

HST-3000 Class of Service (CoS) Test Suite

By John Williams

The development of new Internet Protocol (IP)-packet based, so called Triple-Play, services (voice, video, data) delivered over the telco Access network places new demands on network designs. Each of the services has their own specific quality of service (QoS) requirements, and all have varying bandwidth demands that are dynamic in nature, and, as a result, require prioritized treatment of the three services. In the access network, where bandwidth (BW) is often limited (digital subscriber loop [DSL] links, for example), BW allocation and control is critical. Furthermore, the mix of services supported must match the customer subscriptions and thus expectations: the number of high definition (HD) video streams, standard definition (SD) video streams, and voice calls supported simultaneously, and the amount of BW provided for data service.

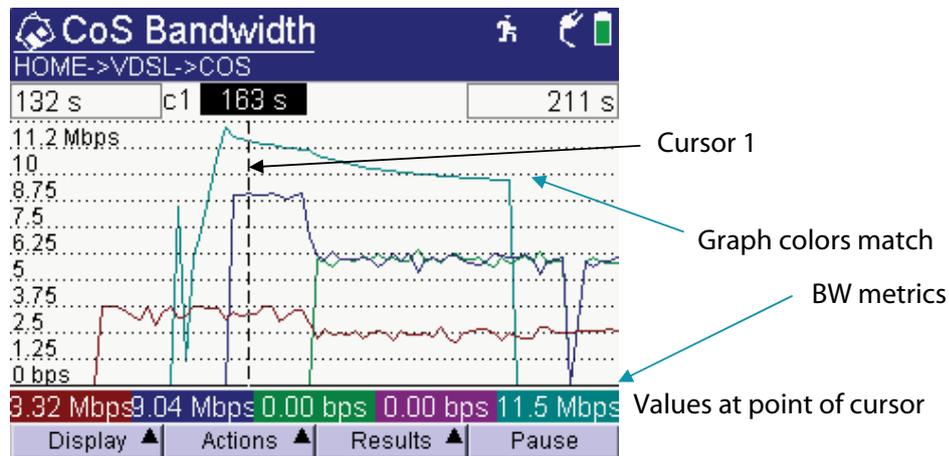
Many mechanisms exist for delivering the proper QoS for each service application. Several network design concepts are typically used to identify the data flows related to the three service types; and based on that, enable network equipments to treat the flows differently when resources become limited. Class of Service (CoS) refers to the treatment of different applications with associated requirements for how data flows are handled in the network. A CoS network design must include strategies for, 1) prioritizing traffic dealing with congestion caused by peak BW demands, which can result in data loss and 2) admission control that can manage service conflicts. They include strategies such as:

- Resource and admission control (RAC)
- Virtual local area network (VLAN) application segregation
- Multiprotocol Label Switching (MPLS) guaranteed BW
- MPLS fast reroute
- Policing and marking on ingress routers
- Differentiated queuing and dropping on core links
- Shaping (or policing, based on line speeds and hardware deployed in the network) and differentiated queuing on egress links

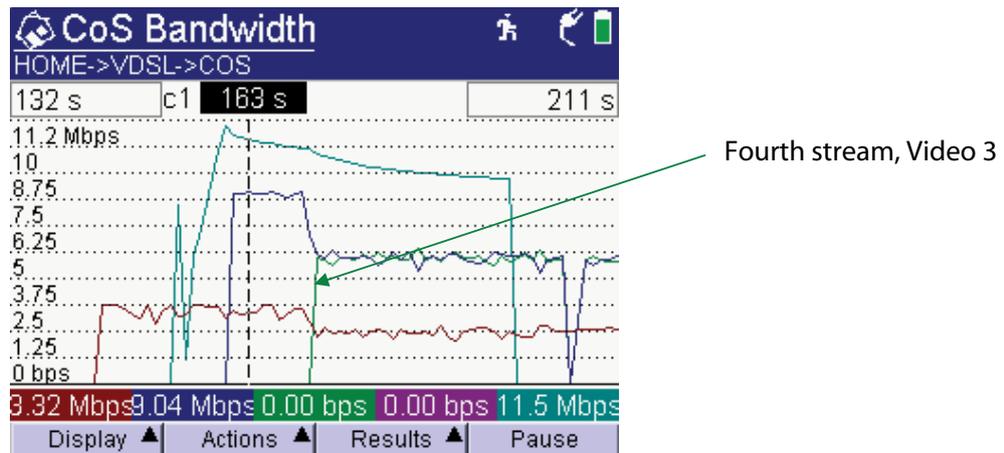
Regardless of the approach a given network may utilize, validation of CoS performance remains critical, especially in the access network where BW is often limited. The interaction between competing application BW demands may affect the individual QoSs. Testing individual applications in a sterile environment will not reveal problems that manifest in the presence of mixed application traffic flows, thus a robust CoS Test Suite is required to analyze these interactions.

