Measurement Results in Qosium

Qosium has four types of results: Average, flow, packet, and pcap results.

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1. Overview

Qosium produces various statistics that can be evaluated in real-time, e.g., with Qosium Scope. The results can also be printed into files for later analysis. During measurement, the results can be injected directly to separate results servers, such as Kaitotek's Qosium Storage or any software that implements the *QMCP* Listener interface. Further, if you have implemented the QMCP Controlling interface, you can control Qosium measurements and gather all the results directly in your software.

It is important to understand how statistics and their direction are dependent on the measurement points. The figure below opens this a bit. As seen, *QoS* and (*QoE* statistics are always two-point statistics. Think, for example, delay/latency: network-wise, it does not exist in a single point. Instead, delay tells how long it takes for a data packet to travel from one point to another. In contrast, traffic statistics (and some general statistics and physical layer statistics as well) are calculated in single points only. Bear in mind also that sent traffic for the primary measurement point is received traffic from the perspective of the secondary measurement point.
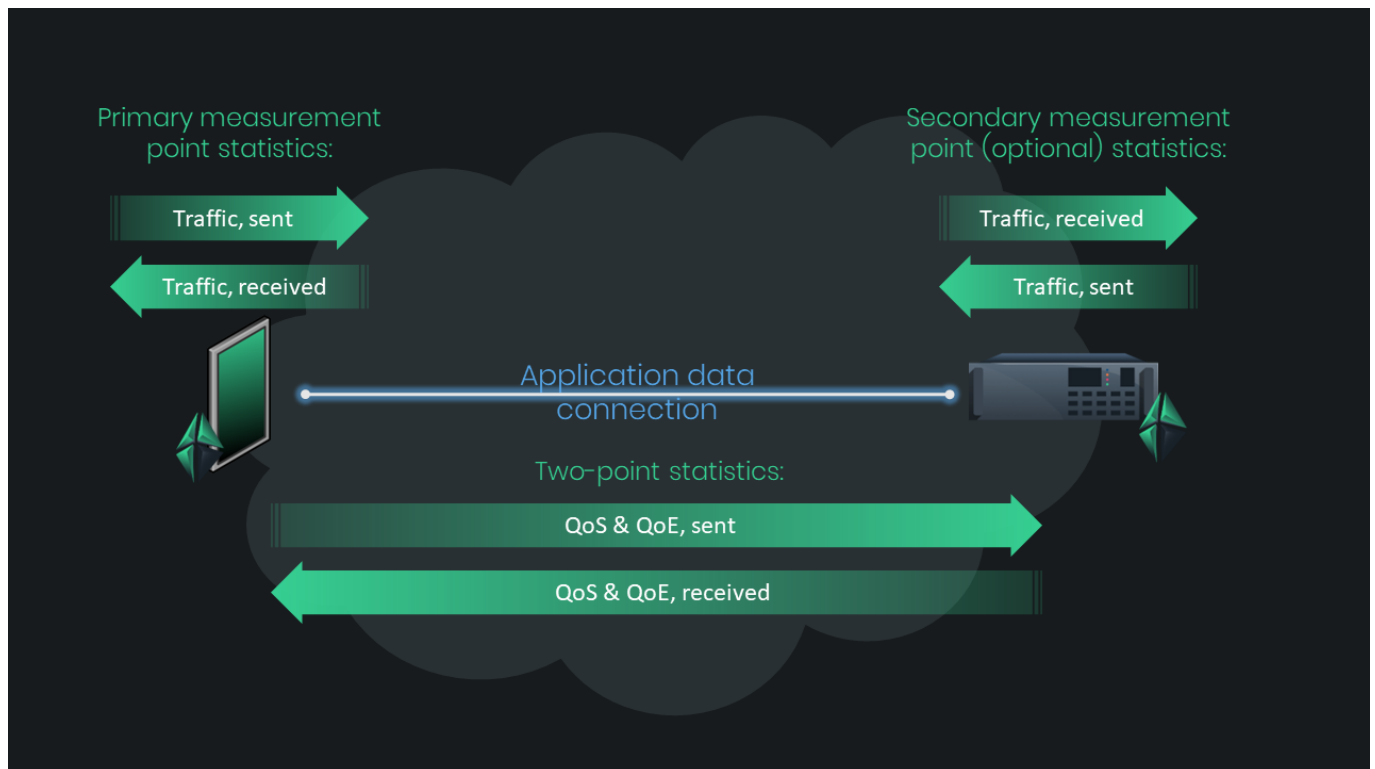
2. Result Files

The results file formats are the same between different Qosium components. Thus, e.g., an average results file generated by Qosium Storage can be read and analyzed using Qosium Scope. The only thing to notice is that the results files evolve with Qosium versions. This does not happen often, but sometimes. Thus, sometimes an older Qosium Scope cannot read results files generated using a newer Qosium component. In this case, please ask Kaitotek to update your Qosium.

