Example configuration | QoS bound | QoS violation (Positive # = Violation) | QoS bound calculations |
|---|---|---|---|
| Interface capacity = 10,000 Mbps<br>AF1 = 5000 Mbps; priority = 1; weight = 60%<br>AF2 traffic = 6000 Mbps; priority = 1; weight = 40% | AF1 = 6000 Mbps<br>AF2 = 5000 Mbps | AF1 = –1000 Mbps<br>AF2 = 1000 Mbps | AF1 = 60% of capacity for all priority 1 queues<br>AF2= 10,000 (interface capacity) – 5000 (consumed by AF1 queue) |

## Police limits

Priority 1 queues have 100% of the interface traffic, and thus starve out the remaining queues. To prevent this queue starvation, use police limits to configure how much of the maximum percentage should be available for a given priority level.

***Table 4: Examples of police limit QoS bound calculations***

| Example configuration | QoS bound | QoS violation (Positive # = Violation) | QoS bound calculations |
|---|---|---|---|
| Interface capacity = 10,000 Mbps<br>EF traffic = 1000 Mbps; priority = 1; police limit = 50%<br>BE traffic = 2000 Mbps; priority = 2 | EF = 5000 Mbps<br>BE = 9000 Mbps | EF = –4000 Mbps<br>BE = –7000 Mbps | EF = 50% of total interface capacity<br>BE = 10,000 (interface capacity) – 1000 (capacity consumed by EF) |
| Interface capacity = 10,000 Mbps<br>EF traffic = 1000 Mbps; priority = 1; police limit = 5%<br>BE traffic = 2000 Mbps; priority = 2 | F = 500 Mbps<br>BE = 9500 Mbps | EF = 500 Mbps<br>BE = –7500 Mbps | EF = 5% of total interface capacity<br>BE = 10,000 (interface capacity) – 500 (capacity consumed by EF) |

| Example configuration | QoS bound | QoS violation (Positive # = Violation) | QoS bound calculations |
|---|---|---|---|
| Interface capacity = 10,000 Mbps<br>EF = 3000 Mbps; priority = 1; police limit = 20%<br>AF1 traffic = 4000 Mbps; priority = 2; police limit = 75%<br>AF2 traffic = 2500 Mbps; priority = 2; police limit 25% | EF = 2000 Mbps<br>AF1 = 6000 Mbps<br>AF2 = 4000 Mbps | EF = 1000 Mbps<br>AF1 = –2000 Mbps<br>AF2 = –1500 Mbps | EF = 20% of total interface capacity<br>AF1 = 75% of (10,000 [interface capacity] – 2000 [capacity consumed by EF])<br>AF2 = 10,000 (interface capacity) – 2000 (capacity consumed by EF) – 4000 (capacity consumed by AF1) |

# Interface QoS bound calculations using multiple QoS parameters

Cisco Crosswork Planning calculates a QoS bound for interface queues based on all three parameters if they are all configured: priority, weight, and police limits.

***Table 5: Examples of interface QoS bound calculations using multiple QoS parameters***

| Example configuration | QoS bound | QoS violation (Positive #= Violation) | QoS bound calculation |
|---|---|---|---|
| Interface capacity = 10,000 Mbps<br>EF = 3000 Mbps; priority = 1; police limit = 20%<br>AF1 traffic = 4000 Mbps; priority = 2; weight = 75%<br>AF2 traffic = 2500 Mbps; priority = 2; weight = 25% | EF = 2000 Mbps<br>AF1 = 6000 Mbps<br>AF2 = 4000 Mbps | EF = 1000 Mbps<br>AF1 = –2000 Mbps<br>AF2 = –1500 Mbps | EF = 20% of total interface capacity<br>AF1 = Maximum of these two values.<br>• 75% of (10,000 [interface capacity] – 2000 [capacity consumed by EF])<br>• 8000 (available capacity) – 2500 (AF2 traffic)<br>AF2 = Maximum of these two values.<br>• 25% of (10,000 [interface capacity] – 2000 [capacity consumed by EF])<br>• 8000 (available capacity) – 4000 (AF1 traffic) |

# Service class QoS bound calculations using multiple QoS parameters

If service classes have policies and they are mapped to queues, Cisco Crosswork Planning calculates a QoS bound for both. Cisco Crosswork Planning then uses the lowest value of the two so as to enforce restrictions in the strictest possible manner.

Example:

Interface capacity = 10,000 Mbps

QoS bound for service class = 50%, or 5000 Mbps based on policy

QoS bound for EF queue = 7500 Mbps based on combined parameters of priority, weight, and police limit

The QoS bound for this service class is 5000 Mbps because the policy QoS bound calculation is lower.

