Qosium Scope

Qosium Scope is a real-time analyzer for managing Qosium measurements. You can use Scope to activate and control Qosium Probes over a network connection. The essential features of Scope are measurement parameterization, running measurements, results collection, and results visualization. Qosium Scope is an excellent tool for manual QoS and QoE measurements.

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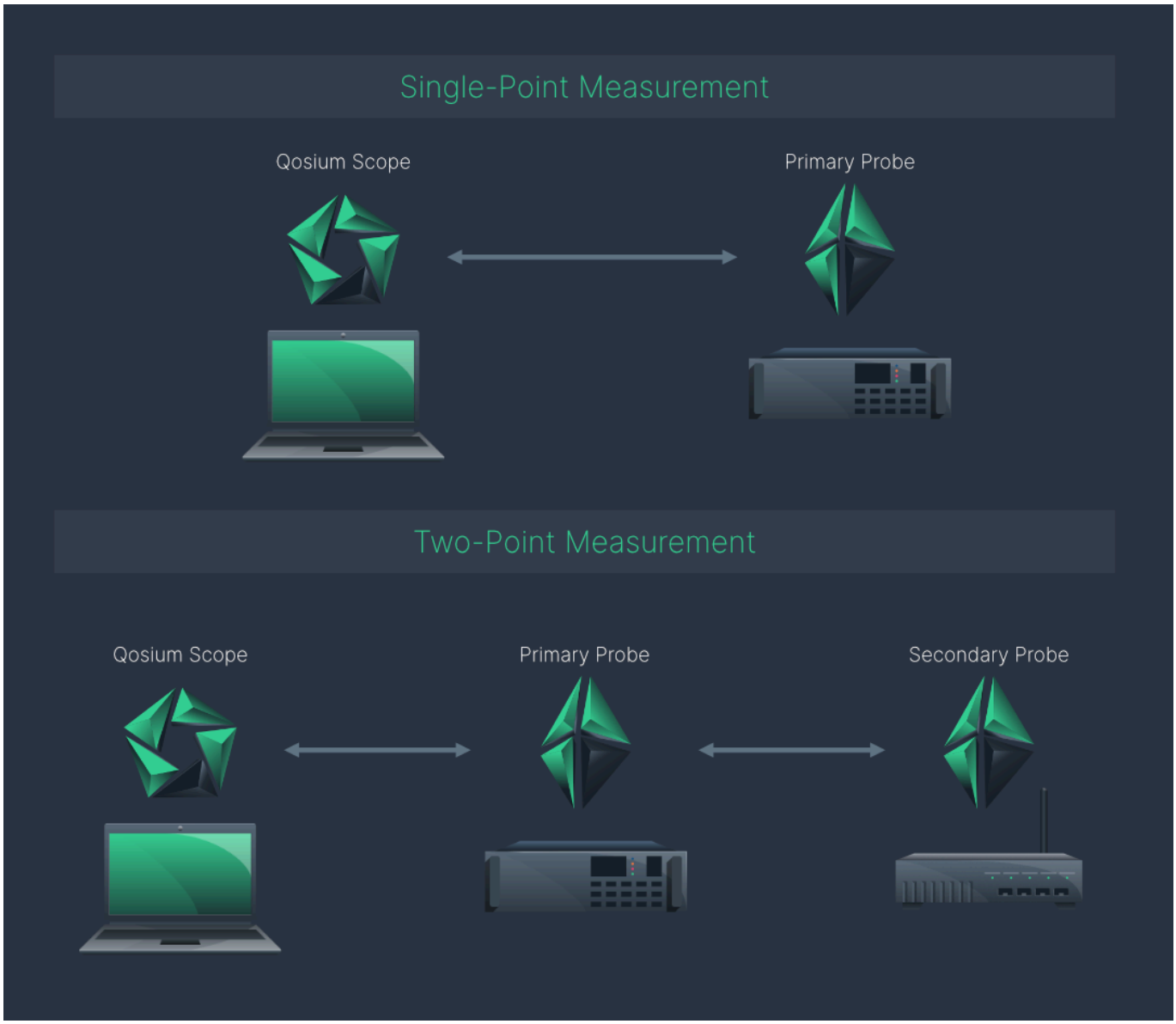
1. Overview

Qosium Scope is the primary tool for carrying out manual measurements in the Qosium product family. It is a *controlling entity*, which means that it connects to Qosium Probes and uses them to do the measurement work. Scope then collects the measurement results and offers various ways to visualize, store, and process these results.

Qosium Scope is like any other desktop application. It doesn't require any external hardware and can be run on a regular PC or laptop. With Scope, all features of Qosium measurements are at your fingertips.

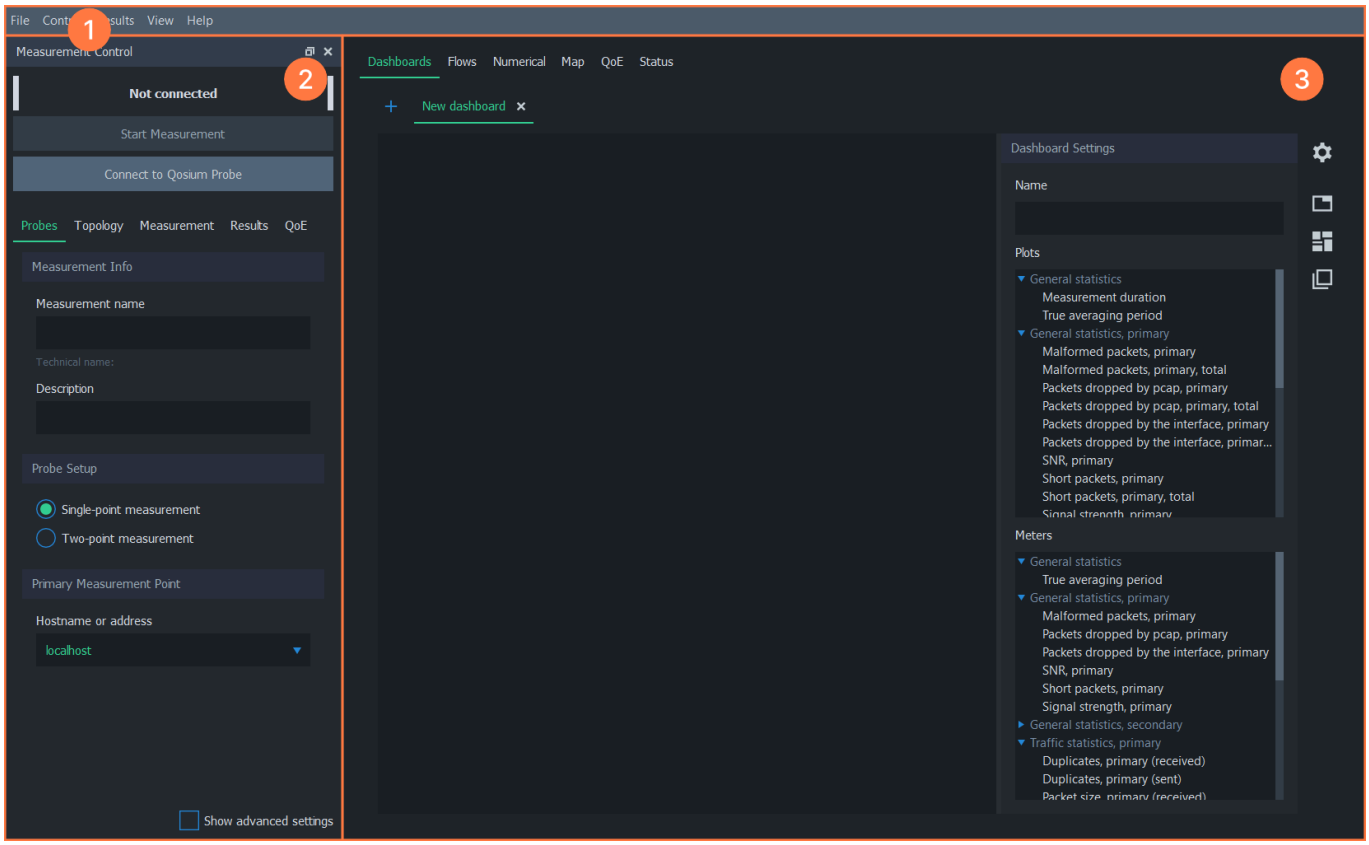
Scope has two distinct measurement modes: **Single-point measurement** and **two-point measurement** . In *single-point measurement*, Scope uses one Probe to measure a single network node or point. In *two-point measurement*, Scope instead uses two Probes to measure a network path.



2. User Interface at a Glance

After installing and launching Scope, the main window opens up. The window consists of the following elements:

1. Menu Bar - Access basic measurement functions, settings, etc.
2. Measurement Control - Configure and start/stop measurements
3. Workspace Area - View and analyze measurement results



3. How to Get Started with Scope

See the sub-sections for more information on installation, launching, and on each UI element. To learn how to use Scope to carry out measurements, see Get Started with Qosium.

4. Install and Launch Qosium Scope

Qosium Scope is a graphical Qosium measurement control and analyzer software. You can run Qosium Scope practically on any device with a modern desktop environment.

Qosium Scope is available to most Windows, Linux, and macOS operating systems equipped with a graphical desktop environment. For heatmap results visualization, a graphics card with OpenGL 3.2+ support is required.

See platform-specific instructions for more information on each operating system. If you wish to install Scope on another system not included in this documentation, ask about OS support from us through a support ticket or by email tuki@kaitotek.fi.

4.1. Installation & Launch on Windows

Qosium has an installer package available for Windows, which also contains Scope. Installation is very similar to other Windows software, and the whole process takes only a few minutes. After installation, Scope can be launched as any other Windows application.

4.1.1. OS Requirements

Windows versions 8 and 10 are currently supported (64bit edition).

4.1.2. Installation

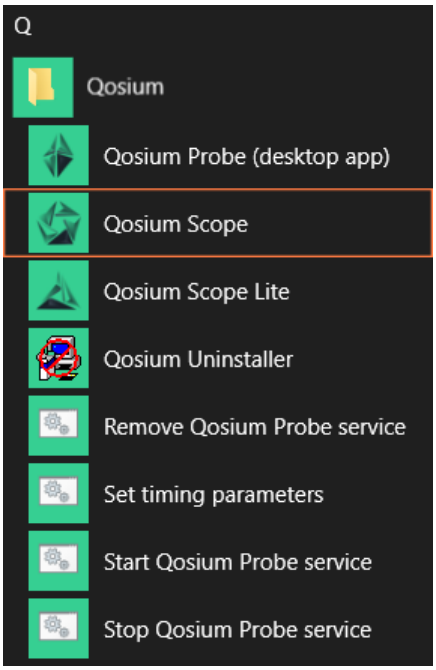
Follow these steps to install Qosium Scope:

1. Sign in to your account
2. Download the Qosium installer from your downloads page
3. Launch the installer, which guides you through the installation process

After completing these steps, Qosium Scope has been successfully installed in your system.

4.1.3. Launching Scope

After installation, the most convenient method for launching Scope is to use Qosium shortcuts, which can be accessed via the Windows start menu.



Another way is to use the executable directly. If installed on the default location, Scope can be launched by executing `C:\Program Files\Qosium\Scope\QosiumScope.exe`.

4.2. Installation on Debian-Based Systems

Qosium Scope can be installed by using the Debian package management system. This works in Ubuntu and other Debian-based Linux systems in Terminal or package manager applications, like Software Center and Synaptic.

4.2.1. Installation

First, sign in to your account and access your downloads page. Then download Qosium products for the target machine.

The name of the product file should have format `QosiumScope_<version_details>.deb`, for example `QosiumScope_Ubuntu_18.04_64_20200513.deb`.

To install a new copy, or to upgrade an existing one, open terminal and run

```
sudo dpkg -i QosiumScope_<version_details>.deb
```

After installation, you can check which version of Qosium Scope is installed by running:

```
dpkg -l qosiumscope
```

4.2.2. Launching Scope

After installation, Scope can be launched by executing the following command in the terminal:

```
/opt/QosiumScope/bin/QosiumScope
```

Qosium Scope does not require root/sudo privileges.

4.2.3. Uninstallation

To remove Qosium Scope from the device, run:

```
sudo dpkg -r qosiumscope
```

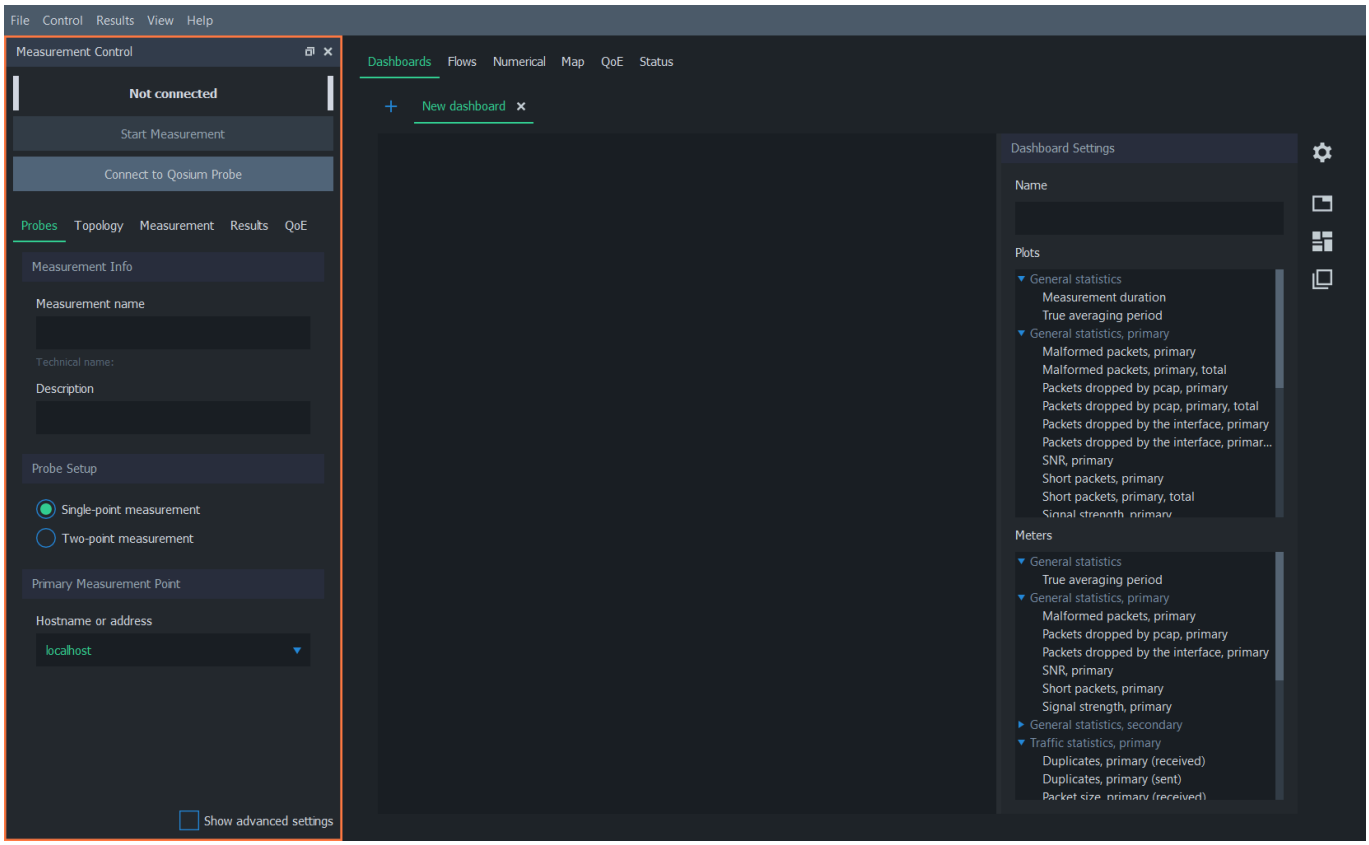
5. Measurement Control

The measurement control panel is used to parameterize and control measurements.

5.1. Overview

The measurement control panel is located on the left side of Scope window. It has three main elements:

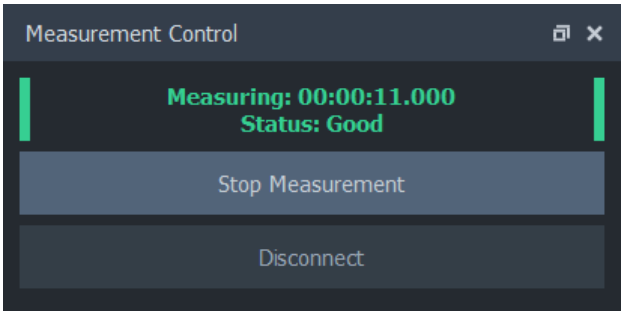
- Status indicator
- Buttons for controlling the measurements
- Tabs for parameterizing measurements



On the bottom of the panel is the **Show advanced settings**. This toggles the visibility of some rarely needed settings.

5.2. Status Indicator

Scope has a simple status indicator located in the upper left corner of the measurement control panel. It shows the Probe connectivity status, whether currently conducting a single or two-point measurement, and whether a measurement is running. For example, when the measurement is running without issues, the status bar appears as follows:



5.2.1. Status Warnings

Qosium has some built-in health inspection checks for the current measurement. If any anomalies are detected, they are reported in the status indicator.

First, if system clocks of measurement points are not in sync together, a warning message appears to the Status. This message is given only for larger synchronization errors (> 100 ms).