A Real-World Example

The true test of a network and how the CoS mechanisms are working is realized when sequencing multiple applications online and then gaining an understanding of the interaction between the different services. In the example below, the maximum DSL BW is 25 Mbps. Therefore when considering the various encapsulations, the actual useable BW for different services is about 4 percent less, in this case 24 Mbps.



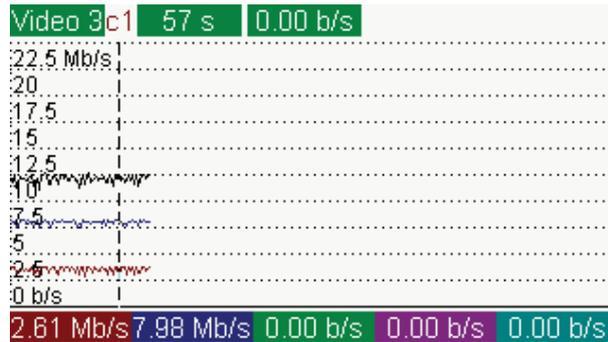
As the graph below shows, stream 1 (red) is a Standard Definition (SD) video stream with a variable bit rate averaging about 3.75 Mbps. Bringing Stream 1 online first followed by the sequencing of the data stream (light blue) online. This stream shows the BW varying during a window size negotiation before peaking at about 12.25 Mbps, and shortly thereafter adding a third stream (dark blue) to the mix. This is High Definition (HD) video stream with a variable bit rate and an average BW of about 8.75 Mbps. At this point, the total average BW is about 24 Mbps, essentially allocating all of the available BW in this particular example. (At the cursor position, the color-coded display shows the exact BWs on the data: Video 1, 3.32 M, Video 2, 9.04 M and Data, 11.5 M with a total of 23.86 M.)



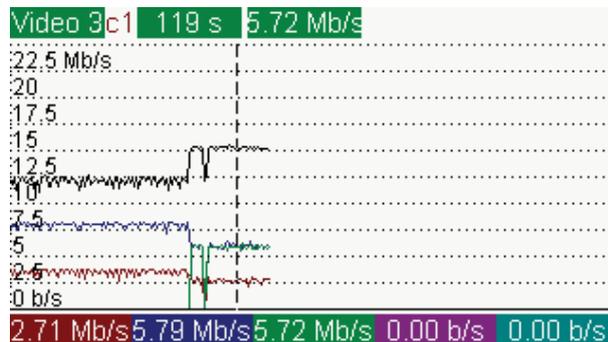
When sequencing a third video stream online, in this example an HD stream (green) that should be running at 8.75 Mbps, the total BW demand exceeds the 24 Mbps maximum. In reaction to this BW demand, the network compensates by simply modifying the BW for all streams so that the total BW demand is 24 Mbps. Video 1 is squeezed to 2.5 M, Video 2 to 6 M, Data to about 10 M, and Video 3 to 6 M for a total of 24 Mbps. As a result, it destroys the QoS for the video services. Massive packet loss occurs on all three video streams and the quality of the video and audio becomes unacceptable to the user. This is an example of a network where the Admission Control and CoS mechanisms are not working or have not been implemented properly.

Using this example, a typical test approach that addresses each application individually would result in a total BW demand of about 21 Mbps for the video application, (all three video streams: 8.75 + 3.75 + 8.75 = 21.25 Mbps) under the 24 Mbps maximum. There would have been no packet loss, leading one to believe the system was operating correctly. However, with no data application active, the impact of a real-world mixed application environment would remain untested and the data service impact would remain unseen, resulting in customer trouble calls upon establishing the mixed traffic.

In another example shown in the graph below, video service is capped at 15 Mbps leaving BW for voice and data services. The first screen shows two active video streams: Video 1 SD stream with a BW of 2.61 M and Video 2 HD stream with a BW of 7.98 M for a total of 10.59 M as shown by the black line graph.