The results files are in *CSV* format, allowing easy import to external statistical tools (e.g., Excel, MATLAB, and R). Absence of a result in a file is notated as *N/A*.

3. Result Types

Qosium can produce four types of results:

- **Average results** - Average results are averaged over **Averaging Interval**, which is a parameter you can define. The average results constitute the most important statistic set with over 50 specific statistics to be evaluated.
- **Packet results** - In a two-point measurement, Packet results give accurate QoS statistics for every single measured data packet. They are useful, e.g., in solving flickering QoS problems. In a single-point measurement, these results provide packet basic information.
- **Flow results** - Flow results give a straightforward view of who is communicating with who, how, and how much traffic there is flowing. Flows consuming high bandwidth are easily detected.
- **Pcap results** - These results provide you with full packet captures of desired traffic in the popular Pcap format, allowing you further to analyze the details with protocol analyzers such as Wireshark. This is an optional feature.

Most of the Qosium's statistics are unidirectional, so they are available for received (downlink) and sent (uplink) directions.

> (i) The units of the statistics might be different in different tools (e.g., Scope vs. Scope Lite) and views (e.g., numeric view vs. graphs). There can also be some differences in the statistics' names depending on where it is used (e.g., real-time visualization vs. results file).

4. Average Results

4.1. General Statistics

This category includes general measurement-level statistics that are informative rather than directly related to the networking performance.

Name	Description	Unit
Control Packet Number	The number of the control packet (an increasing counter)	Count
Measurement Duration	The duration of the measurement.	Seconds
True Averaging Period	The true (accurate) averaging period length. Why is there such a value when one has particularly specified, e.g., 1 s averaging interval? In a non-real-time operating system, it is challenging to achieve highly accurate timings if not operating the program in a way that consumes a lot of processor resources. And, while this is not the way Qosium is built, then the true averaging interval will mostly have a slightly different value from the set one.	Seconds
Timestamp	The timestamp at the time when the current results were calculated. This value is taken at the Primary Probe.	Unix epoch

4.2. Single-Point General Statistics

This category includes single-point general statistics that are Probe-specific.

Name	Description	Unit
Malformed packets	The number of packets whose internal structure is not correct.	Packets
Malformed packets, total	The number of packets whose internal structure is not correct (total, measurement)	Packets
Drops, NIC	The number of interface's dropped packets during the measurement. Many Pcap versions (e.g., WinPcap) do not support this yet. This is calculated on the Primary Probe side only.	Packets
Drops, NIC, total	The same as above, but the total value over the measurement.	Packets
Drops, Pcap	The number of Pcap's dropped packets. NOTE: If this starts to increase, it typically means that the Pcap driver is not able to capture the packets as fast as there is traffic, meaning typically that the computer is running out of resources. This is calculated on the Primary Probe side only.	Packets
Drops, Pcap, total	The same as above, but the total value over the measurement.	Packets
Location: Accuracy	Accuracy of the current location.	Meters
Location: Altitude	Altitude of the current location.	Meters
Location: Duration from last update	The age of the last location update. This parameter is handy in checking that the positioning is working correctly.	Seconds
Location: Heading	Heading at the current location if the node is moving.	Degrees
Location: Latitude	Latitude coordinate of the current location.	Degrees [-90°, 90°]
Location: Longitude	Longitude coordinate of the current location.	Degrees [-180°, 180°]
Location: Mode	Operation mode of the positioning (Qosium specific):	
Location: Speed	Speed of at the current location if the node is moving:	Meters / s
Short packets	The number of packets that are too short for analysis.	Packets
Short packets, total	The number of packets that are too short for analysis (total, measurement).	Packets

4.3. Physical Layer Statistics

This category includes single-point Probe-specific statistics related to the physical layer properties, typically radio interface, including signal performance, cell information, etc. The availability of these statistics is dependent on the platform where Qosium Probe is running.