Another warning is given if Qosium observes some issues in one of the measurement points, e.g., dropped

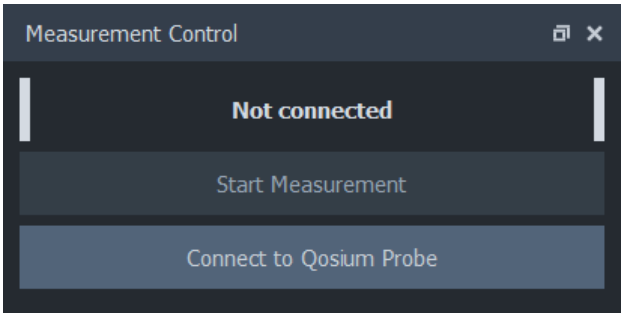
packets. These are typically caused by too high CPU load or insufficient system resources.

Also, temporary connection breaks between entities are shown here.

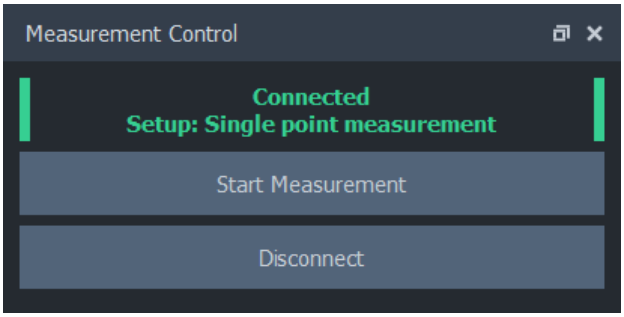
5.3. Control Buttons

Control buttons below the status indicator can be used to control the measurement. The actions of the two buttons vary depend on the current state of Scope as follows:

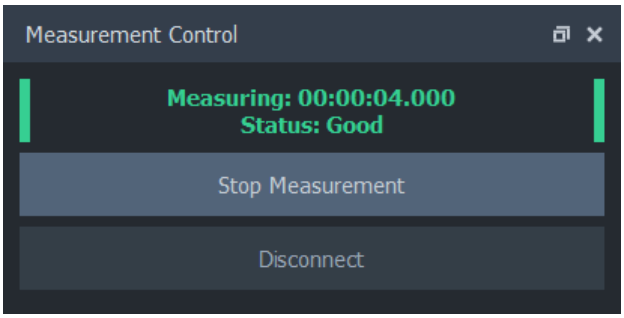
When no connection to Probe(s) is active, only connect button is available:



When a connection has been established, it's possible to either start a new measurement or disconnect:

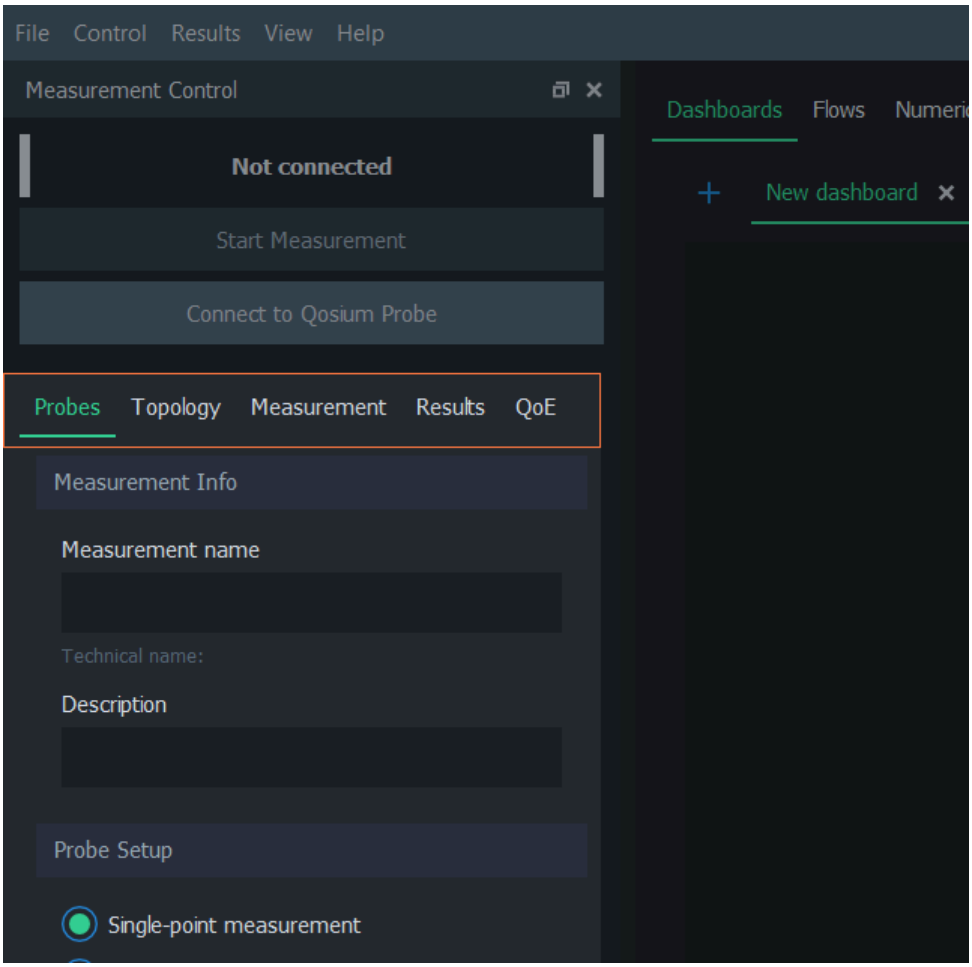


During measurement, the only action available is stopping the measurement:



5.4. Parameterization Tabs

Measurements are configured by adjusting parameters. These parameters are located in the five tabs of the measurement control panel. See more details on each tab.



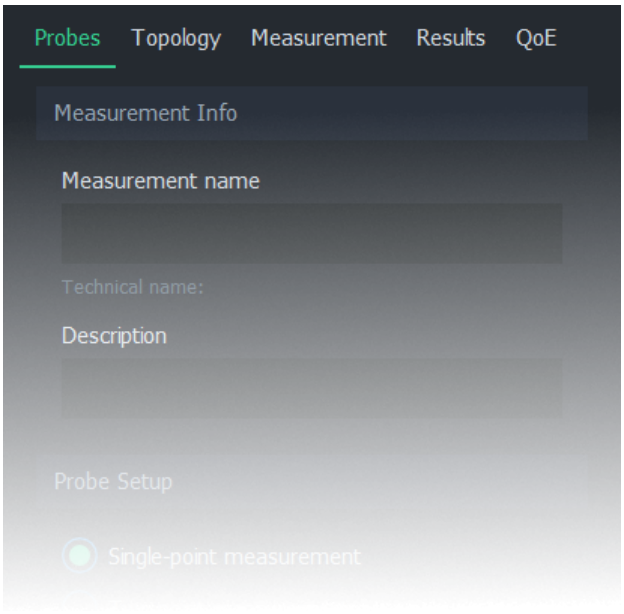
5.5. Probes Tab

The Probes tab in Scope measurement control panel contains Probe connection settings and other general settings for the measurement. It's usually the place where a new measurement parameterization is started.

5.5.1. Overview

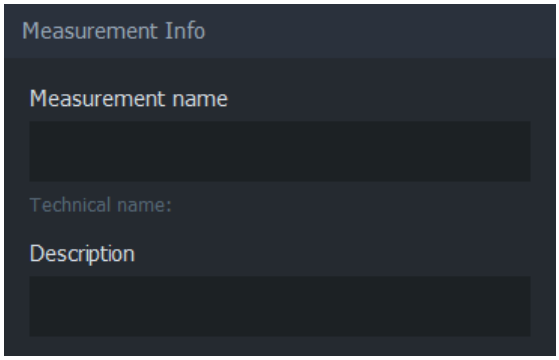
This tab consists of the following settings groups. Detailed information on each group can be found in the following sections. All groups in this tab, excluding *Measurement Info*, are disabled when a connection to Probe(s) is active. To re-enable the tab for editing, stop the current measurement and disconnect from Probes.

- **Measurement Info**
- **Probe Setup**
- **Primary Measurement Point**
- **Secondary Measurement Point** - Visible when two-point measurement is selected
- **Client Settings** - Visible when advanced settings are enabled



5.5.2. Measurement Info

The measurement info group contains the basic information of the measurement. While optional, it's a good practice to fill out this information for each measurement.



5.5.2.1. Measurement Name

The name or title of the measurement. Naming the measurement is optional.

Technical name is a machine-friendly version of measurement name, which is used by Scope to, for example, suggest a filename for settings

5.5.2.2. Measurement Description

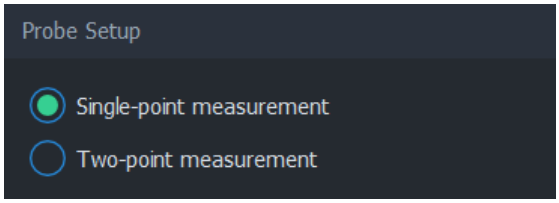
Measurement description is an optional text you can use as you wish, e.g., to describe the measurement scenario or some details in the measurement. The text set here will be part of measurement results, appearing in the results files and results systems like Qosium Storage. It is up to you how to use this.

5.5.3. Probe Setup

In the Probe setup group, the selection between *single-point measurement* and *two-point measurement* can be made.

- **Single-point measurement** mode uses one Probe to measure a single network node or point

- **Two-point measurement** mode utilizes two Probes to measure a network path

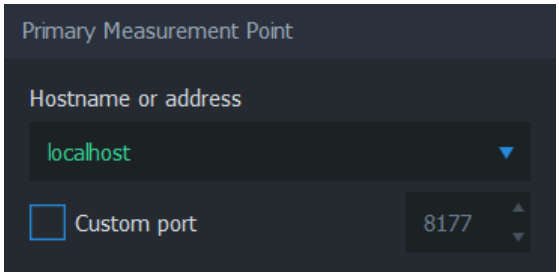


Some measurement result types are not available in single-point measurement

Some options in Scope are visible only when a two-point measurement is selected

5.5.4. Primary Measurement Point

The primary measurement point group contains connection settings for the Probe installed in the primary measurement point. Qosium Probe must be running and reachable via this address and port. For more information on installing and launching Probes, see Qosium Probe documentation.



5.5.4.1. Hostname or Address

The address can be either a hostname or an IPv4 address. If the primary Probe is installed on the same PC where Scope is running, use local address `127.0.0.1` or `localhost`.

5.5.4.2. Custom Port

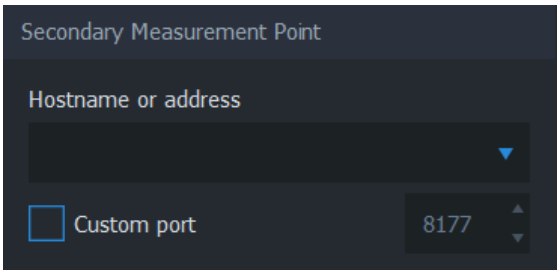
Visible when advanced settings are enabled

If the primary Probe has been configured to listen to other than the default Qosium port `8177`, set the correct port number here before connecting.

5.5.5. Secondary Measurement Point

Visible only when a two-point measurement is selected

The secondary measurement point group contains connection settings for the Probe installed in the secondary measurement point. Qosium Probe must be running and reachable via this address and port. For more information on installing and launching Probes, see Qosium Probe documentation.



5.5.5.1. Hostname or Address

The address can be either a hostname or an IPv4 address. If the secondary Probe is installed on the same PC where Scope is running, use local address `127.0.0.1` or `localhost`.

5.5.5.2. Custom Port

Visible when advanced settings are enabled

If the secondary Probe has been configured to listen to other than the default Qosium port `8177`, set the correct port number here before connecting.

5.5.6. Client Settings

Visible when advanced settings are enabled

5.5.6.1. User ID

User ID is used to identify this controlling entity and differentiate it from other controlling entities. Setting user ID is typically not needed, except when multiple controlling entities collect measurement results to the same result pool. In that scenario, a user ID can be used to identify the user/device which carried out the measurement since it's saved into the measurement result files.

5.6. Topology Tab

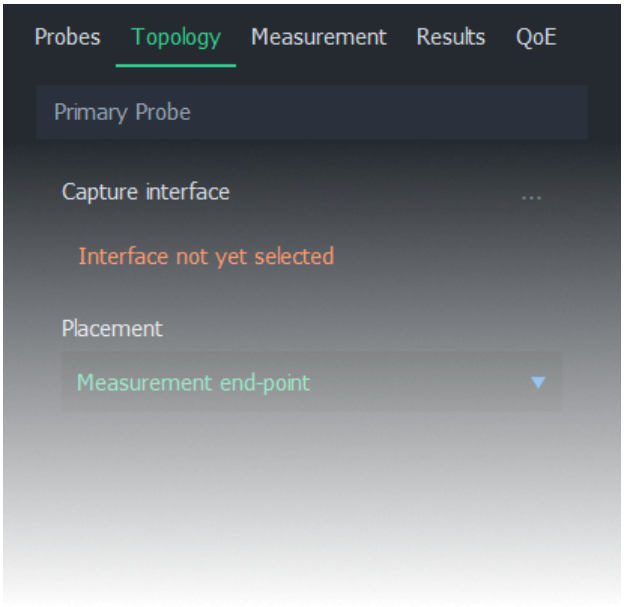
Topology defines how Qosium Probes are located concerning the target network traffic. In Scope, this means defining network capture interfaces and Probe placement. Depending on the settings, it may also be necessary to define senders and receivers manually.

5.6.1. Overview

This tab consists of the following settings groups. Detailed information on each group can be found in the following sections.

- **Primary Probe**
- **Secondary Probe** - Visible when a two-point measurement is selected
- **Primary Probe Senders** - Visible when manual senders definition is required

- **Secondary Probe Senders** - Visible when a two-point measurement is selected, and manual senders definition is required
- **NAT Settings** - Visible when a two-point measurement is selected

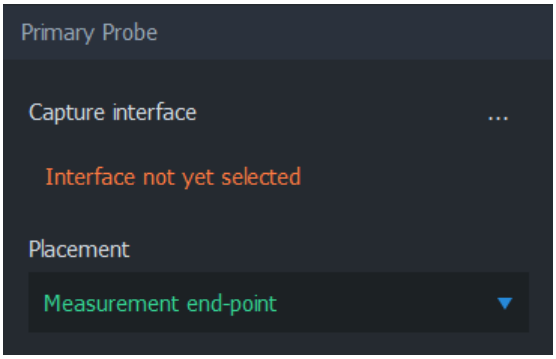


Before proceeding, it is recommended to complete the Probes tab, connect to Probes(s), and then edit this tab. A connection must be made in any case for Scope to receive the list of available capture interfaces.

For more information on topology, see Understanding Measurement Topology.

5.6.2. Primary Probe

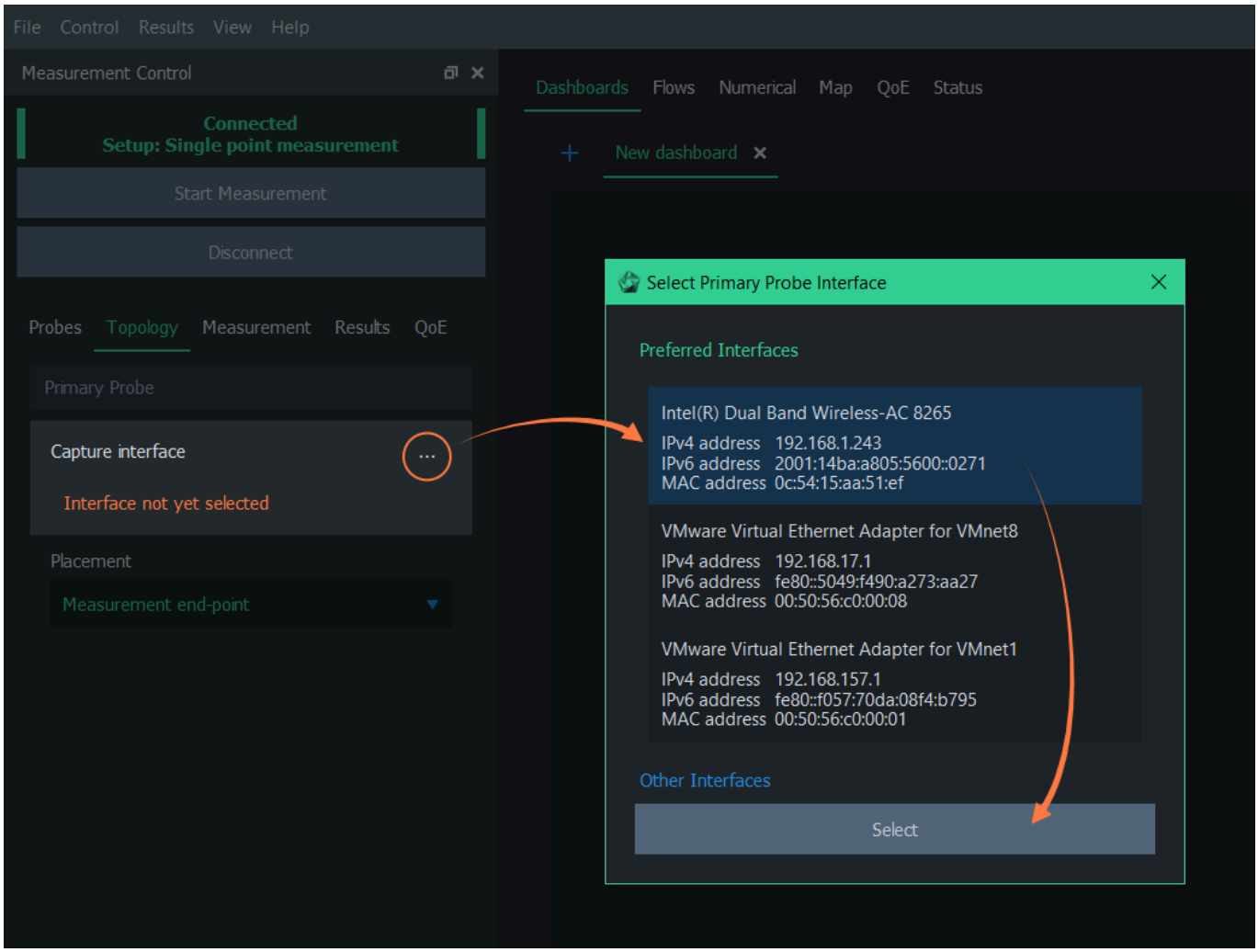
In this group, capture interface and placement can be selected for the primary Probe.