The graph below clearly shows the effects of adding a third video HD stream, exceeding the 15 M limit. The network responds by reducing the BW for the two HD streams from about 8 M each to 5.79 M and 5.72 M, respectively, resulting in massive packet loss. The Total line graph shows the newly combined total BW at 15 M. Adding a data flow to this particular test would reveal that the data application would not impact the video flows, because data service BW is reserved separately from the video service in this network example.



In these cases, it is difficult to identify the root cause or perform timely trouble resolution without the ability to test the interaction of video, voice, and data services together. The individual application tests cannot duplicate the failure or clearly show the interaction between streams. With the many different CoS configurations deployed in today's IPTV networks, use of this CoS test concept is important for proper, new service installation testing. Validating that the CoS setup is working correctly is critical. It is also a valuable tool for use in trouble resolution testing.

Summary

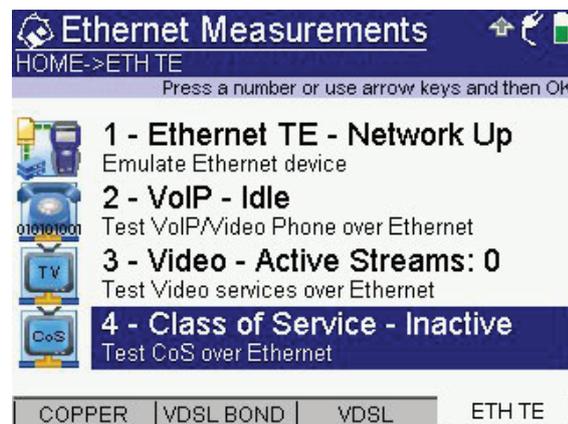
The CoS Test Suite enables field technicians/engineers to validate that CoS mechanisms are performing correctly in a real-world mix of applications. In the Access network, where BW is often limited, CoS analysis may reveal interaction problems or BW-limitation problems that would otherwise remain unidentified. A CoS test should be standard in a new service installation test process. A CoS Test Suite also serves as an important tool for dealing with some trouble-resolution cases.

CoS Operation Detail

The JDSU CoS Test Suite

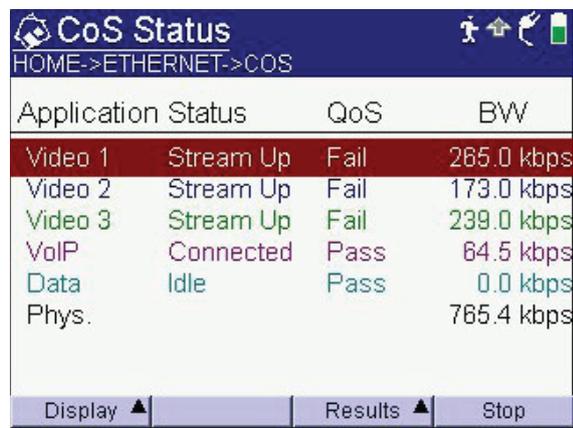
- Enables testing of all three applications simultaneously and allows analysis to reveal their interaction emulating the real-world mixed traffic environment
- Applications are those supported on the instrument, and the CoS does not limit or change them
- Operates only in Terminate mode
- Operates over DSL or Ethernet test access points
- Patent granted based on the ability to bring up all three applications simultaneously for the purpose of showing their interaction
- First of its kind in the industry

As the screen below shows, users can select the CoS Test Suite from the top-level graphical user interface (GUI). When selected, a new GUI appears showing the QoS status for each of the three applications: Video first, VoIP second, and Data third (as shown below).



CoS Status

In the CoS Test Suite, all three applications can run simultaneously to validate whether multiple streams can run at once and to ensure that the network CoS mechanisms are working correctly. Adding new streams lets users see if a negative impact occurs on the existing streams. For example, users can determine whether adding a third video stream, which exceeds the total BW available, degrades the existing streams or causes it to fail to come up at all. In the example screen below, voice and video applications are running with three video streams, one VoIP call, and ftp data is idle. The next step is to sequence the data application online to analyze the condition with all three applications online.



The screenshot shows the 'CoS Status' application interface. At the top, there is a title bar with the application name and navigation icons. Below the title bar, the path 'HOME->ETHERNET->COS' is displayed. The main content is a table with three columns: 'Application', 'Status', 'QoS', and 'BW'. The table lists several applications: Video 1, Video 2, Video 3, VoIP, Data, and Phys. The 'Status' column shows 'Stream Up' for videos, 'Connected' for VoIP, and 'Idle' for Data. The 'QoS' column shows 'Fail' for videos and 'Pass' for VoIP and Data. The 'BW' column shows bandwidth usage in kbps. At the bottom of the screen, there are three buttons: 'Display', 'Results', and 'Stop'.