# View queue and service class information

***Table 6: Queue and service class information***

| To view | Show or select |
|---|---|
| Queue information | Show the Interface Queues table. Select the queue from the **QoS** drop-down list in the visualization toolbar. Both the network plot and the **Traff meas** and **Traff sim** columns display traffic data specific to the queue type selected. |
| Per-queue traffic in the Interfaces table | Select the queue from the **QoS** drop-down list. Both the network plot and the **Traff meas** and **Traff sim** columns display traffic data specific to the queue type selected. |
| Service class demands | Show the **Service class** column in the Demands table. |
| Per-service-class traffic | Select the service class from the **QoS** drop-down list. Both the network plot and the **Traff meas** and **Traff sim** columns in the Interfaces table display data specific to the service class selected. |

# View QoS bounds and QoS violations

Table 7: QoS bounds and QoS violations , on page 8 lists the available column options to display numeric values of the QoS bound calculations. For information on QoS values as they relate to VPNs, see Simulate VPN.

***Table 7: QoS bounds and QoS violations***

| To view | Show this column in Interfaces, Circuits, or Interface queues table |
|---|---|
| **Measured Traffic** | |
| Maximum capacity before a QoS bound is violated under normal operations | QoS bound meas |

| To view | Show this column in Interfaces, Circuits, or Interface queues table |
|---|---|
| QoS bound as a percentage of total interface capacity | QoS bound meas (%) |
| QoS violations under normal operations; if the number is positive, there is a violation | QoS violation meas |
| QoS violation as a percent of the total interface capacity | QoS violation meas (%) |
| **Simulated Traffic** | |
| Maximum capacity before a QoS bound is violated under normal operations | QoS bound sim |
| QoS bound as a percentage of total interface capacity | QoS bound sim (%) |
| QoS violations under normal operations; if the number is positive, there is a violation | QoS violation sim |
| QoS violation as a percent of the total interface capacity | QoS violation sim (%) |
| **Worst-Case Traffic** | |
| Maximum capacity before a QoS bound is violated under worst-case operations | WC QoS bound |
| WC QoS bound as a percentage of total interface capacity | WC QoS bound (%) |
| QoS violations under worst-case operations; if the number is positive, there is a violation | WC QoS violation |
| WC QoS violation as a percent of the total interface capacity | WC QoS violation (%) |
| Service class causing the worst-case utilization | WC service class |

# Create queues

This topic describes how to create new interface queues.

Cisco Crosswork Planning discovers queues. However, you can manually add them. Once discovered or created, queues appear in the Interface Queues table.

### Procedure

**Step 1** Open the plan file (see Open plan files). It opens in the **Network Design** page.

**Step 2** From the toolbar, choose **Actions** > **Insert** > **Others** > **Interface Queues**.

OR

In the Network Summary panel on the right side, click + in the **Interface queues** tab.

The **Interface queues** tab is available under the **More** tab. If it is not visible, then click the **Show/hide tables** icon ( ) and check the **Interface queues** check box.

**Step 3** Select the required interfaces.

**Step 4** Click **Next**.

**Step 5** Enter the queue name.

**Step 6** (Optional) Enter the queue properties of priority, weight, and police limit. For information on how these queue properties behave, see Interface queue properties and QoS bound calculations, on page 4.

**Step 7** Click **Submit**.

**Step 8** (Optional) Map a service class to the queue. For instructions, see Map service classes to queues, on page 11.

The new queue appears as an option in the **QoS** drop-down list in the toolbar.

# Edit interface queue properties

Follow these steps to edit the QoS parameters using Interface queues properties.

**Procedure**

**Step 1** Open the plan file (see Open plan files). It opens in the **Network Design** page.

**Step 2** In the Network Summary panel on the right side, select the interface queues from the **Interface queues** table.

If the **Interface queues** tab is not visible, then click the **Show/hide tables** icon ( ), select the **Interface queues** check box, and click **Apply**.

**Step 3** Click .

**Step 4** Update one or more QoS fields (Priority, Weight, and Police limit) to create the desired QoS requirement.

**Step 5** Click **Save**.

# Create service classes

This topic describes how to create new service classes.

**Procedure**

**Step 1** Open the plan file (see Open plan files). It opens in the **Network Design** page.

**Step 2** In the toolbar, select **Manage QoS** from the **QoS** drop-down list, or use the **Actions** > **Edit** > **Manage QoS** option.

**Step 3** In the **Service Classes** section, click .

An empty row appears.

**Step 4** Enter a unique name under the **Name** column.

**Step 5** (Optional) If queues exist and if you want to map this new service class to one or more queues, select them from the list.

If queues do not exist, but you want them, you must manually create the queues and then return to this dialog box to select them. For more information, see Map service classes to queues, on page 11.

**Step 6** Click **Save**.

The newly created service class appears under this section and in the **QoS** drop-down list in the toolbar.

# Map service classes to queues

This topic describes how to map service classes to queues.

### Before you begin

To map service classes to queues, those queues must first exist either because they were discovered by Cisco Crosswork Planning or because you manually added them. For details, see Create queues, on page 9.