5.6.2.1. Capture Interface

Interface can be selected only while connected to Probes

This field displays the selected interface, which the primary Probe uses for capturing network traffic. An interface can be selected by clicking the "..." icon on the right side. This opens up an interface selection dialog, which lists interfaces available for this Probe.



The interface selection dialog is split into two views:

- **Preferred Interfaces** - Interfaces that have valid addresses
- **Other Interfaces** - Other available interfaces

Locate the desired interface. Double-click on the interface, or click once and then press *Select*. It appears on the topology tab as the selected interface.

5.6.2.2. Placement

Placement indicates the location of the Probe concerning the measured network traffic. The options are:

- **Measurement end-point** - The Probe is in either one of the measured traffic endpoints. In other words, the device Probe is installed to is either sending or receiving the measured network traffic.
- **Within measured path** - The Probe is not located at either one of the end-points but instead resides somewhere along the path where the measured traffic traverses. Note: This option uses MAC addresses in flow direction analysis. Thus, if your measured interface does not have a MAC address (e.g., a cellular modem), select the **Off-path** option instead.
- **Off-path (e.g., mirrored traffic)** - The Probe is not located within the measurement path at all. This is the case, for example, when using mirror ports in switches. Also, if you wish to define *Senders* (see below) manually, select this option.

Only end-point placements allow the Packet filter to be calculated automatically.

For more information on placement, see Understanding Measurement Topology.

5.6.3. Secondary Probe

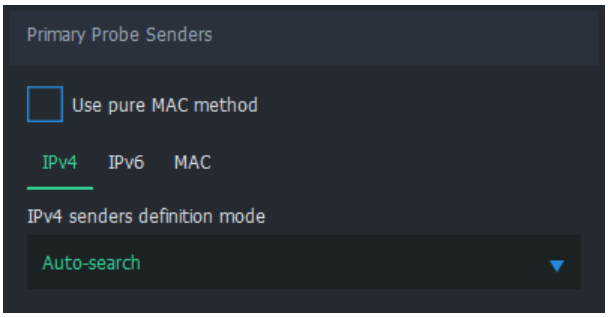
Visible only when a two-point measurement is selected

This group contains topology settings for the secondary Probe. These settings are identical to the Primary Probe group, but they consider the secondary Probe instead.

5.6.4. Primary Probe Senders

Visible only when manual senders definition is required

If Qosium is unable to determine the senders and receivers for the primary Probe automatically, the Primary Probe Senders group appears, allowing defining senders manually instead.



For more information on manual senders definition, see Understanding Measurement Topology.

5.6.4.1. Pure MAC

First, senders definition has one top-level option: **Use pure MAC method**. If this method is desired, select it. Nothing more is required for senders definition for this measurement point.

When this mode is active, traffic direction is checked from the MAC-addresses. If the interfaces and the traffic is such that there are MAC-addresses, e.g., Ethernet NIC, then this setting works very well. However, in some interfaces, like Linux *any* interface, the MAC header is not visible, causing this mode to fail.

5.6.4.2. Manual Senders Definition

There are multiple methods of defining which addresses are considered senders. Any address that does not meet the given criteria is deemed to be a *receiver*.

The available options depend on the protocol. These options are covered in the following sections.

5.6.4.2.1. IPv4

The following options are available:

- **Auto-search** - Look up known addresses in interfaces and declare these as senders
- **According to secondary Probe** - Take the definition of the secondary Probe and reverse it
- **Mask** - Define a network address (e.g., 192.168.1.0) and a mask (e.g., 255.255.255.0)

- **Manual select** - Define a list of sender addresses

5.6.4.2.2. IPv6

The following options are available:

- **Auto-search** - Look up known addresses in interfaces and declare these as senders
- **According to secondary Probe** - Take the definition of the secondary Probe and reverse it
- **Mask** - Define a network address (e.g., fe80:1ab3:8f01:12df::0 and a mask (e.g., ffff:ffff:ffff:ffff::0)
- **Manual select** - Define a list of sender addresses

5.6.4.2.3. MAC

The following options are available:

- **Auto-search** - Look up known addresses in interfaces and declare these as senders
- **According to secondary Probe** - Take the definition of the secondary Probe and reverse it
- **Manual select** - Define a list of sender addresses

When using the Pure MAC method or when sender addresses are defined inversely in one of the ends (According to primary/secondary Probe), the Packet filter cannot be calculated automatically.

5.6.5. Secondary Probe Senders

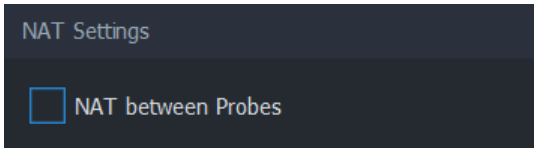
Visible only when a two-point measurement is selected and manual senders definition is required

This group contains sender settings for the secondary Probe. These settings are identical to the Primary Probe Senders group, but they consider secondary Probe senders instead.

5.6.6. NAT Settings

Visible only when a two-point measurement is selected

Qosium needs to be aware if a Network Address Translation (NAT) occurs between Probes. If this is the case, check the option **NAT between Probes**. For more information, see How to Measure over NAT.



5.7. Measurement Tab

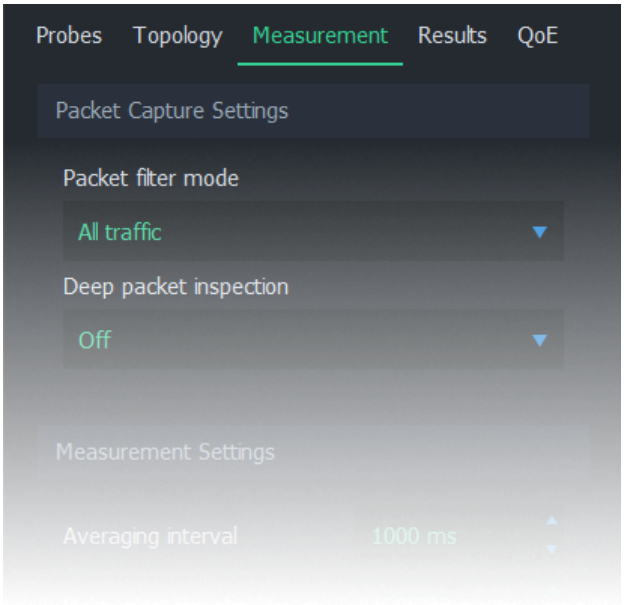
Qosium offers a wide selection of parameters for configuring how measurements are performed. In Qosium Scope, these parameters are configured in the measurement tab.

5.7.1. Overview

This tab consists of the following settings groups. Detailed information on each group can be found in the

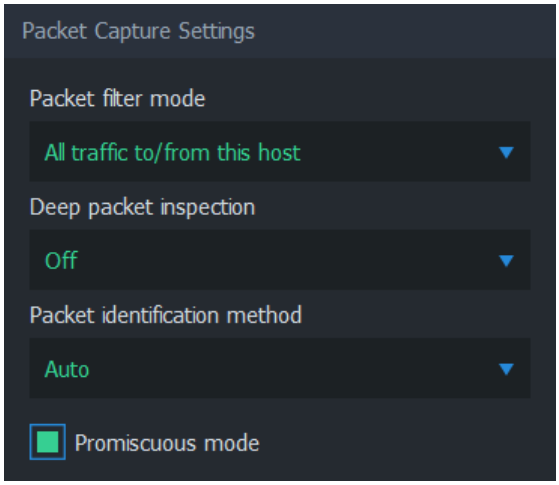
following sections.

- **Packet Capture Settings**
- **Measurement Settings**
- **Control Connection Settings** - Visible when advanced settings are enabled



5.7.2. Packet Capture Settings

This group contains settings on how packets are captured and identified.



5.7.2.1. Packet Filter Mode

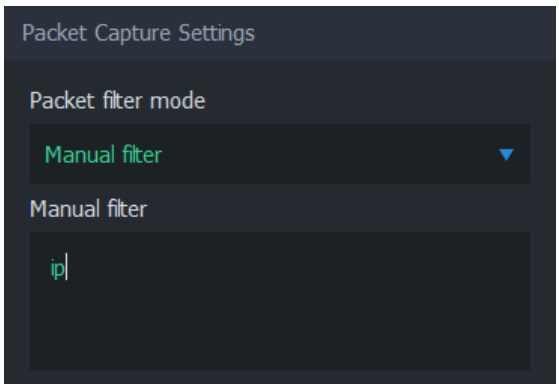
Packet filter mode determines how packets are filtered. In other words, packets that meet the given filter criteria contribute to the measurement results. The available options depend on current settings. For more information, see Packet Filters in Qosium.

The first option in the list is an *automatic* mode. The name and function of this setting depend on whether a single-point or two-point measurement is selected:

- In a single-point measurement, this option is named **All IP traffic to/from this host**. Only (IPv4 or IPv6)

traffic originating from or targetted to the measurement point is captured.
- In a two-point measurement, this option is named **All IP traffic between hosts**. Only (IPv4 or IPv6) traffic that is generated by the measurement points and is targeted to the other measurement point is captured.

The second option in this list is **Manual filter**. When selected, a text field appears below, where an arbitrary packet filter can be typed manually.



Regardless of the choices made, the final filter applied to the measurement can be seen on Status Tab once the measurement is started.

5.7.2.2. Secondary Probe Filter Mode

Visible when two-point measurement, NAT between Probes, and manual filter are selected

Secondary Probe Filter Mode determines how the given manual packet filter is treated in the secondary Probe. Setting this option is relevant only if NAT occurs on the measurement path. For more information, see How to Measure over NAT.

- **Equal filter** (default) - The same filter as to the primary Probe is set to the secondary.
- **Strict autofilter** - The filter is composed automatically based on what kind of flow the primary Probe with its filter observes. The IPv4 addresses, protocol, and ports (when they exist) are included in the filter. Thus, this filter is *strict* in the sense that only a single flow will fit it.
- **Loose autofilter** - Similar to **Strict autofilter**, but only the IPv4 addresses of the flow are included in the filter. The filter is loose in the sense that multiple flows will fit that.

5.7.2.3. Deep Packet Inspection

Available only in single-point measurements

Two measurement points are always required to perform a QoS measurement. However, some protocols themselves carry information from the other end, allowing QoS calculations to be made by a single Qosium Probe. Thus, this is still a two-point measurement, but now there is no Probe in the other end. Instead, the application/service acts as the secondary measurement point, providing valid information and enabling QoS calculation.

Qosium currently supports two protocols for this kind of deep packet inspection: RTP and MPEG-2 (TS). These methods enable packet loss statistic calculation by a single Qosium Probe. Please note that this QoS calculation can be done for received traffic only as there is no feedback channel for the sent traffic.

- **RTP** - Use RTP protocol header information.

- **MPEG-2 (TS)** - Use MPEG-2 Transport stream header information.

The measured traffic stream must be of the selected type. Otherwise, the DPI-based QoS calculations cannot be made.

5.7.2.4. Packet Identification Method

Visible when advanced settings are enabled.

The packet identification method defines how Qosium identifies packets between measurement points. Thus, the meaning of this is important under a two-point measurement and not that much in a single-point measurement. This is one of the parameters that you generally do not need to touch since the default automatic setting will handle most of the measurement cases. However, if you do need to set this manually, here are the options and their explanations.

- **Auto** (default) - Qosium selects the method from the options below based on the measurement scenario. The selection is made safely, i.e., a method typically known to function in most of the cases in a similar scenario is selected. This might not always be the optimal method.
- **IPv4 ID Field** - Qosium uses the *Identification field* in the IPv4 header for packet identification. Naturally, the first requirement for this to work is that the measured traffic shall be of IPv4 type. A second requirement is that the measured stream is using the IPv4 Identification field as specified. This is not always the case, but luckily the non-standard usage is rare. A restriction lies in the fact that the *Identification field* has only 16 bits, limiting the available unique numbering per time instance to 65536. Thus, if you are using a 1 s averaging interval, your measurement should be working fine, as long as the target measurement stream's packet rate is clearly less than this (e.g., < 30000 pkts/s). Beyond that, QoS calculation is not guaranteed to be entirely accurate. Then, if you are using a longer averaging interval, e.g., 10 s, the safe packet rate drops to one-tenth of the previous, accordingly.
- **RTP Sequence Number** - Qosium uses the *Sequence number field* in the RTP header for packet identification. This lightweight option is ideal for measuring RTP streams. But, be aware that while Qosium checks that there is room in the packet for the RTP header, it does not check its actual existence. Thus, setting this option with non-RTP traffic can result in unpredictable behavior.
- **Payload-Based ID** - Qosium calculates the identification based on the packet payload. This method is not dependent on the protocol headers, so it works for IP packets and pure L2 (e.g., Ethernet) packets. If a packet has no payload, **IP4 ID Field**, when present, is used.
- **Extended Payload-Based ID** - Qosium calculates the identification based on the packet payload, including some parts of the transport layer header. This can be your choice if the measured traffic stream is composed of, e.g., very short packets or packets with duplicated data in their payloads. However, if your NIC is using offloading methods, this method might not always work correctly.
- **Pure Payload-Based ID** - This is a very similar method with **Payload-Based ID**, but packets without payload are just ignored from QoS calculation. In many ways, this is the most robust identification method. However, the drawback, as with all the payload-based methods, is that if the payloads between packets have little or no variation, QoS calculation might not always be accurate.
- **NAT bypasser + Payload based ID** - Operates as **Payload-Based ID** but with NAT bypasser functionality enabled. NAT bypasser lets you perform a passive measurement in a scenario where there is a NAT between the measurement points.
- **NAT Bypasser + Pure Payload Based ID** - Operates as **Pure Payload-Based ID** but with NAT bypasser functionality enabled.

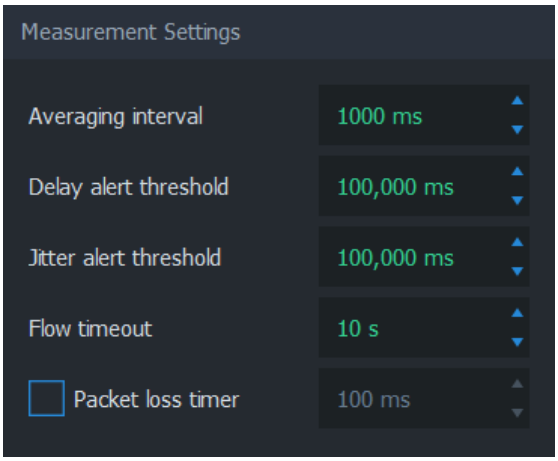
5.7.2.5. Promiscuous Mode

Visible when advanced settings are enabled.

Promiscuous Mode allows Qosium to capture packets that are not designated to the network card performing the capture. This is a fairly common case with Qosium, and it's recommended to leave this option enabled unless there's a specific reason to disable it. Some network cards might not support promiscuous mode, which is an example of such a specific reason.

5.7.3. Measurement Settings

Measurement settings contribute to the way how measurement results are gathered and interpreted.



5.7.3.1. Averaging Interval

As the name implies, this parameter defines the time interval each average sample represents. Coincidentally, averaging interval also determines how often Scope receives average results.

Please note that this sets the target averaging interval.

If Qosium Probe is not running in a platform with a real-time operating system, the target is hardly ever fully met. For example, in Windows, it is quite common to see that the real averaging interval varies between 999 – 1001 ms when 1000 ms averaging interval is set. Instead of the target value, Qosium always uses *the true averaging period* in its calculations. Qosium also follows and corrects the behavior of the averaging interval's variations over time. Thus, the long-term averaged averaging interval should be relatively close to the set target value.

5.7.3.2. Delay Alert Threshold

Packets with a delay above this threshold are counted in QoS Statistics: Th. ex. delay pkts. This statistic provides a way to understand the number of highly delayed single packets without actual packet-level statistics.

5.7.3.3. Jitter Alert Threshold

Packets with a jitter above this threshold are counted in QoS Statistics: Th. ex. jitter pkts. This statistic provides a way to understand the number of single packets with high jitter without going to the actual

packet-level statistics.

5.7.3.4. Flow Timeout

Visible when advanced settings are enabled.

Flow timeout determines the duration in which a flow remains in the flow map after the most recent packet belonging to the flow has been registered.

Ideally, this value should be set as small as possible. However, if packets are arriving sporadically, flows may disappear from the flow map too early. This results in flows disappearing and re-appearing, as Scope deems these flows terminated prematurely. To counter this phenomenon, increase the flow timeout. As a result, the correct value is always somewhat dependent on the traffic flows' properties to be measured.

5.7.3.5. Packet Loss Timer

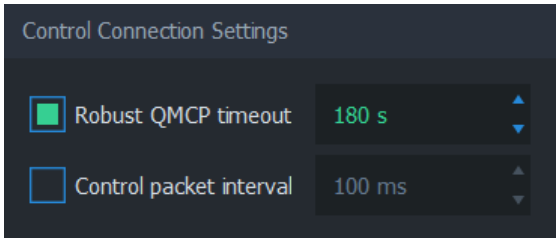
Visible when advanced settings are enabled.