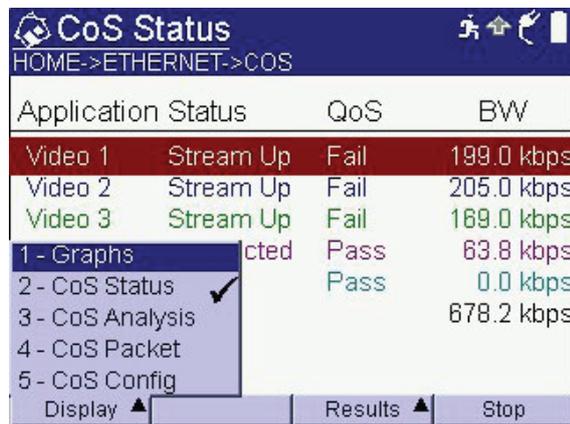
Application	Status	QoS	BW
Video 1	Stream Up	Fail	285.0 kbps
Video 2	Stream Up	Fail	173.0 kbps
Video 3	Stream Up	Fail	239.0 kbps
VoIP	Connected	Pass	64.5 kbps
Data	Idle	Pass	0.0 kbps
Phys.			765.4 kbps

With a stream highlighted, press the right hand soft key to control the start and stop actions for the stream. This is the application control screen where users start and stop streams.

CoS Analysis Details

As shown below, selecting the Display soft key causes a pop-up window to appear and lets users select other analysis screens.

- **Graphs:** Shows various views of stream BWs
- **2-CoS Status:** Controls the starting a stopping of streams
- **3-Analysis:** Shows a summary of possible error conditions for the streams
- **4-CoS Packet:** Shows a summary of packet loss
- **5-CoS Config:** Shows the stream configuration details



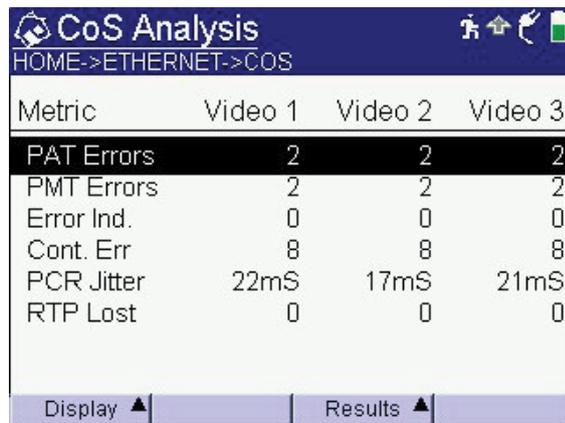
Note: From the CoS Status screen, users can highlight one of the streams, such as Video 1 in this case, and press OK to go to the QoS screen for that stream in the video application. Likewise for the other streams, the QoS screen for the application can be reached directly.



While in the QoS screens, users press Cancel to move back to the CoS Status screen.

CoS Analysis

The CoS Analysis screen below summarizes key metrics for three video streams on a single screen.



Metric	Video 1	Video 2	Video 3
PAT Errors	2	2	2
PMT Errors	2	2	2
Error Ind.	0	0	0
Cont. Err	8	8	8
PCR Jitter	22mS	17mS	21mS
RTP Lost	0	0	0

Display ▲ Results ▲

CoS Packet—Analysis

The CoS Packet Analysis screen below summarizes any RTP packet loss for all three applications.



Application	Packet Loss	Error
Video 1	0	No Errors
Video 2	0	No Errors
Video 3	0	No Errors
VoIP	0	No Errors
Data	0	No Errors

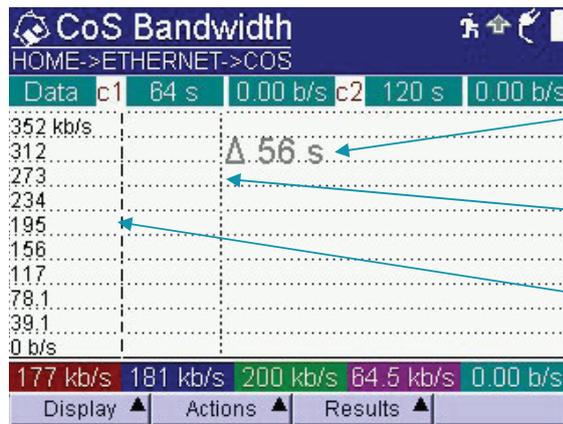
Display ▲ Results ▲

Users can press OK to move to the detailed Packet Loss Summary screen for the selected application. Pressing cancel returns users to this screen.