### Procedure

**Step 1** Open the plan file (see Open plan files). It opens in the **Network Design** page.

**Step 2** In the toolbar, select **Manage QoS** from the **QoS** drop-down list, or use the **Actions** > **Edit** > **Manage QoS** option.

**Step 3** In the Service Classes section, select the service class.

**Step 4** Click **Edit**.

**Step 5** In the **Mapped to queues** column, select one or more queues.

**Step 6** Click **Save**.

**Step 7** Repeat for each service class to which you are mapping queues.

# Create policy groups for interfaces

Creating a policy group for interfaces lets you set policies for the group in the Manage QoS page.

### Procedure

**Step 1** Open the plan file (see Open plan files). It opens in the **Network Design** page.

**Step 2** In the Network Summary panel on the right side, select one or more interfaces from the **Interfaces** table.

**Step 3** Click  .

**Step 4** Click the **Advanced** tab.

**Step 5** Expand the **QoS** panel.

- To add this interface to an existing policy group, select it from the drop-down list.
- To add a new policy group, type the name of the new group in the drop-down field and click **Add** "*PoliyGroupName*".

**Step 6** Click **Save**.

**Step 7** To assign a service class to this policy group, select this policy group while configuring the Service Class Policy. For details, see Create or edit service class policies, on page 12.

# Create or edit service class policies

This topic describes how to create or edit service class policies.

You can configure policies for undifferentiated traffic and for service classes.

### Procedure

**Step 1** Open the plan file (see Open plan files). It opens in the **Network Design** page.

**Step 2** In the toolbar, select **Manage QoS** from the **QoS** drop-down list, or use the **Actions** > **Edit** > **Manage QoS** option.

**Step 3** To click a new service class policy:

a) In the **Service Class Policies** section, click  .

The New Service Class Policy page opens.

b) If creating a policy for undifferentiated traffic, select **Undifferentiated traffic**. If creating a policy for an existing service class, select **Service class**. Then, select the service class from the **Service Class** drop-down list.

c) To apply this service class mapping to a group of interfaces, select from or enter the name in the **Interface policy group** drop-down list. You can enter a name that does not exist and a policy group will be created with the name you entered. For details on creating policy groups for interfaces, see Create policy groups for interfaces, on page 11.

d) In **Normal operation (in %)**, enter the percentage of bandwidth capacity that you do not want this interface (or group of interfaces) to exceed for this traffic or service class under normal conditions.

e) In **Worst-case (in %)**, enter the percentage of bandwidth capacity that you do not want this interface (or group of interfaces) to exceed for this traffic or service under worst-case operating conditions.

f) Click **Submit**.

**Step 4** To edit an existing service class policy:

a) In the **Service Class Policies** section, select the service class row you want to edit.

b) In the **Actions** column, click ••• > **Edit**.

The Edit Service Class Policy page opens.

c) Enter the details as described in Step 3.

d) Click **Save**.

# Apply QoS settings globally

This topic describes how to apply the QoS parameters globally for an opened plan file.

Selecting QoS settings and the traffic level at the global level determines the network summary table calculations and what is displayed in the network plot.

**Before you begin**

Ensure that the required queue or the service class is available.

**Procedure**

**Step 1** Open the plan file (see Open plan files). It opens in the **Network Design** page.

**Step 2** In the toolbar, select **Manage QoS** from the **QoS** drop-down list, or use the **Actions** > **Edit** > **Manage QoS** option.

**Step 3** Select the service class or queue from the **QoS** drop-down list.

The selected QoS setting applies globally to your network plan. The network plot and the network summary table display data based on the selected QoS parameter.

# How QoS violations are indicated in the topology

**Summary**

Cisco Crosswork Planning visually signals when network interfaces exceed QoS bounds. This feature helps you quickly identify and address potential performance issues.

The key components involved in the process are:

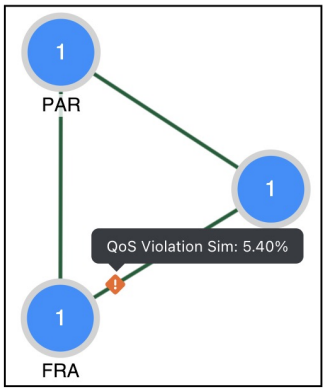
- Topology plot: Displays network interfaces and their current status.
- QoS violation icon (  ): Marks interfaces that violate QoS thresholds.
- Severity text: Provides details about the violation.

**Workflow**

The process includes these stages:

1. The system monitors interface utilization and QoS thresholds.
2. When an interface exceeds its QoS bound, a violation icon appears on the topology plot.
3. The severity text provides details about the violation.

*Figure 2: QoS violation*




**Note** Cisco Crosswork Planning indicates when an interface violates a QoS bound in the network plot, but does not display the QoS bound values on the interfaces.