Packet Loss Timer determines the duration used to determine packet losses. Setting this parameter is always a compromise between reactivity and the capability to detect long delays. If not enabled, Qosium automatically sets a generally well-functioning value for this parameter. The final value can be seen on the Status Tab during the measurement.

5.7.4. Control Connection Settings

Visible when advanced settings are enabled.

These settings are related to the QMCP connections between Qosium Products (e.g., from Scope to primary Probe to external Listener and Secondary Probe). Adjusting these settings is not typically needed.



5.7.4.1. Robust QMCP Timeout

This parameter is for toggling *Robust QMCP Mode* on/off and for adjusting the duration of how long reconnection is tried before giving up. This is especially useful when measuring over a weak, unreliable network path.

Set this value according to your needs. Very large values are ideal while carrying out long-term monitoring, while small values are recommended for carrying out short measurement campaigns.

5.7.4.2. Control Packet Interval

This parameter affects the control packet interval between the Qosium Probes in a two-point measurement. It is recommended to leave this option unchecked to allow Qosium to calculate an optimal value automatically instead. The final value can be seen on the Status Tab.

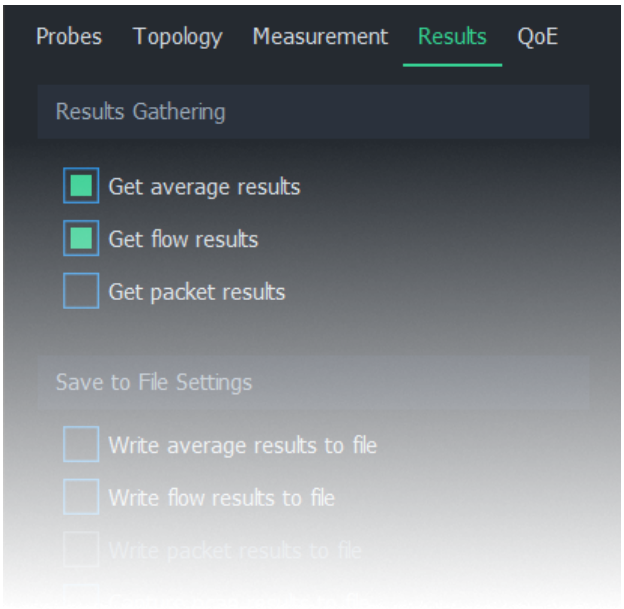
5.8. Results Tab

In Scope, each result type has to be explicitly selected for gathering. The selected result types can then be selected to be saved to file for later analysis. These and other results-related parameters are configured in the results tab.

5.8.1. Overview

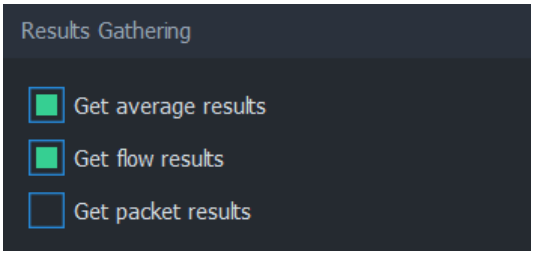
This tab consists of the following settings groups. Detailed information on each group can be found in the following sections.

- **Results Gathering**
- **Save to File Settings**
- **Limit Results**
- **Results Direct Distribution** - Visible when advanced settings are enabled



5.8.2. Results Gathering

Scope gathers different types of results only when explicitly instructed to do so. In this group, you may select the result types for the next measurement.



For more information on each result type, see Measurement Results in Qosium.

5.8.2.1. Get Average Results

When this option is selected, average results will be gathered during measurement. Average results are the

most common type of results in Qosium measurements. In Scope, there are several options available for handling average results:

- View the results in dashboards
- View the results in numerical form
- Save the results to file during measurement
- Save the results to file after measurement

5.8.2.2. Get Flow Results

When this option is selected, flow results will be gathered during measurement. In Scope, there are two options available for handling flow results:

- Observe flowmap, which displays currently active flows
- Save the complete list of flows to file during measurement

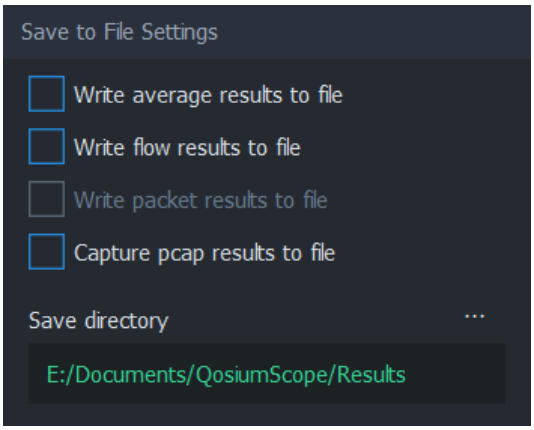
5.8.2.3. Get Packet Results

When this option is selected, packet results will be gathered during measurement. In Scope, there are two options available for handling packet results:

- View the results in numerical form
- Save the packet results to file during measurement

5.8.3. Save to File Settings

Each result type can be selected to be saved to files in real time during measurement.



5.8.3.1. Write Average Results to File

Enabled when Get average results is selected

When this option is selected, average results will be written to file in real time during the measurement. The directory where this file will be saved is determined by Save directory.

The file will be named `averages_[technical_name].txt`, where `[technical_name]` is auto-generated from the Measurement Name.

5.8.3.2. Write Flow Results to File

Enabled when Get flow results is selected

When this option is selected, flow results will be written to file in real time during the measurement. The directory where this file will be saved is determined by Save directory.

The file will be named `flows_[technical_name].txt`, where `[technical_name]` is auto-generated from the Measurement Name.

5.8.3.3. Write Packet Results to File

Enabled when Get packet results is selected

When this option is selected, packet results will be written to file in real time during the measurement. The directory where this file will be saved is determined by Save directory.

In a single-point measurement, this option produces a single file with filename format `pk_info_[technical_name].txt`.

In a two-point measurement, this option produces two files with filename formats `pk_qos_DL_[technical_name].txt` and `pk_qos_UL_[technical_name].txt`.

The `[technical_name]` is auto-generated from the Measurement Name.

5.8.3.4. Capture Pcap Results to File

When this option is selected, full packet traces will be written to file in real time during the measurement. The directory where this file will be saved is determined by Save directory.

For more information, see How to Take Packet Capture?.

5.8.3.5. Save Directory

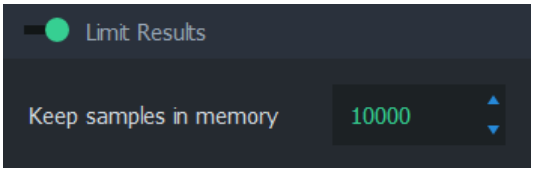
The save directory determines the folder where results files will be written during measurement. Click on **...** to select another directory.

It's recommended to have a separate directory for each measurement scenario to avoid mixing up the results.

Save directory has no effect if none of the result types have been selected for real-time saving.

5.8.4. Limit Results

The number in **Keep samples in memory** states how many results per result type Scope holds in memory. Set this value high enough for the measurement purpose. The limit can also be disabled, but this is not recommended, as this will eventually consume the available memory of the computer where Scope is running.



Limiting results in memory does not have an impact on results saved to files. The selected results will be

saved regardless of whether this setting is enabled or what limit is given.

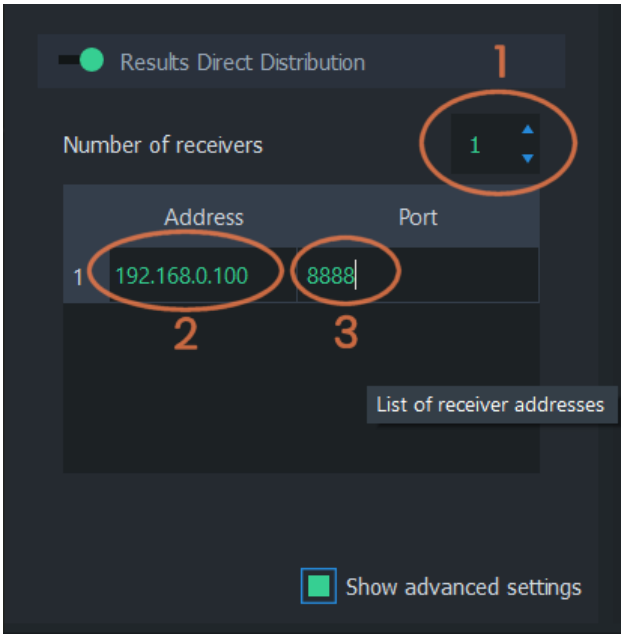
5.8.5. Results Direct Distribution

Visible when advanced settings are enabled

Qosium supports direct results sending to external systems. Such a system can be, for example, Qosium Storage or any QMCP listener. See the possibilities for integration if you are interested in receiving results directly in your system.

In Qosium Scope, the external receivers are defined in this group. Activating results distribution is straightforward:

1. Set the number of result destinations,
2. Set the IPv4 address(es) of the destination(s), and
3. Set the port(s) of the destination(s).



Once you start the measurement, the results distribution destinations will be connected. The distribution takes place in the same phase as Qosium Scope's result reception.

Result receivers have to be running before starting the measurement.

5.9. QoE Tab

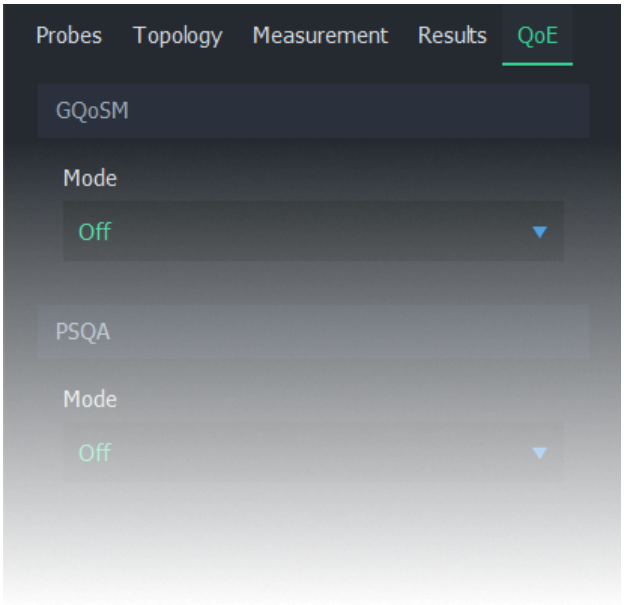
Configuring Quality of Experience models has its own dedicated tab in Qosium Scope. GQoSM and PSQA models can be selected and parameterized in this tab.

5.9.1. Overview

This tab consists of the following settings groups:

- **GQoSM**
- **PSQA**

- **Sample Averaging** - Visible when advanced settings are enabled



5.9.2. GQoSM

Setting this option from *Off* to **Manual** enables GQoSM samples in *average results*.

The model can use up to 4 QoS parameters in QoE calculation: **Delay**, **jitter**, **packet loss**, and **connection break length**. Each of these parameters can be enabled/disabled individually. Each parameter has 2 adjustments: **Bad performance limit** and **form factor**. For more information on how to configure this model, see Quality of Experience.

5.9.3. PSQA

Pseudo-Subjective Quality Assessment (PSQA) uses a trained feed-forward neural network for determining quality. For more information on how to configure this model, see Quality of Experience.

The available options depend on the current

- **Off** - The model is not calculated
- **VoIP Listening** - A model for voice over IP for one-way listening
- **VoIP Conversational** - A model for voice over IP for a two-way conversation
- **Streaming Video (H.264) AV** - A model for streaming video
- **Streaming Video (H.264) AV MLP** - A model for streaming video

5.9.3.1. VoIP Listening

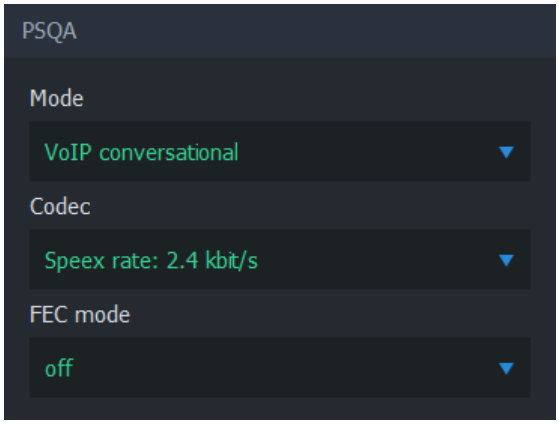
This listening model is applicable when the targeted traffic consists of a one-direction VoIP flow. The model has a few parameters:

- **Codec** - The codec of the VoIP stream
- **FEC mode** - The Forward Error Correction mode
- **Packetization interval** - The duration of audio each packet contains

5.9.3.2. VoIP Conversational

This conversational model is applicable when the targeted traffic consists of a two-direction VoIP conversation flow. The model has a few parameters:

- **Codec** - The codec of the VoIP stream
- **FEC mode** - The Forward Error Correction mode



5.9.3.3. Streaming Video (H.264) AV

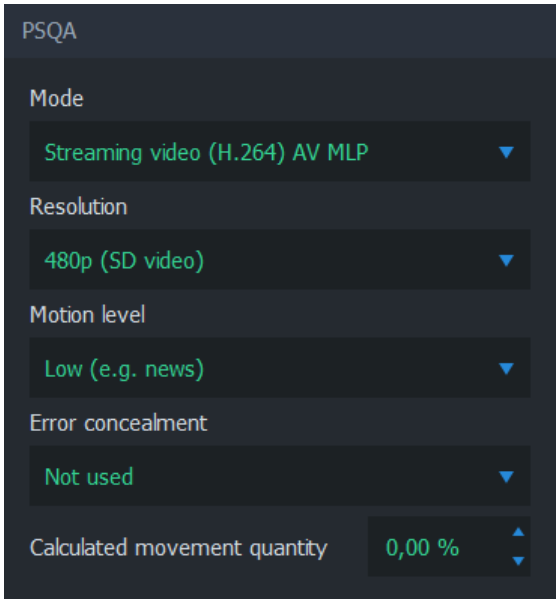
This streaming video model is applicable when the targeted traffic consists of a video stream. The model has a few parameters:

- **Resolution** - The resolution of the video frame
- **Motion level** - The amount of motion in the video content

5.9.3.4. Streaming Video (H.264) AV MLP

This streaming video model is applicable when the targeted traffic consists of a video stream. The model has a few parameters:

- **Resolution** - The resolution of the video frame
- **Motion level** - The amount of motion in the video content
- **Error concealment** - Whether the codec is attempting to conceal errors or not
- **Calculated movement quantity**



5.9.4. Sample Averaging

Visible when advanced settings are enabled

Sample averaging settings can be adjusted to pre-average QoE samples. This reduces sporadic fluctuations in the results when using small averaging interval, or when the quality model yields low scores for brief deterioration of network conditions not visible in the end-application.

5.9.4.1. Weighted Moving Averaging

When enabled, the average is calculated by using the weighted moving average algorithm. See Wikipedia article on weighted moving average.

5.9.4.2. Sliding Window Averaging

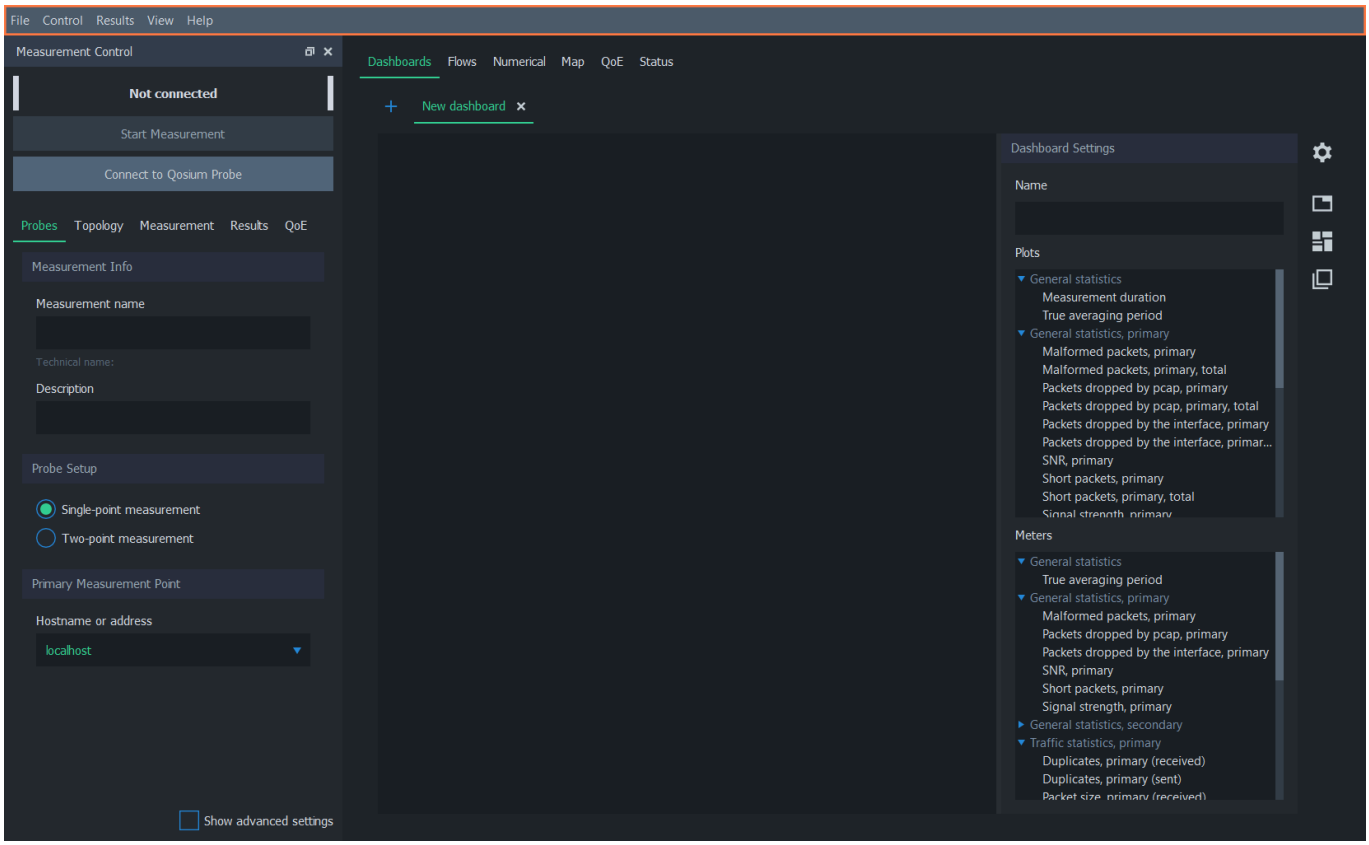
When enabled, the average is calculated from a fixed number of most recent samples. The number can be adjusted manually.