Graphs

Selecting graphs moves users to the summary BW screen, where:

- Labels at the top coordinate with the stream colors
- Label in the upper left corner identifies the graph data type; total, video1, video 2, etc.
- Use the two cursors (select under the actions key) to determine time intervals as the screen below shows with the delta symbol.



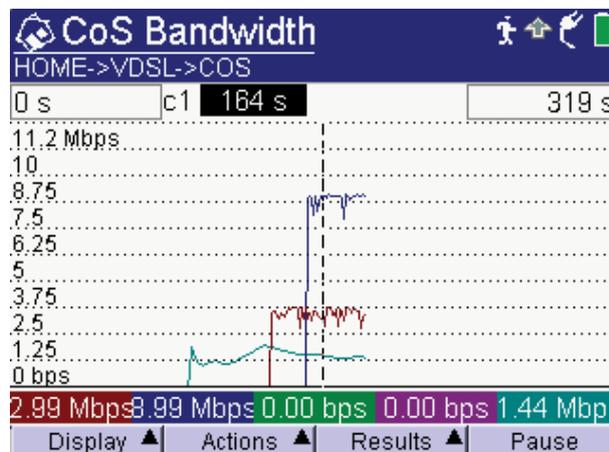
Difference in seconds between c1 and c2

c2 is cursor 2, position in seconds since the start of the test

c1 is cursor 1, position in seconds

Graph colors match BW metrics at cursor 1

- Action key also allows zooming in and out and works similar to the graphical displays on the HST.
- Labels at the top show elapsed time in seconds from the start of a stream. The graph can show about 320 seconds of data. When the graph reaches 320 seconds, the graph is saved in the CoS/Graphs directory and users can select Results and then View Saved Graph on the CoS Bandwidth screen to view earlier graphs.
- The up and down NAV keys cycles between the various graphs reveal: total graph view and individual stream views (Video 1, 2, 3, Data, VoIP).
- The total graph shows all of the active streams. The example below shows three streams operating.



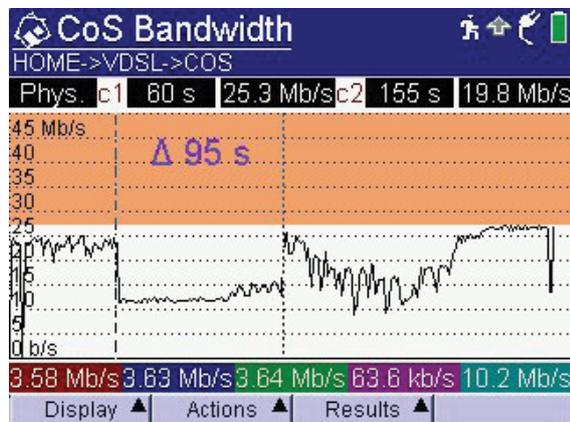
Graph colors match BW metrics at c1

Below are examples for the BW graphs for individual streams. Users can scroll between screens using the up/down NAV keys.

Physical Layer

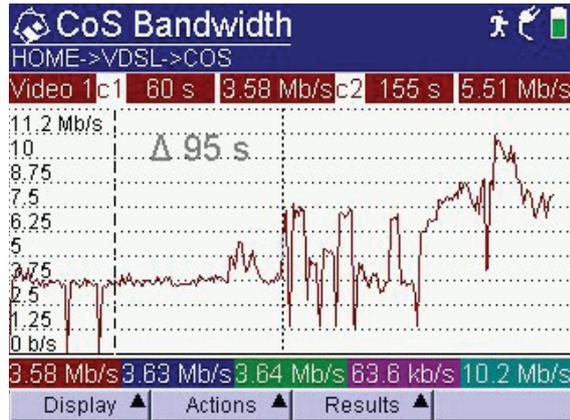
The display below shows the total of all active flows using the IP throughput for very high-speed digital subscriber line (VDSL) and the asynchronous transfer mode (ATM) throughput for an asymmetric digital subscriber line (ADSL) interface. The lower limit of the shaded area is the actual BW limit set for a given DSL interface. This graph easily shows whether or not the combined service flows are nearing the maximum possible.