Name	Description	Unit
Base Station MAC address	The current Base Station MAC address (e.g., in WLAN).	String
Cell ID	The cell ID of the current mobile network. Note: in the case of *5G-NSA*, the Cell ID is the Physical Cell ID instead of the Cell ID identifying the LTE cell.	Number
Handover events	This statistic can be directly used to show whether or not a handover occurred during the last averaging interval. Currently, if the serving base station has changed during the averaging interval, value 1 is given as an output and 0 otherwise. Multiple handovers during an averaging interval cannot be currently counted. Thus, also, if the device visits another base station but comes back to the earlier one during the averaging interval, this event cannot be yet detected, and zero handovers are given as an output.	Count
Network type	The type of the network (e.g., LTE, WLAN, 5G).	Coded value / clear text
SINR	The signal to noise and interference ratio at the interface.	dB
Signal (RSRP)	The signal strength (Reference Signal Received Power) at the network interface.	dBm
Signal (RSRQ)	The signal quality (Reference Signal Received Quality) at the network interface.	dB
Signal (RSSI)	The signal strength (Received Signal Strength Indication) at the network interface.	dBm

4.4. Traffic Statistics

Traffic information that the single-point measurement can provide includes load, packet sizes, etc. These statistics are available from both primary and secondary Probe.

Name	Description	Unit
Duplicates	The observed duplicate packets (based on the packet identification method).	Packets
Duplicates, total	The observed duplicate packets as above, but summed over the measurement.	Packets

Name	Description	Unit
Packet size	Average packet size during the last averaging interval. Note: The packet size means the total size at the link layer, so there is the link-layer header (Ethernet, etc.) also included.	Bytes
Protocol	Dominating protocol number in the measured stream.	Protocol number
Traffic, bits/s	The traffic load in bits/s (offered load and throughput).	Bits / s
Traffic, bytes	The amount of transmitted/received data.	Bytes
Traffic, bytes, total	The amount of transmitted/received data summed over the measurement.	Bytes
Traffic, packets	The amount of transmitted/received packets.	Packets
Traffic, packets, total	The amount of transmitted/received packets summed over the measurement.	Packets
Traffic, packets/s	The traffic load calculated in pkts/s (offered load and throughput).	Packets / s

> ⓘ Be aware of duplicate packets
>
> Some duplicate packets are normal since not all traffic is unique, and also, because of retransmissions (e.g., by TCP), there are real payload-level duplicates. However, if there are a lot of duplicate packets when compared to the number of total packets, it might be an indication that the selected Packet Identification Method does not work correctly in the context of the measured stream. QoS will, generally, not be calculated for duplicated packets. Thus, the overall QoS calculation accuracy may weaken in the presence of duplicated packets.

4.5. QoS Statistics

QoS statistics are mostly two-point statistics that are calculated for a flow over a network path. They describe the flow's behavior over the network path and include important statistics like delay, packet loss, etc. Some of the QoS statistics can also be calculated in a single-point measurement for a restricted set of protocols (e.g., RTP and MPEG-2 TS).

All the QoS statistics Qosium produces are one-way statistics between the measurement points. These statistics are available in a two-point measurement only.

> ⓘ Definition of a connection break
>
> Note: a *connection break* as a Qosium statistic means that there were one or more sequential lost packets detected. For example, the following sequence during an averaging interval contains two connection breaks: a lost packet, a correctly delivered packet, a lost packet, and a correctly delivered packet. Thus, a measured connection break does not necessarily mean a protocol-level connection break.