6. Menu Bar

Scope's top menu bar offers global actions and options, such as measurement control, Probe discovery, themes, and measurement settings management.

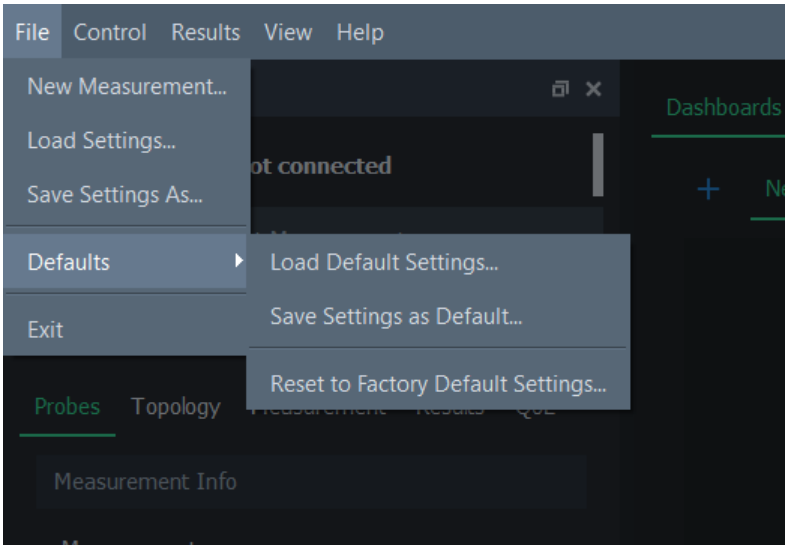
6.1. Overview

The menu bar is located at the top of the Scope main window. This menu contains useful options for saving and loading measurement settings, controlling measurements, and managing results. Each menu item is described in the following sections.



6.2. File

The *File* menu contains options for saving and loading settings.



- **New Measurement...** - Clear all current measurement results and load the default settings
- **Load Settings...** - Load a measurement settings file
- **Save Settings As...** - Save the current measurement settings to a file
- **Defaults** - Scope loads default settings automatically after launch. These settings can be modified to avoid setting the same initial settings repeatedly
  - **Load Default Settings...** - Load default settings as current settings

- **Save Settings as Default...** - Save the current settings as new default settings
- **Reset to Factory Default Settings** - Load factory defaults as current settings

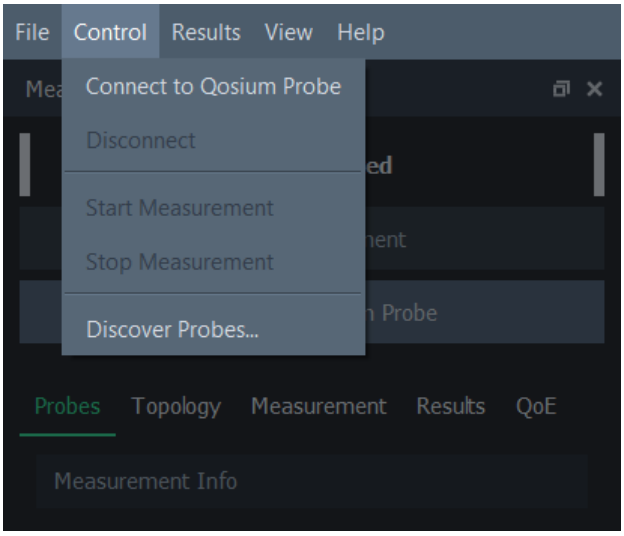
- **Exit** - Quit Scope

Restore Factory Defaults Permanently

To permanently restore "factory defaults", select *Reset to Factory Default Settings* and then select *Save Settings as Default...*

6.3. Control

These options are used to control the current measurement. The first four options are identical to the control buttons in the measurement control panel. Also, the Probe discovery feature can be accessed via this menu.

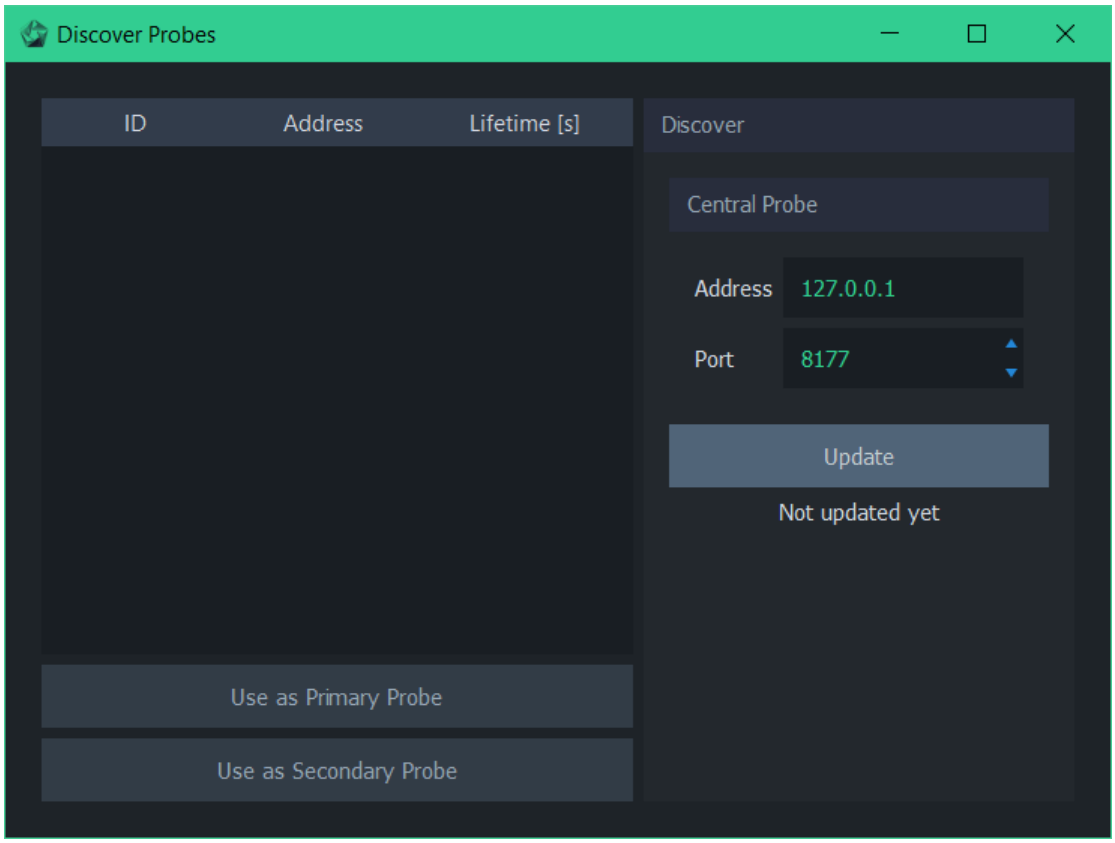


- **Connect to Qosium Probe** - Connect to Probe(s)
- **Disconnect** - Disconnect from Probe(s)
- **Start Measurement** - Start a new measurement
- **Stop Measurement** - Stop ongoing measurement
- **Discover Probes** - Discover Probes registered to a central Probe

6.3.1. Discover Probes

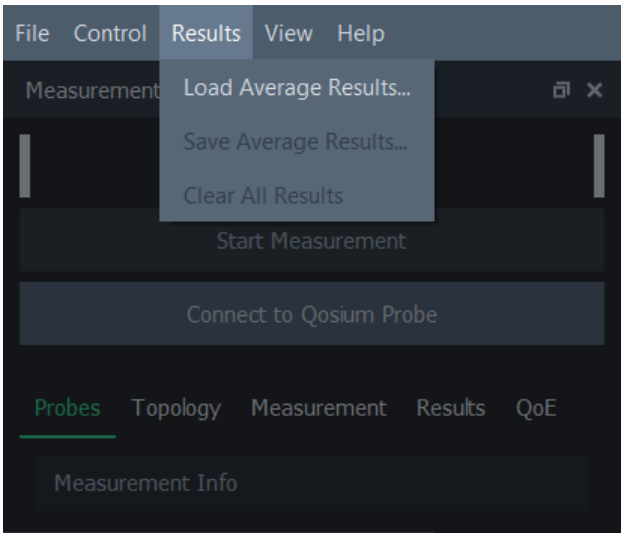
This option opens a dialog where Probes can be discovered automatically. Type the address and port of the central Probe and click *Update* to get a list of available Probes.

Using Probe discovery requires setting up a central Probe. To learn more about this functionality, see How to Discover Probes.



6.4. Results

The results menu can be used to load and save average results or to clear all measurement results.



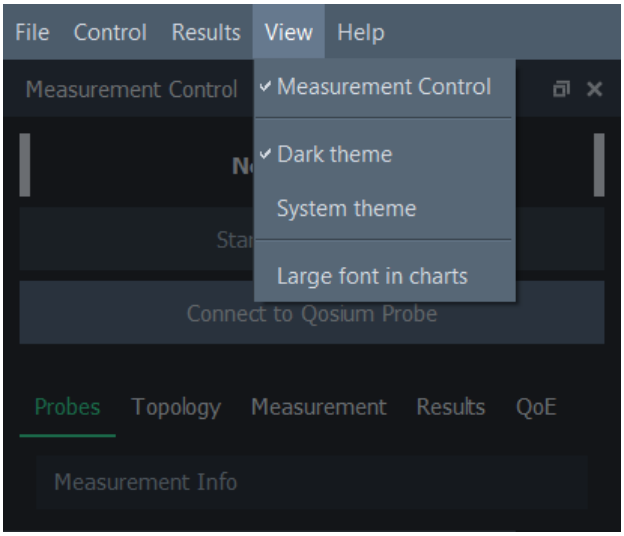
- **Load Average Results...** - Load average results from a file
- **Save Average Results...** - Save current average results to a file
- **Clear All Results...** - Remove all current measurement results from Scope.

Clearing the measurement results does not affect measurement settings or result files.

Average results can also be selected for automatic saving during measurement, as with all other measurement result types. For more information on real-time saving, see Results Tab.

6.5. View

The view menu contains options for changing the visual appearance of Scope.

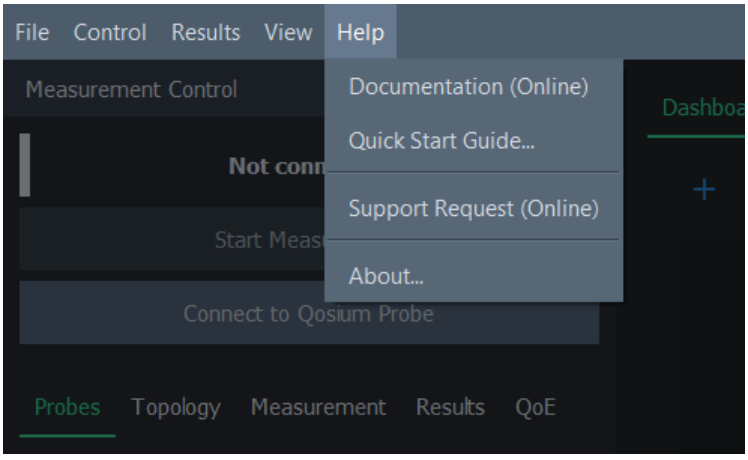


- **Measurement Control** - Toggle the visibility of the Measurement Control panel
- **Dark Theme** - Apply the default theme of Qosium Scope
- **System Theme** - Apply the legacy system theme of Qosium Scope
- **Large Font in Charts** - Use large font size in dashboard charts to allow better visibility, for example, in demo events

Hiding the *Measurement Control* panel is useful, for example, when a maximal amount of space is required for results visualization. Note that the *Measurement Control* panel can also be undocked from the main window by dragging.

6.6. Help

The help menu contains the quick start guide and software information.

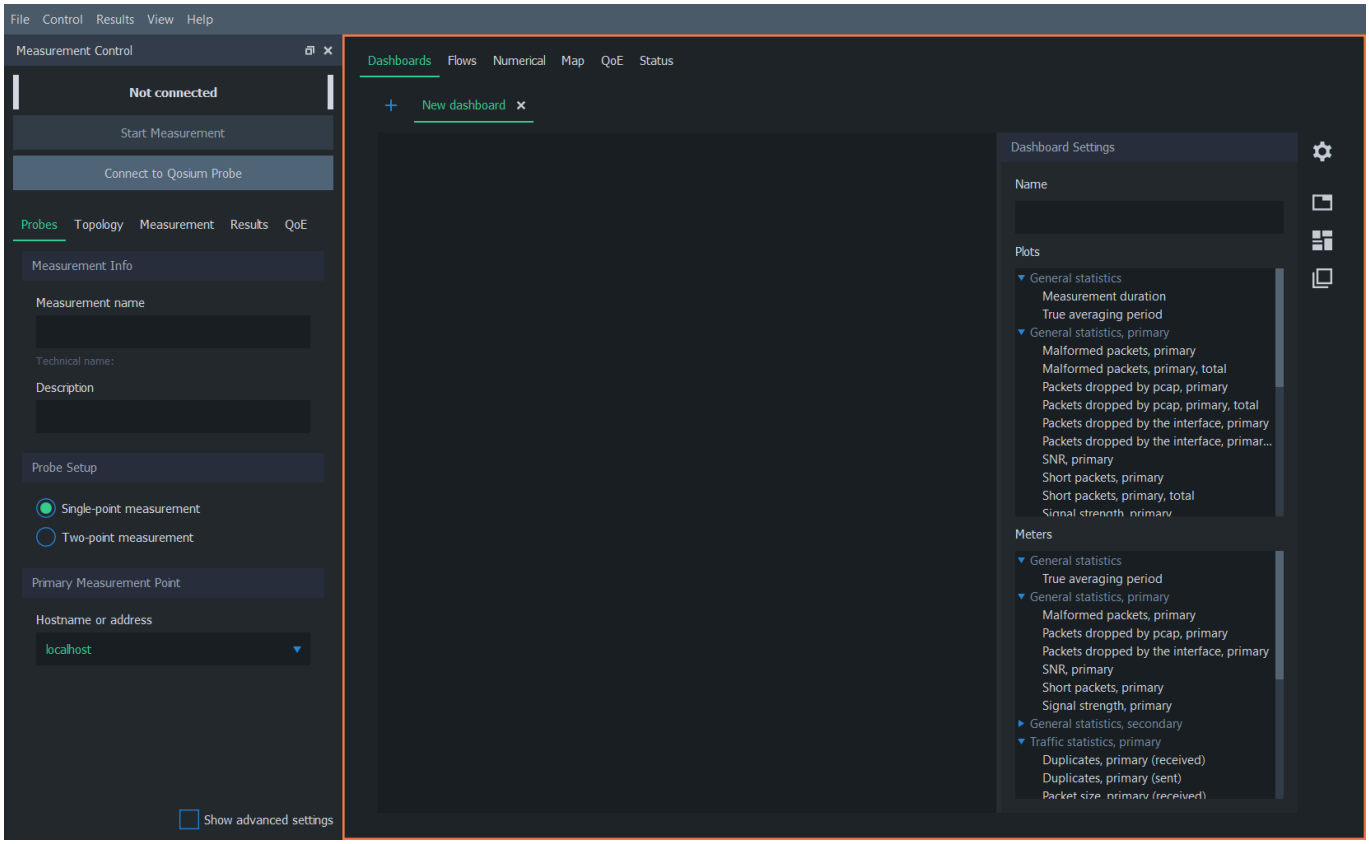


- **Documentation (Online)** - Link to this documentation
- **Quick Start Guide...** - Show the quick start guide for tutorials and exercises
- **Support Request (Online)** - Link to our support ticket form
- **About...** - Show technical information about Qosium Scope, such as software version

7. Workspace Area

The workspace area in Scope hosts the result visualization views. In this area, measurement results can be configured, viewed, and analyzed.

The workspace area is on the right side of the window:



The workspace area is divided into six main tabs, which offer various methods to view and analyze measurement results. See the subsections below for more information on each tab.

7.1. Dashboards Tab

Visualizing average results in charts is the most common way to analyze measurement results in Qosium Scope. This can be done in the dashboards tab.

7.1.1. Overview

The dashboards tab contains, as the name implies, dashboards. Dashboards visualize *average results* with plots and charts. Each dashboard has its own tab, and you can freely create, remove, and switch between tabs, even during an ongoing measurement.

Dashboards tab has four main elements. These elements are further explained in the following sections.