Note: For reference, this screen also shows the physical layer BW possible for the test access point. On a DSL interface, this is the maximum BW available. For the maximum possible application BW on a DSL link, reduce the DSL (physical layer BW) maximum by 4 percent to consider the encapsulation of the packetized data.

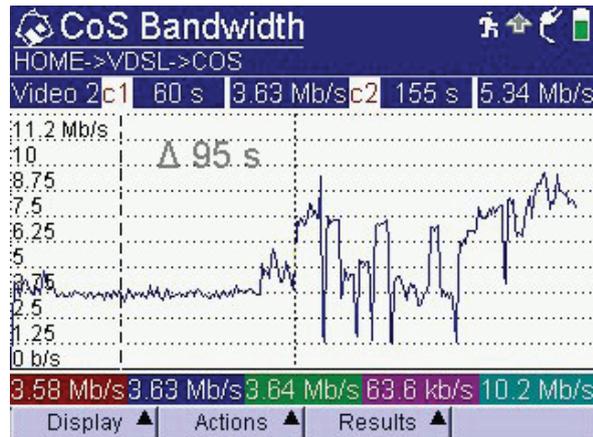


The following three video stream displays show the video BW in a fairly constant state for many seconds and then becoming much more dynamic. This is characteristic of the impact of motion in the program content. During the low dynamic state, almost to the position of the second cursor, the BW does not vary significantly, because the video motion content is low. To the right of cursor 2, the video BW varies significantly due to high motion content.

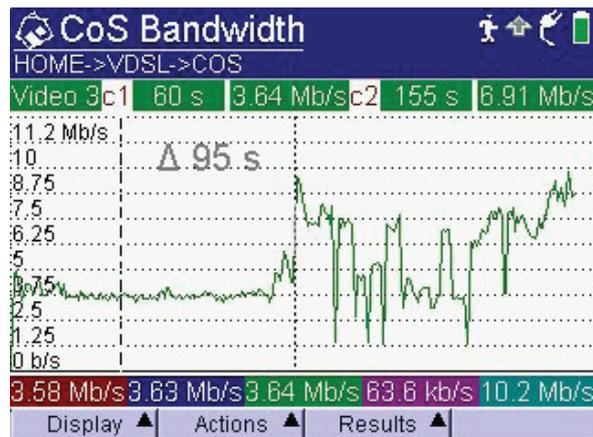
Video 1



Video 2

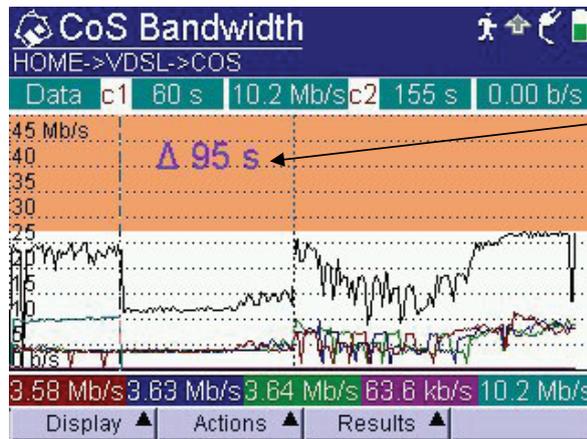


Video 3



All Traces Display

Under the Actions key users can select Single Trace or All Traces. The above screens are single trace screens. The screen below shows an example of an all trace screen. In this mode, users can press the up and down NAV keys to change the BW readouts for the cursors cycling between the streams. In this example the cursor readouts show values for Video1.



The difference between the two cursor positions in seconds facilitates temporal analysis of the BW variations.

This overlay view enables easy comparative pattern analysis, which is most valuable for video stream analysis where comparing a change in BW for one stream to another might more easily reveal important details. For example, the identification of a difference in variable bit rate (VBR)-capped BW levels between streams versus a VBR stream. The Zoom In and Zoom Out on both the X and Y axis feature, selectable under the Actions key, is especially helpful here.

Configuration

Selecting CoS Config changes the GUI to show the configuration screen that shows the setups for each of the streams. Users can press OK for a highlighted stream to move to the setup screen within the application for that stream. The setup screen lets users make changes regarding each stream. Pressing Cancel moves them back to the configuration screen.



Typically there is no need to change the configurations once they are configured for field technicians/engineers because they do not change within the local serving area.

JDSU offers the industry's most comprehensive CoS Test Suite via a patented software option available for the HST-3000 Handheld Services Tester and T-BERD®/MTS-4000 Multiple Services Test Platform.

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