Name	Description	Unit
Connection break count	The number of connection breaks during the last averaging interval.	Count
Connection break duration	Connection break duration (time-domain)	Seconds
Connection break length	Connection break length (packet domain), often as mean loss burst size.	Packets
Connection break length, total	As previous, but averaged over the whole measurement.	Packets
Connection break maximum duration	The maximum connection break duration in the last averaging interval.	Seconds
Delay	Delay (latency) – one-way – as all the QoS statistics, calculated from network interface to another.	Seconds
Delay threshold crossings	The number of packets whose delay exceeded the set threshold.	Packets
Delay threshold crossings, total	The number of packets whose delay exceeded the set threshold (total, measurement).	Packets
Delay, max	The maximum observed sample delay during the last averaging interval	Seconds
Delay, min	The minimum observed sample delay during the last averaging interval	Seconds
Delay, estimated	This is an estimation, a drift-corrected value, of the delay. It is based on the raw measured delay, but the possible drift of the clocks between the measurement points is strived to be compensated by Kaitotek's intelligent estimation algorithm.	Seconds
Delay samples	The number of Delay samples, i.e., how many values have been used to calculate the QoS statistics	Samples
Jitter	The pure delay variation	Seconds
Jitter threshold crossings	The number of packets whose jitter exceeded the set threshold	Packets
Jitter threshold crossings, total	The number of packets whose jitter exceeded the set threshold (total, measurement)	Packets
Jitter, max	The maximum observed sample jitter during the last averaging interval	Seconds
Jitter, MA	Moving average jitter (similar as in RTP)	Seconds
Lost Packets	The number of lost packets included in the QoS calculation	Packets
Lost Packets, total	The number of lost packets included in the QoS calculation (total, measurement)	Packets

Name	Description	Unit
Packet loss ratio	The ratio of those packets that were lost in the measured network path against all packets	Percentage
Packet loss ratio, total	Packet loss ratio (total, measurement)	Percentage
QoS samples	The number of packets that were used to calculate the QoS statistics.	Packets
Sent info not found	This special statistic is, in a way, *negative packet loss*, meaning that a packet was received but was not indicated sent on the other end. As understood, this is not a normal situation, so having non-zero values here is an indicator of events that should be investigated. See this to understand the possibilities of what is happening.	Packets
Sent info not found, total	The summed value of the previous over the measurement.	Packets
Successful packets	The number of successfully transmitted packets included in the QoS calculation	Packets
Successful packets, total	The number of successfully transmitted packets included in the QoS calculation (total, measurement)	Packets

4.6. QoE Statistics

This category includes higher-level statistics refined typically from the QoS statistics. The Quality of Experience (QoE) is closer to the user's observations than the pure QoS. These statistics are available only for certain applications.

> While QoE refers to real user tests, the QoE statistics provided here are QoE approximations based on the measured QoS metrics and correlation with measurement data gathered with real user tests.

Name	Description	Unit
GQoSM	QoE evaluation by using GQoSM algorithm	MOS (1–5)
PSQA	QoE evaluation by using PSQA algorithm	MOS (1–5)

5. Packet Results

5.1. Packet Statistics

These are single-point statistics, giving general information on captured packets. Why not always evaluate full Pcap traces instead, since Qosium also provides them? First, taking Pcap traces from a remote point generates a control load roughly equal to the amount of measured traffic. Getting Qosium's Packet statistics generates only a fraction of that. The same goes for the required storage space as well. Second, Qosium can be used in sensitive environments, where full packet capturing is not even allowed. In many cases, the general packet information is enough, and full captures are taken only when really needed.

Name	Description	Unit
Timestamp	The packet capture time	Microseconds
Direction	Indicates whether the packet received or sent from the perspective of the measurement point.	
Source Address	The source address (Ethernet, IPv4, and IPv6 addresses currently supported) of the packet	String
Destination Address	The destination address (Ethernet, IPv4, and IPv6 addresses currently supported) of the packet	String
Source Port	The source port at the transport layer, when available	
Destination Port	The destination port at the transport layer, when available	
ID	The Identification number of the packet given by the chosen method	
Protocol	This indicates the protocol number above the network layer. If the network layer is absent, this indicates the protocol number above the link layer. Standard protocol numbering is used added with some of Qosium's own definitions.	Protocol number
Fragment offset	The fragment offset of the packet, when fragmented at the IPv4 network layer	8-byte blocks
Size	The total size of the packet	Bytes

5.2. Packet QoS Statistics

Name	Description	Unit
Timestamp	The packet capture time at the sending end	Microseconds
Direction	Indicates whether the packet received or sent from the perspective of the primary measurement point.	
Source Address	The source address (Ethernet, IPv4, and IPv6 addresses currently supported) of the packet	String
Destination Address	The destination address (Ethernet, IPv4, and IPv6 addresses currently supported) of the packet	String
Source Port	The source port at the transport layer, when available	
Destination Port	The destination port at the transport layer, when available	
ID	The Identification number of the packet given by the chosen method	