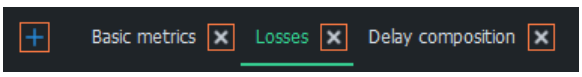
1. **Dashboard Tabs** - List of created dashboards
2. **Charts Area** - Active plots and meters in the current dashboard
3. **Settings** - Settings for the current dashboard
4. **Toolbar** - Quick actions for the current dashboard

7.1.2. Dashboard Tabs

The dashboard tabs panel is used to organize and browse dashboards. In a typical, simple measurement, a single dashboard is sufficient. However, when viewing many various statistics, organizing the charts in multiple dashboards helps keep the interface neat and tidy.

Dashboards can be freely added and removed to allow better organization of measurement results. For example, you can add plots in one dashboard and meters in another. Also, arranging different statistics in their own dashboards is a good option.

- To add a new empty dashboard, click the *blue plus-sign* on the left side of the tab panel
- To remove an existing dashboard, click the *white x* next to the dashboard name in the tab panel

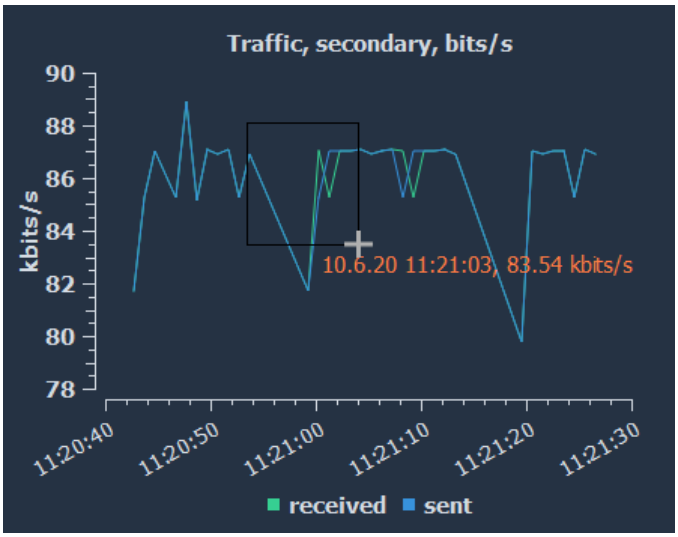


Removing dashboards does not remove any measurement results

7.1.3. Chart Area

This region of the dashboard shows the opened charts. Each chart represents a single statistic in average results. Some plots have the combined *sent* and *received* directions of the same metric.

Plots have a few mouse controls available for viewing the results. Hover cursor over plots lines to inspect values. To zoom, draw a rectangle over the area of interest with the left mouse button. Use the right mouse button to zoom back out.

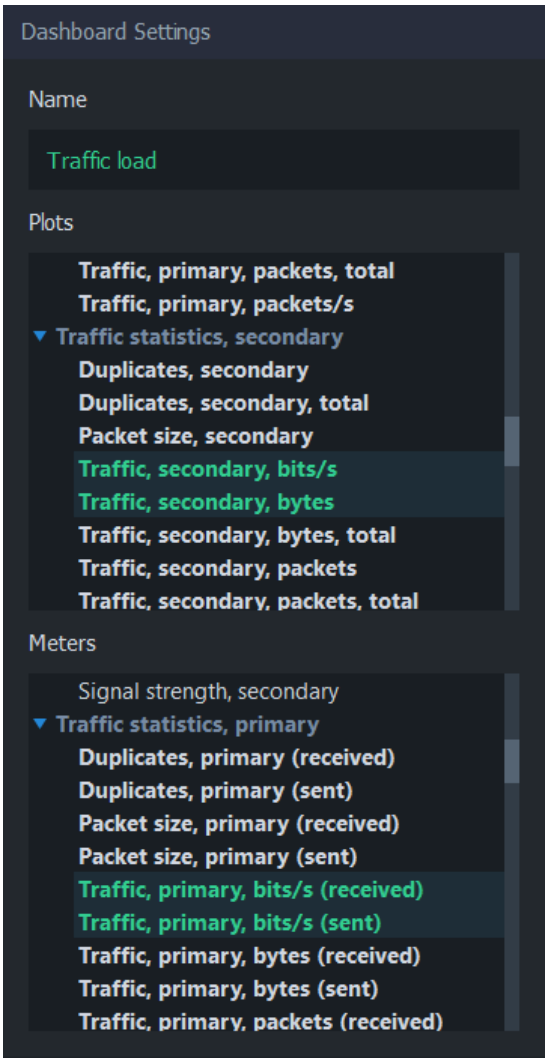


7.1.4. Settings

Each dashboard has its own settings panel, where you can select the charts from two categories: plots and meters. You can also give the dashboard a name, shown in the dashboard tabs panel, for easy recognition.

Use the *blue triangles* to expand/collapse each statistics group in *Plots* and *Meters* lists. Left-click on any statistics to display them immediately in the charts area. To select multiple statistics, press and drag with the left mouse button over the preferred statistics. Statistics, which have results, are marked with *bold* text. Clicking an active statistic removes the corresponding chart from the chart area.

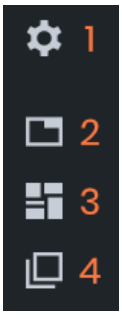
For more information on each statistic in average results, see Average Results.



7.1.5. Toolbar

The buttons on the right side of each dashboard can be used to control the settings group's visibility and the arrangement of charts.

1. **Dashboard Settings** - Show/hide Dashboard settings
2. **Arrange in Tabs** - Arrange charts in tabs, where only one chart can be visible at a time
3. **Arrange in Tiles** - Arrange charts in tiles, where charts are stacked in a grid-like format (*default*)
4. **Arrange Freely** - Move and resize charts manually



7.2. Flows Tab

The Flows tab of Scope contains the flow map, which lists currently active flows and their statistics in a table.

The flow map in Scope is a convenient way of observing the captured traffic overview or verifying that the packet filter is functioning as expected.

	Source	Destination	Protocol	State	Load [b/s] (downlink)	Load [b/s] (uplink)	Age [s]	Inactivity
1	fe80::3efa:43ff:fe45:7ce5	ff02::0016	IPV6	New	0	0	0.1	0
2	00:d8:61:7a:ba:94	18:d6:c7:18:76:0a	ARP	Old	0	0	10.3	10
3	b8:d9:4d:61:85:64	01:80:c2:00:00:0e	GENER	Persistent	0	0	8.2	8
4	b8:d9:4d:61:85:64	01:80:c2:00:00:13	GENER	Persistent	0	0	8.2	8
5	192.168.0.112 : 63229	62.109.214.74 : 443	TCP	Persistent	0	0	25.7	2
6	62.109.214.74 : 443	192.168.0.112 : 63230	TCP	Persistent	4750	57787	25.9	0
7	62.109.232.63 : 443	192.168.0.112 : 63256	TCP	Persistent	0	0	25	1
8	62.109.232.63 : 9000	192.168.0.112 : 59537	UDP	Persistent	751	751	25.9	0
9	62.109.232.63 : 9000	192.168.0.112 : 59540	UDP	Persistent	8046	72479	25.9	0
10	192.168.0.112 : 52987	62.241.198.245 : 53	UDP	Persistent	0	0	1.9	1
11	192.168.0.112 : 63183	62.241.198.245 : 53	UDP	Persistent	0	0	1.9	1
12	80.75.96.37 : 143	192.168.0.112 : 65319	TCP	New	19032	229674	0.6	0
13	192.168.0.112 : 49224	85.23.94.194 : 443	TCP	Persistent	0	0	11.9	6
14	192.168.0.112 : 49225	85.23.94.194 : 443	TCP	Persistent	0	0	11.9	6
15	192.168.0.112 : 49231	85.23.94.194 : 443	TCP	Persistent	0	0	1.9	1
16	192.168.0.112 : 49232	85.23.94.194 : 443	TCP	Persistent	0	0	1.9	1
17	192.168.0.112 : 49217	91.197.85.151 : 443	TCP	Persistent	0	0	21.7	6
18	192.168.0.1 : 1901	239.255.255.250 : 1900	UDP	Persistent	0	0	9	9
19	192.168.0.100 : 123	192.168.0.112 : 123	UDP	Old	0	0	10.7	10
20	192.168.0.112 : 49891	192.168.0.100 : 55999	UDP	Persistent	0	4257742	25.9	0
21	192.168.0.100 : 63002	192.168.0.112 : 55999	UDP	Persistent	0	4225158	25.9	0
22	192.168.0.101 : 1900	239.255.255.250 : 1900	UDP	Persistent	0	0	6.9	6
23	192.168.0.112 : 54915	192.168.0.255 : 54915	UDP	Persistent	0	2439	25.2	0
24	192.168.0.112 : 123	194.100.49.152 : 123	UDP	Persistent	0	0	3.5	3

Flow map has a set of fixed columns. For more information on the columns and flow results in general, see Flow Results.

Column Header	Description
`Source`	The source address and port (if port number is available)

Column Header	Description
`Destination`	The source address and port, (if port number is available)
`Protocol`	The protocol above the address layer
`State`	0 = new, 1 = persistent, 2 = old
`Load [b/s] (downlink)`	The current throughput in the downlink (received direction)
`Load [b/s] (uplink)`	The current throughput in the uplink (sent direction)
`Age [s]`	The age of the flow in seconds
`Inactivity`	The time passed in seconds since the last packet detected in this flow

Each flow has a **state**, which can have one of three values:

- **New** - The flow is new and reported for the first time in the flow map
- **Persistent** - The flow is receiving packets or has been inactive less than the allowed inactivity time
- **Old** - The flow did not receive any more packets during the allowed inactivity period and will be removed the next time flow results arrive

The **inactivity** counts duration from the last received packet. If the flow is active, this number remains at or near zero. When inactivity begins to increase, the flow has either stopped or not receiving any more packets. Once it reaches the flow timeout, the flow is deemed ended and will be removed from the flow map.

No flows

If flows do not appear in the flow map during measurement:

- Check that flow results are selected in the Results Tab
- Check that the capture interface is pointing to the correct interface
- If using manual packet filter, make sure that the packet filter is not too strict
  - Test by switching to automatic filtering and see if flows begin to appear in the flow map

7.3. Numerical Tab

The numerical tab in Scope has two sub-tabs: Average results and Packet results. As the names imply, these two tabs show the corresponding result types in numerical table format.

7.3.1. Average Results Tab

This tab displays the average results in a table format. The table has a set of columns that can be selected for view. For more information on the columns and average results in general, see Average Results in Qosium.

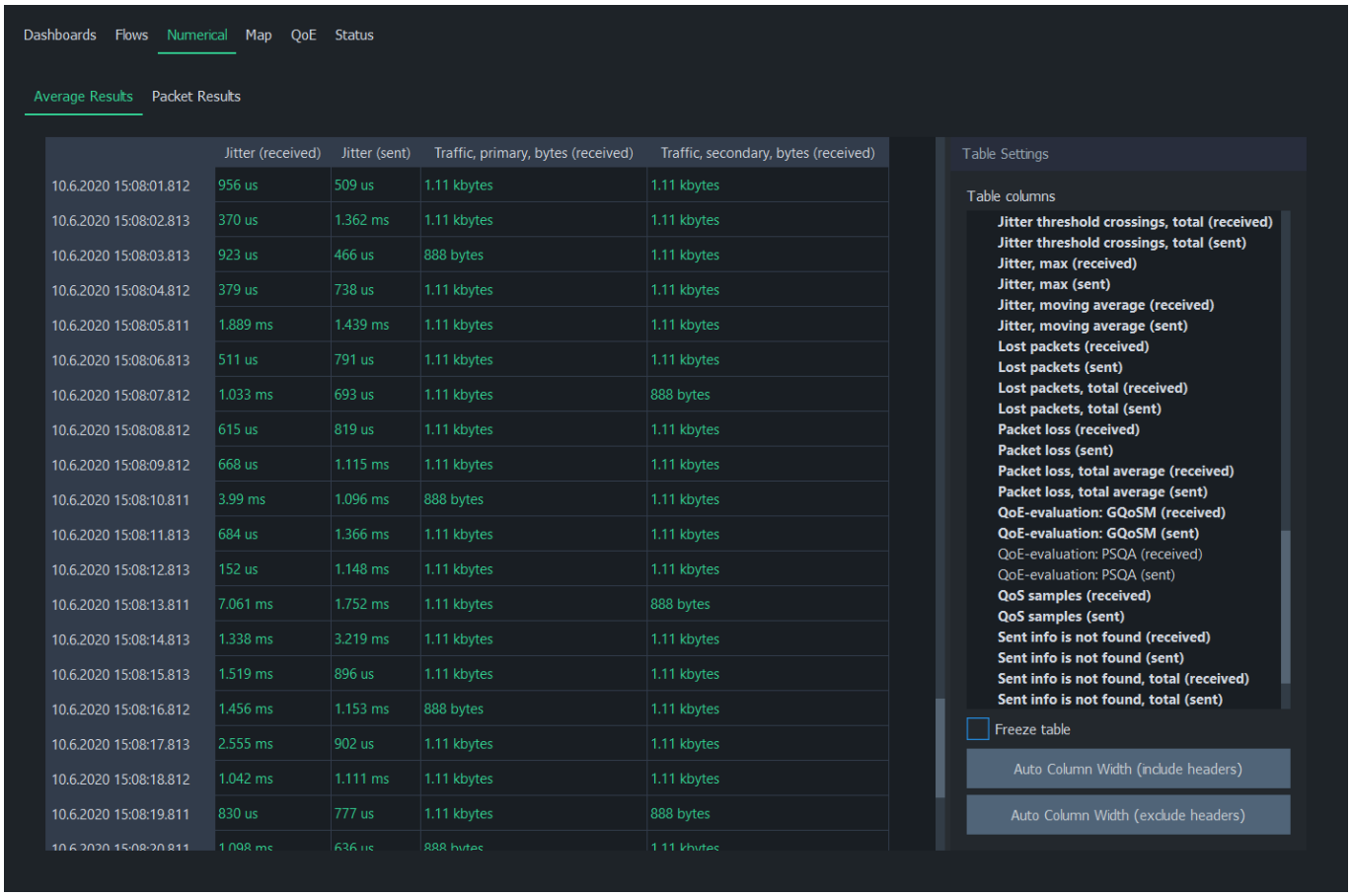


Table columns lists all available average results. Use the *blue triangles* to expand/collapse each statistics group. Left-click on any statistics to display it immediately in the table as a column. Left-clicking an active statistic again will remove the column. To select multiple statistics, press and drag with the left mouse button. Statistics, which have results, are shown with bold text.

Freeze table stops automatic update of the table. This is especially helpful if there's a need to study the results in more detail during the measurement.

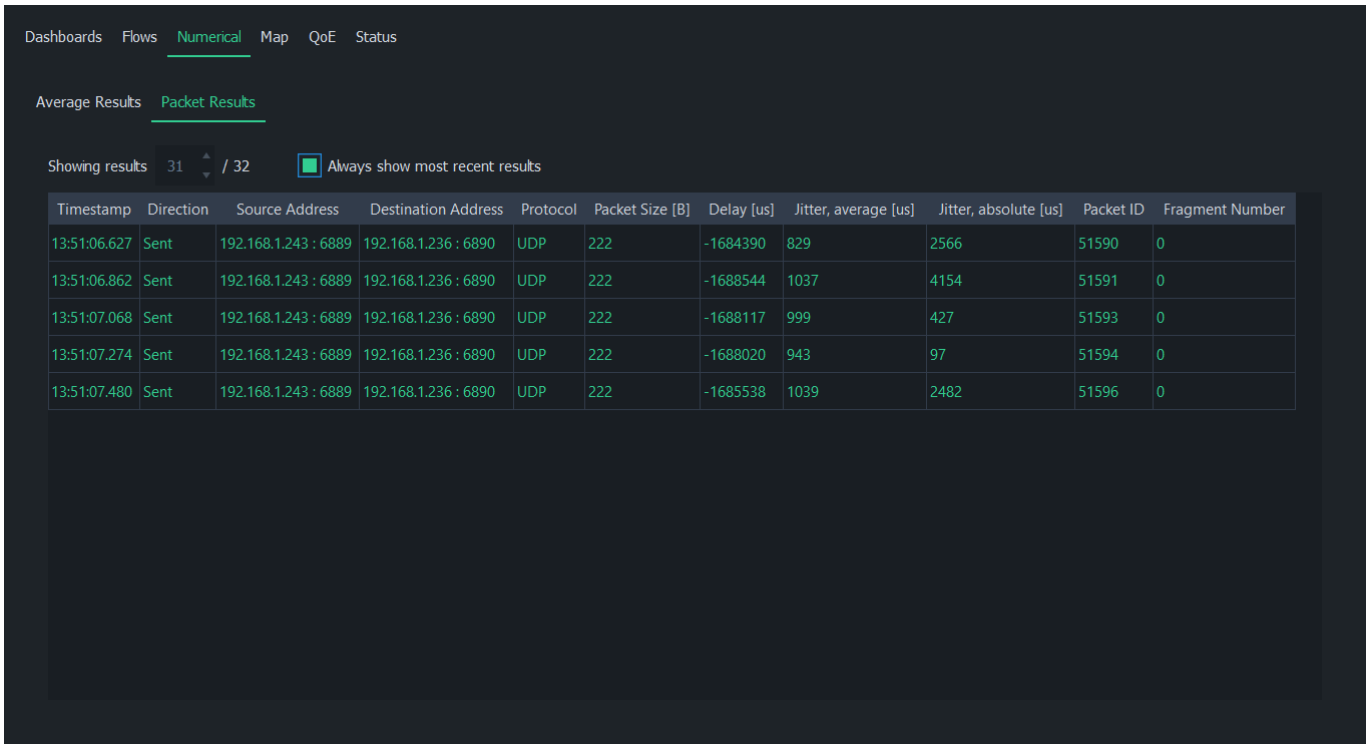
Auto Column Width (Include Headers) resizes columns according to the widest row. If you want to resize columns without taking the header row's width into account, use **Auto Column Width (Exclude Headers)**.

Tip

Double-click a result row to see the corresponding packet results in Packet Results Tab.

7.3.2. Packet Results Tab

This tab displays the packet results in a table format. The table has a set of fixed columns. For more information on the columns and packet results in general, see Packet Results in Qosium.



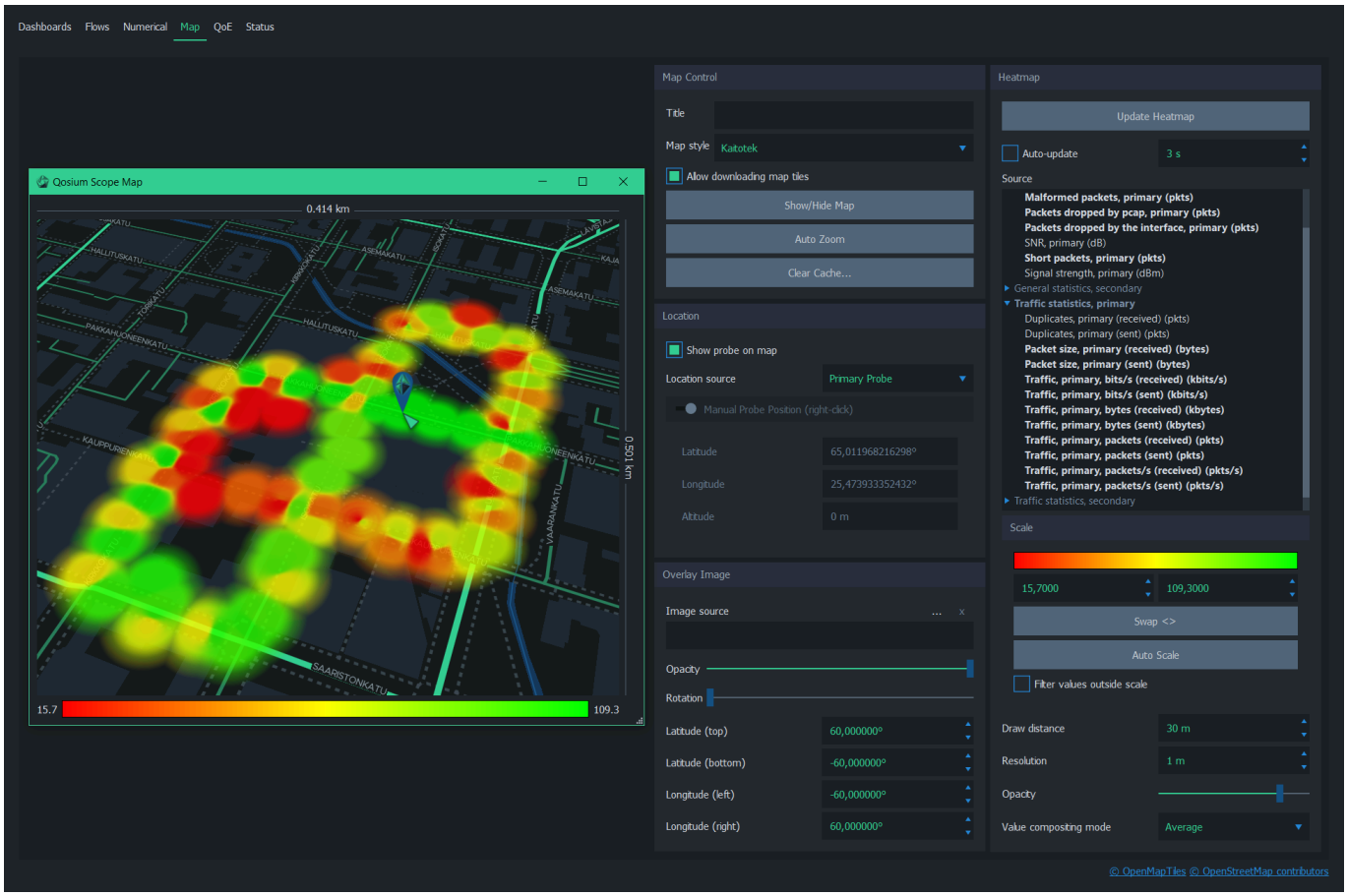
When **Always show most recent results** is checked, Scope will automatically switch to the newest complete result. Unchecking it allows you to select any result index.

7.4. Map Tab

The map tab in the Scope workspace area is used to draw heatmaps on a geographical map. This type of visualization is beneficial when measuring Quality of Service or Quality of Experience in a real location.

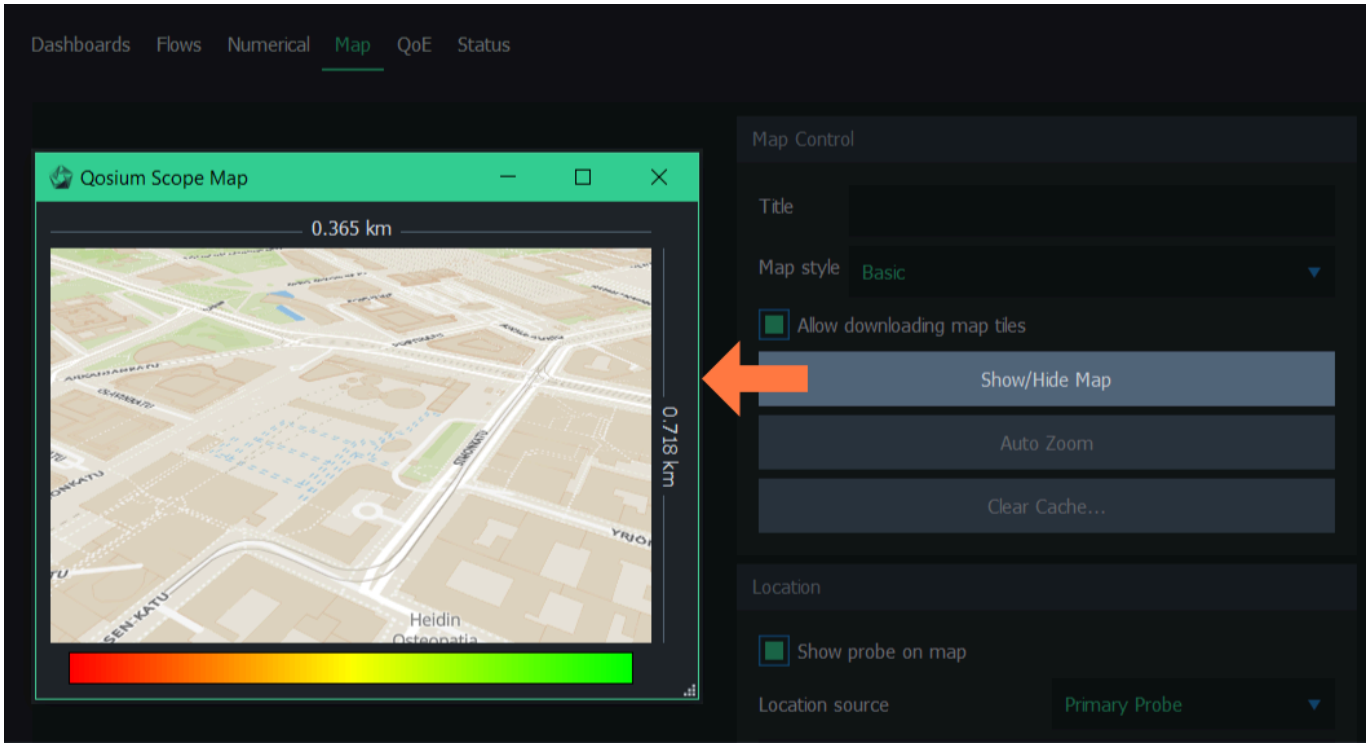
7.4.1. Overview

The map tab consists of two main elements: *Map Window* and *Settings*. See the following subsections for more information on these elements. For a practical example of using this tab, see resources/documentation/how-to-guides/qos-heatmaps-with-scope.



7.4.2. Map Window

To open the map window, press **Show/Hide Map** in the *Map Control* settings group.



The window can be moved, scaled, maximized, and minimized normally as any other window. The map can be navigated with a few mouse/keyboard controls:

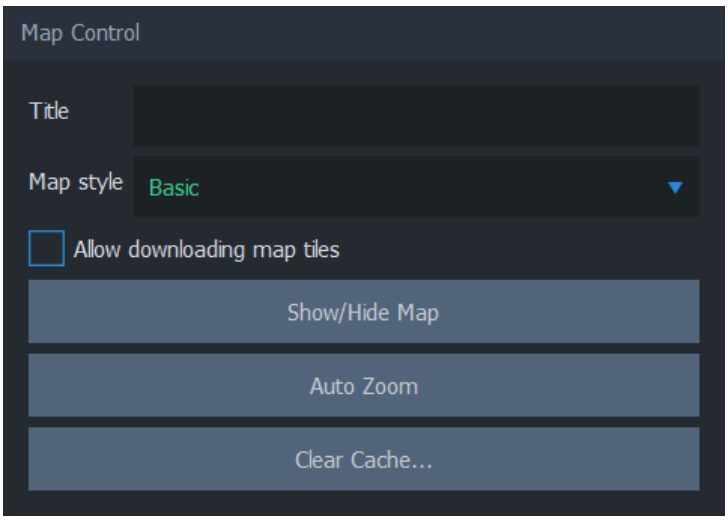
- **Zoom in/out** - Mouse wheel up/down
- **Pan map** - Press and hold the left mouse button and drag
- **Pitch/rotate map** - Press and hold either left or right *Ctrl* button on the keyboard, then simultaneously press and hold the left mouse button and drag

7.4.3. Settings

The map is configured via settings displayed on the right side of the tab. See the following subsections for more information on each settings group.

7.4.3.1. Map Control

The map control group has controls for showing/hiding the map window, selecting map theme, and controlling map data download and caching.



When **Allow downloading map tiles** is checked, Scope can download map data from the map cloud service. It is recommended to keep this option checked when preparing a measurement but unchecked during measurement if there's a risk that the traffic between Scope and map cloud service will disrupt measurement results.

Show/Hide Map toggles the visibility of the map window.

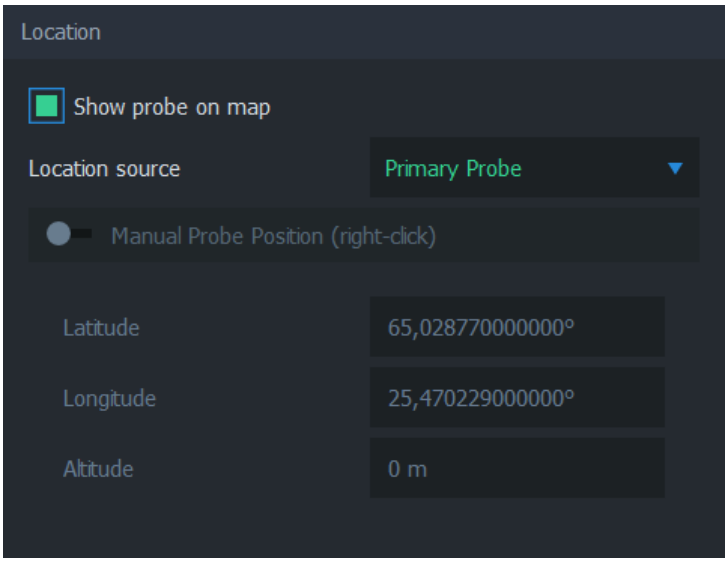
Use **Auto Zoom** to reset pitch and rotation. Auto-zoom also sets location and zoom according to the following priority:

- Focus on the heatmap, if available
- Focus on overlay image, if available
- If neither heatmap nor overlay image is visible, focus on the map cursor

Clear Cache... removes the map cache file from the computer. Use it to release disk space (typically ~10-60MB). Removing the cache file can be helpful when resolving issues related to map data download & rendering. Removing the map cache does not affect heatmap or measurement results.

7.4.3.2. Location

The location group considers the geographical location of the Probes.



Show Probe on map toggles the visibility of the selected source Probe icon on the map. The icon appears on the map as follows:

If the Probe icon is not visible on the map even when this option is checked, it may be due to the Probe having no location info yet, or the map hasn't been updated.

Manual Probe Position allows placing the location of the source Probe manually. This is useful functionality when you are performing, e.g., indoor measurements, where it is not possible to enable GNSS or other automatic positioning systems to Probe. During measurement, enable this option, then right-click anywhere on the map. The map cursor appears in this location. Manual positioning is available only when the measurement is running.

7.4.3.3. Overlay Image

The overlay image can be used to add an image on top of the map. Typically, this feature is used to add a floor plan for an interior measurement or another layout image of a known location whenever the map itself is visually inadequate.

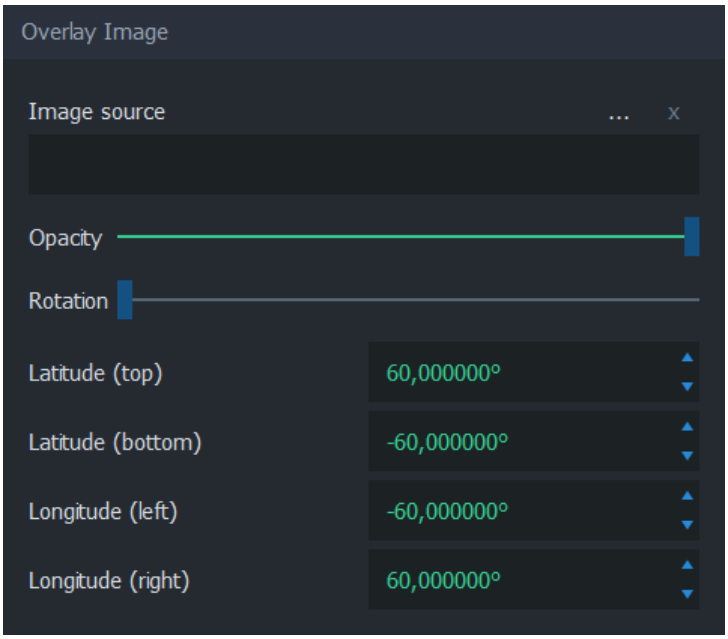


Image source indicates the filename of the current overlay image. Use **...** to select the image file or **x** to remove the current overlay image.

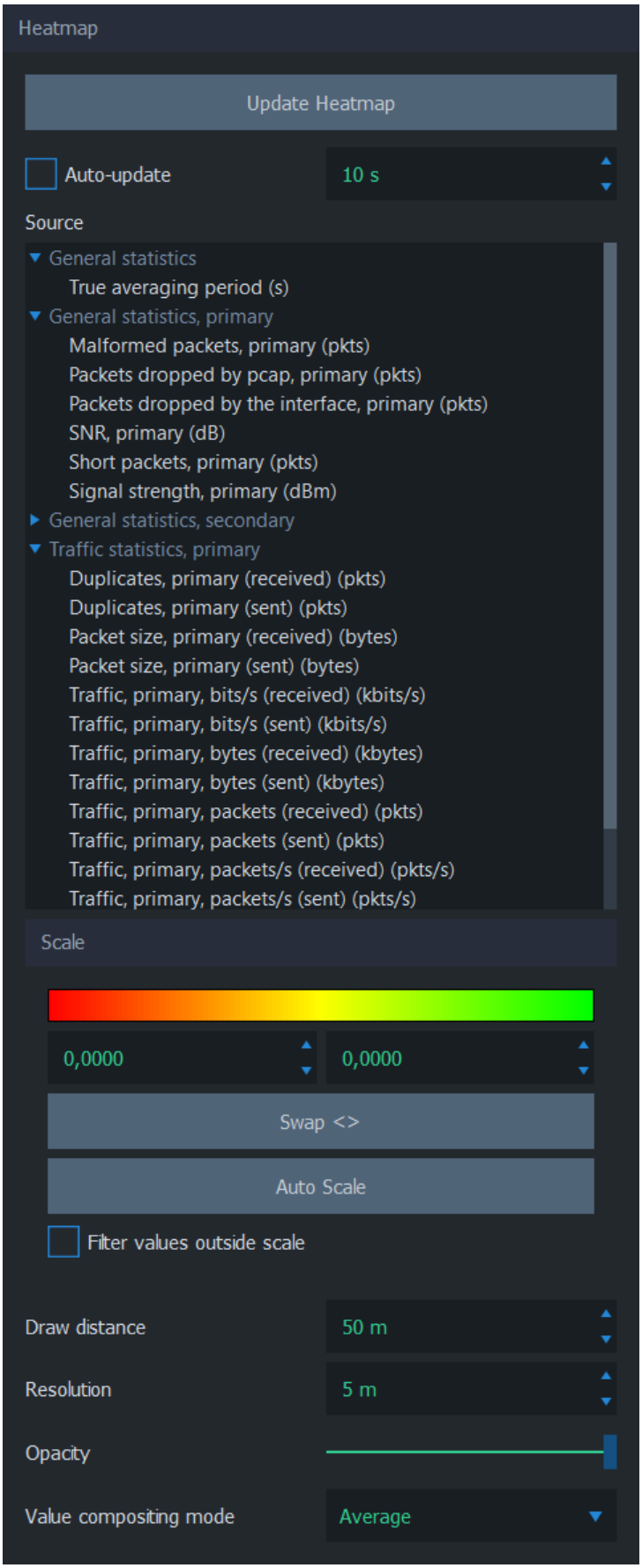
Opacity controls the transparency of the image. By default, the overlay image is fully opaque. Adjust the opacity to allow map visuals to pass through the overlay image partially.

Rotation allows adjusting the overlay image orientation if the source image is not aligning with the map projection.

Latitude (top), **Latitude (bottom)**, **Longitude (left)**, and **Longitude (right)** are used to align the overlay image on top of the map.