Name	Description	Unit
Protocol	This indicates the protocol number above the network layer. If the network layer is absent, this indicates the protocol number above the link layer. Standard protocol numbering is used added with some of Qosium's own definitions.	Protocol number
Fragment offset	The fragment offset of the packet, when fragmented at the IPv4 network layer	8-byte blocks
Size	The total size of the packet	Bytes
Delay	The duration of time it took the packet to traverse from one measurement point to another.	Microseconds
Jitter	The absolute delay variation between consecutive packets	Microseconds
Jitter (MA)	Packet's delay variation calculated as moving average (similarly as in RTP)	Microseconds
Delivery information	Indicates whether the packet was delivered correctly, lost, etc. This information might not be directly available in all visualization tools, but it is present, e.g., in the packet QoS results file (see below).	

In the Qosium results file, the **Delivery information** is coded as follows:

- `0` - The packet was delivered correctly.
- `1` - The packet was lost.
  - The packet is calculated in the Packet loss ratio statistic.
  - Reception timestamp is missing (because the packet was never received).
  - QoS values are missing.
- `2` - The packet's sent information is not found.
  - The packet is calculated in the Sent info not found statistic.
  - The sent timestamp is missing (because the packet was never marked as sent).
  - QoS values are missing.
  - Read [this](#) for more information.

6. Flow Results

The flow results present captured traffic as *conversations* between source and destination hosts. What constitutes a conversation is determined by 3 - 5 identifiers:

- Source address (and port, when available)
- Destination address (and port, when available)
- Protocol

When a packet is captured, these identifiers are compared to each existing flow's identifiers. If none of the flows in the current flow results have the exact same identifiers, then a new flow is created instead. If no packets are detected in the given flow for the duration of the Flow timeout parameter, then Qosium determines that the flow has ended and it is removed.

Name	Description	Unit
Source address	The source address (Ethernet, IPv4, and IPv6 addresses currently supported)	string;
Source port	The source port (transport layer). 0 is used if the transport layer does not have ports	string;
Destination address	The destination address (Ethernet, IPv4, and IPv6 addresses currently supported)	Number;
Destination port	The destination port (transport layer). 0 is used if the transport layer does not have ports	Number;
Protocol	This indicates the protocol number above the network layer. If the network layer is absent, this indicates the protocol number above the link layer. Standard protocol numbering is used added with some of Qosium's own definitions.	Protocol number
Flow start time	The time when the flow was first registered.	Microseconds
Flow end time	The time when the flow was terminated. In results files, `N/A` is used if the flow had not ended at the end of the measurement.	Microseconds
Flow age	The age of the flow.	Seconds
Sent traffic	The amount of sent traffic, reported in different ways in different places. For example, Qosium Scope reports this in real time as bits/s, but in results files, this is the total amount of data (bytes).	Bytes
Received traffic	The same as previous but for received direction	Bytes
Inactivity	Indicates the duration, how long the flow has been idle (no packets detected).	Seconds

7. Pcap Results

Qosium can capture and save full packet captures as Pcap files. While Qosium itself doesn't have a way to view these files' contents, they can be opened with any packet analyzer tool that supports a well-known Pcap file format. For more information, see [How to Take Packet Capture?](#).

> ⓘ Qosium Without Packet Capture
>
> Being able to capture the full data of packets can be a security hazard in certain environments. By request, we can deliver a version of Qosium where the packet capture feature is completely excluded from the build. This makes Qosium a safe choice even with strict security requirements.

8. Glossary

QoS Measurement Control Protocol

Kaitotek's proprietary protocol for controlling measurements and gathering measurement results.

QMCP is a protocol made by Kaitotek to optimize QoS measurement control communications. TCP is used in the transport layer (currently), but QMCP controls its sessions. All Qosium products use QMCP.

Quality of Service

Indicates the overall performance of the network and its ability to serve applications.

For more information, see our article on [Quality of Service](#).

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](#).

Comma-Separated Values

Originally CSV was only about values that were separated by commas, but nowadays the separation mark can also be something else like a semicolon.

Qosium, for example, uses tabs as separation marks in its CSV-formatted results files.

5G Non-Standalone

A mobile network technology providing a pathway for 5G New Radio workloads to connect to a 4G/LTE core.