7.4.3.4. Heatmap

The heatmap group contains controls for drawing and displaying the QoS heatmap on the geographical map.



Update Heatmap, as the name implies, updates the heatmap immediately. The time the update takes

depends on the amount of data and the visualization settings.

Auto-update can be used to update the heatmap in every *n*th second. Use the spin box to adjust the interval.

Source determines the QoS statistic that the heatmap visualizes. Use the *blue triangles* to expand/collapse each statistics group.

The **Scale** group controls how the sample values are scaled linearly into the displayed gradient. Give the scale limits manually, or use **Auto Scale** to automatically use the current minimum and maximum samples as scale limits. Use **Swap <>** to swap the given scale limits, effectively inverting the heatmap colors. When **Filter values outside scale** are checked, values outside scale limits are not included in the heatmap.

Draw distance indicates the radius of influence of each data point. There's no right or wrong value for draw distance; instead, choose a value that serves the best visual appearance. For an outdoor measurement, values starting from 10 m are usually sensible. For small indoor spaces, values between 1 and 10 meters make more sense.

Resolution determines the draw precision of the heatmap image. Low-resolution values yield more accurate images than higher values. Keep in mind that the heatmap's actual precision depends on the amount and distribution of the measurement samples.

Opacity controls the transparency of the heatmap. By default, the heatmap is fully opaque. Adjust the opacity to allow map visuals to pass through the heatmap partially.

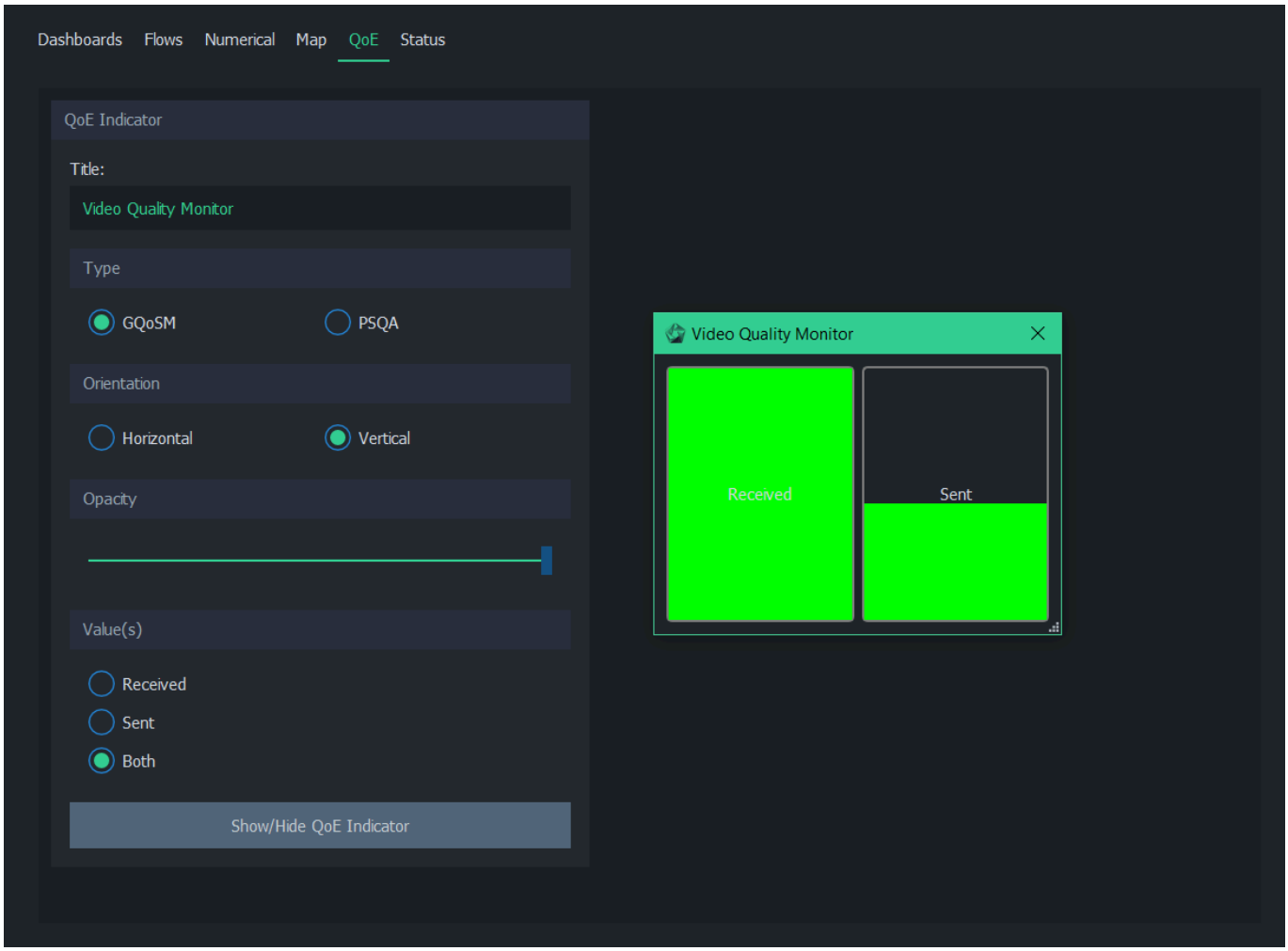
Value compositing mode determines the method of resolving the value of overlapping samples. Overlapping samples occur when two or more measurement samples are taken from the same location. The options are:

- **Average** - Calculate the average of the samples
- **Worst value** - Take the worst value and visualize it
- **Best value** - Take the best value and visualize it

7.5. QoE Tab

The QoE tab can be used to configure and show a Quality of Experience indicator window. This window visualizes QoE statistics from average results and can be placed, for example, next to an external application window for quality reference.

The *QoE* tab contains one group for configuring and displaying a QoE indicator window. This window can be placed anywhere on the screen visualizing QoE results.



The QoE indicator has the following options:

- **Title** - Type the title of the QoE Indicator Window
- **Type** - Use either *GQoSM* or *PSQA* as the source model
- **Orientation** - Display quality bars either with horizontal or vertical orientation
- **Opacity** - Change the opacity of the indicator window
- **Value(s)** - Show either the *received*, *sent*, or both directions
- **Show/Hide QoE Indicator** - Toggle visibility of the QoE indicator window

No Quality Results

If the quality bars remain colorless during measurement:

- Verify from numerical average results that quality results are received properly
- If quality results are not received (all values are `-`):
  - See No QoS Results in Troubleshooting. If QoS results are missing, then the QoE indicator won't work either
- If quality results are received (values are `-` or `1`):
  - If using GQoSM, try relaxing the model settings in QoE Tab by disabling QoS parameters used for calculating the results
- If quality results are received properly (values range from `5` to `1`):
  - Check that the correct source model is selected in **Type** (GQoSM or PSQA)

Scopemon

Scope is intended for targeted manual measurements. For continuous QoE monitoring needs, see Qosium Scopemon. Scopemon has, in fact, a QoE visualization similar to Scope's, but it has some advanced features, such as automated alerts.

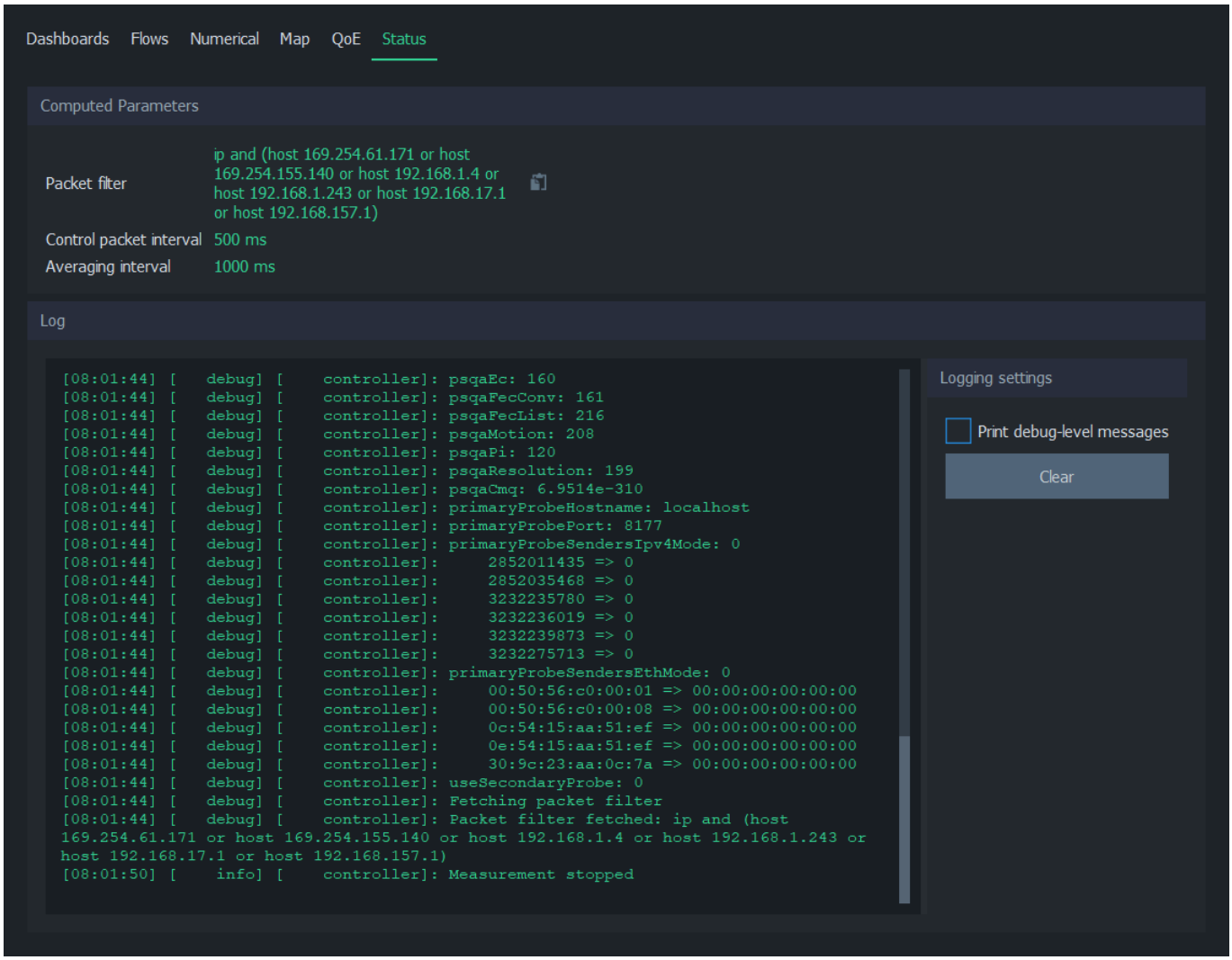
7.6. Status Tab

The status tab displays information about the current measurement and the operation of Scope.

7.6.1. Overview

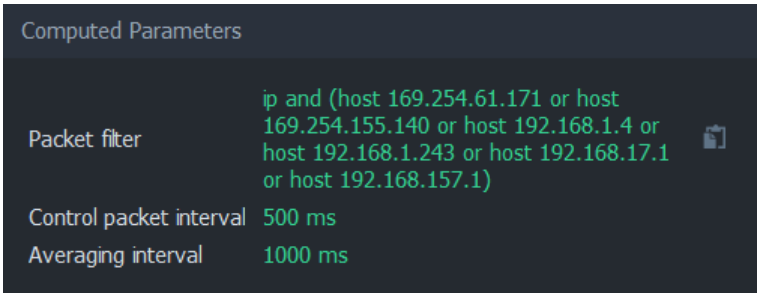
The status tab contains two groups:

- **Computed Parameters**
- **Log**



7.6.2. Computed Parameters

The computed parameters group displays the values, which are automatically calculated by Qosium when a measurement is started. Depending on the measurement settings, these may be the given manual values, but they may also differ if Qosium can determine values better suited for the measurement scenario.



Tip

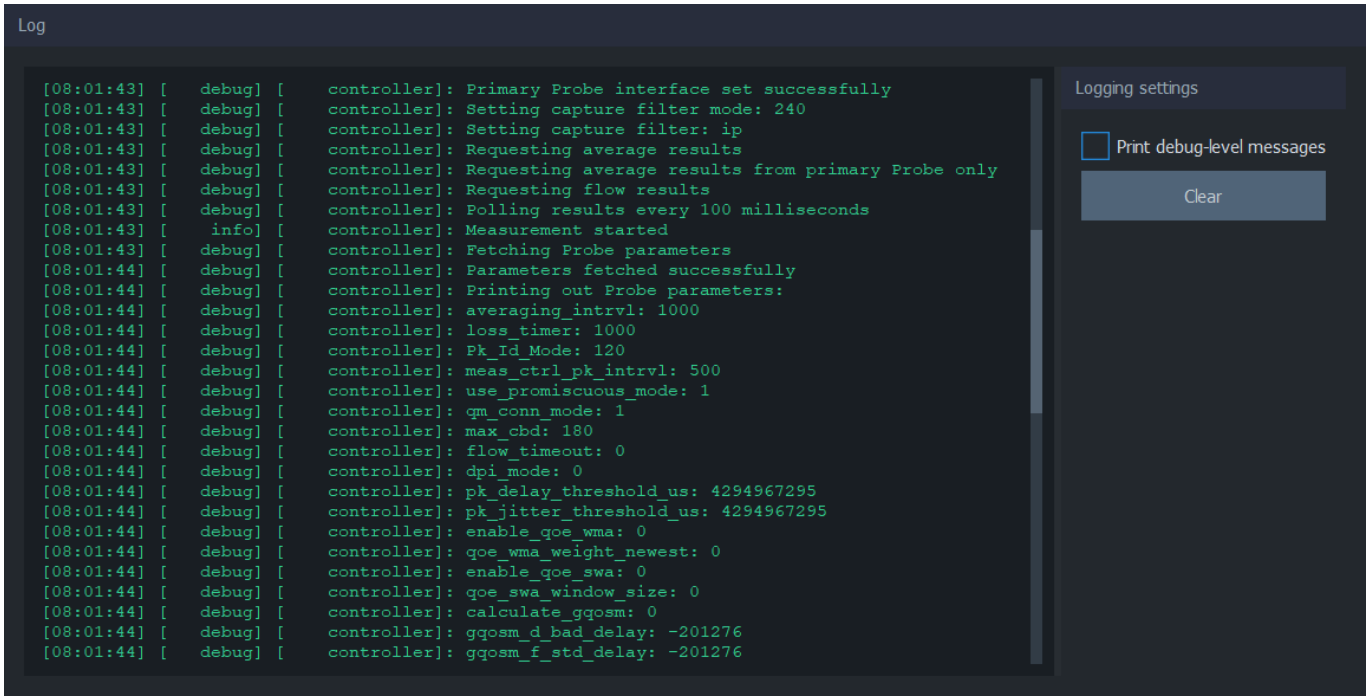
Use the button next to the computed packet filter to copy it to the clipboard. You can then paste it as a template for a manual packet filter.

7.6.3. Log

The log window contains information on the operation and events of Scope. Error and warning messages are also printed in the log for later review.

This group contains a few settings:

- **Print debug-level messages** - When checked, debug-level messages are also included in the log, which contains more fine-grained information
- **Clear** - Clear the log window



Accessing the log file

Scope also saves the log to a file. The location of the log file depends on the operating system.

In Windows, the filename is `C:\Users\[username]\AppData\Local\Kaitotek\QosiumScope\debug.log`.

In Linux, the filename is `~/.config/QosiumScope/debug.log` or `/etc/xdg/QosiumScope/debug.log`.

8. Glossary

Promiscuous Mode

A mode in network interfaces, which allows packet sniffers to process packets even if they are not designated to said network interface.

This mode is essential in Qosium, since it's fairly common to measure network traffic by placing Probes somewhere in-path or off-path via port mirroring instead of end-points.

Some network interfaces do not support promiscuous mode, so try turning it off if starting measurement results in an error, or no packets are captured.

For more information, see the Wikipedia article on Promiscuous mode.

Packet Loss Timer

Qosium determines packet losses by waiting each packet a predefined amount of time. Packet loss timer defines this duration.

If this value is set too small, packets exceeding this duration in the traversal of the measurement path will be incorrectly considered lost. A large value yields more precise results, but causes a lag to the reporting of lost packets, since Qosium needs to wait for this duration for packets before reporting them as lost.

Loss timer should be always at least 2 × control packet interval. The latter parameter is typically set automatically according to the averaging interval, but it can be also changed manually. In order to have short packet loss timer value, set the control packet interval as well.

Robust QMCP Mode

A feature which allows Qosium products to re-connect each other and carry on the measurement, even if connectivity is momentarily lost.

If robust QMCP mode is not enabled, the measurement is stopped if the connection between Qosium products is lost. It is recommended to keep this feature always on unless there's a good reason to disable it.

Uplink / Sent Direction

Refers to a network path direction where traffic is flowing away from the observer towards a remote point.

Downlink / Received Direction

Refers to a network path direction where traffic is flowing from a remote point towards the observer.

Quality of Experience

Indicates the overall performance of a network application, and how user's experience is affected by the network conditions.

For more information, see our article on Quality of Experience.

Generic QoS Measure Algorithm

A parameter based QoS mapping algorithm allowing to map a single quality indicator from several parameters. When tuned with real user tests, GQoSM allows also QoE estimations.

GQoSM, however, is meant for evaluating the influence of the network to the quality – not for estimating the absolute quality (e.g., including the defects of codecs, etc.). For more information, see our article on Quality of Experience.

Pseudo-Subjective Quality Assessment

A neural network based model for estimating QoE.

For more information, see our article on Quality of Experience.