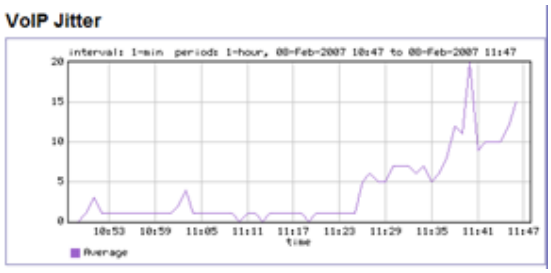
Jitter in the path

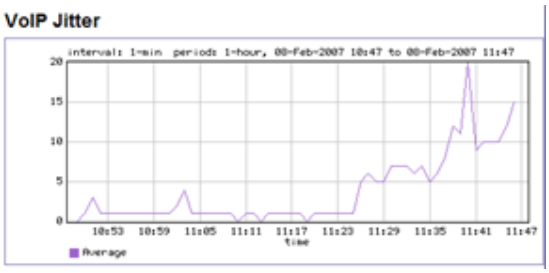
created by: Rainer Bemsel – **Version** 1.0 – **Dated:** Aug/23/2010

One of my clients asked me on how go get insights for Jitter on the path. Troubleshooting, Monitoring, Service Assurance or any other reporting functionality requires data collection. On one hand, monitoring active traffic will provide observations during the interval and report on experience. The "line" quality on the other hand is often measured by synthetic transactions, which can be done with several vendors' hardware.

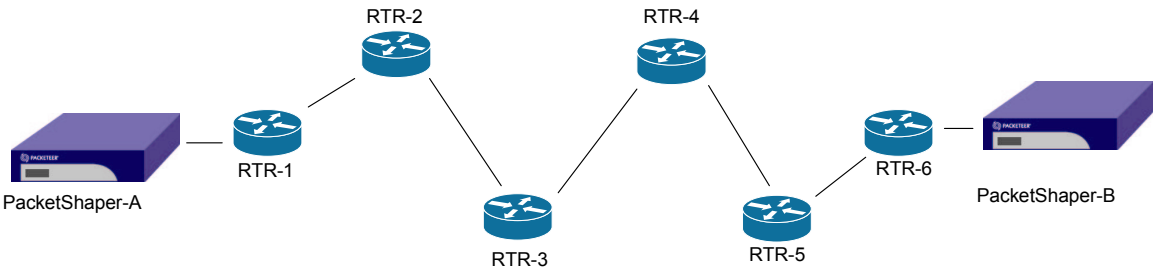
Packeteer's PacketShaper (now BlueCoat) introduced in PacketWise 7.3 an RTP Synthetic Transaction, which could be used to report on

- Jitter—the variation in the delay of received packets in a flow
- Latency—the time required for packets to travel from one PacketShaper to another, as measured by the formula round-trip time / 2.
- Packet loss—the percentage of lost packets

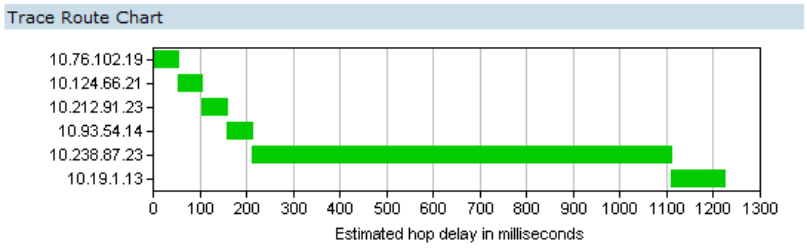




Using PacketShaper's Method of investigating Jitter will deliver an end-to-end view, but no insights on the path. So you won't be able to see, that RTR-5 is busy with a saturated link and therefore you experience a high VoIP Jitter.



The question is to find a more detailed view on the path. Trace Route may tell the delay, but nothing more.

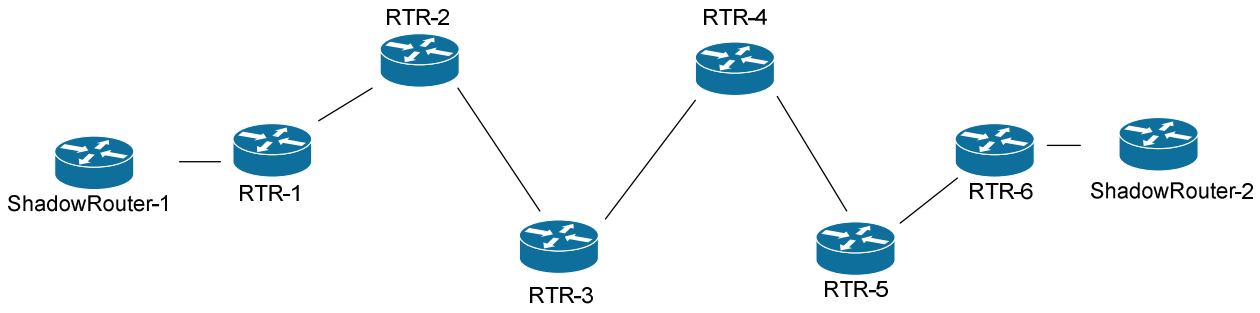


Getting Access to each router via SNMP, you are able to tell on 1.5MBits/sec is filling the T1 Link.

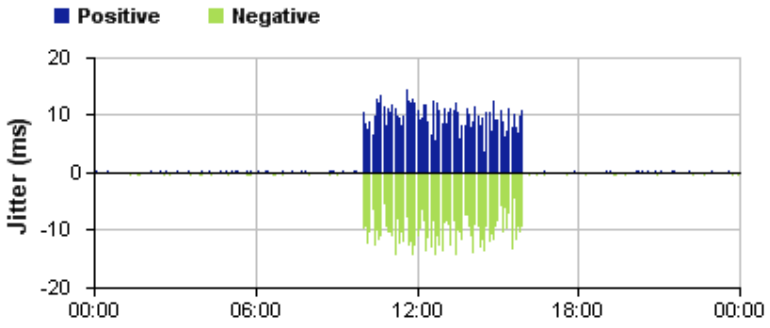
Serial 2/0.1 - T1 Link			In	Out
IP Address	10.238.87.24	Bits/sec	1.5 M	1.5 M
Physical Address	[redacted]	Packets/sec	380	378
Status	Up	Errors	0	0
Speed	1.5 Mbit/s	Discards	4,632	4,632

IPSLA is an agent, built into Cisco IOS/CatOS software to allow for interface-to-interface synthetic transactions. Similar technology is also available from Juniper, called RPM (Real-Time Performance Module), PacketShaper (as described on previous page), Brix Networks provides a dedicated appliance to do this. Synthetic transactions are the base of such idea to send in periodic intervals the same type of request and measure the result.

Jitter (aka "delay variation) is a measure of the differences in arrival times. ShadowRouter-1 (Sender) is sending packets with a constant interval, say 10ms. ShadowRouter-2 (Responder) receives those packets with delay variations introduced by the network (RTR-1 to RTR-6). Responder adds a receive time stamp and calculates the delta.

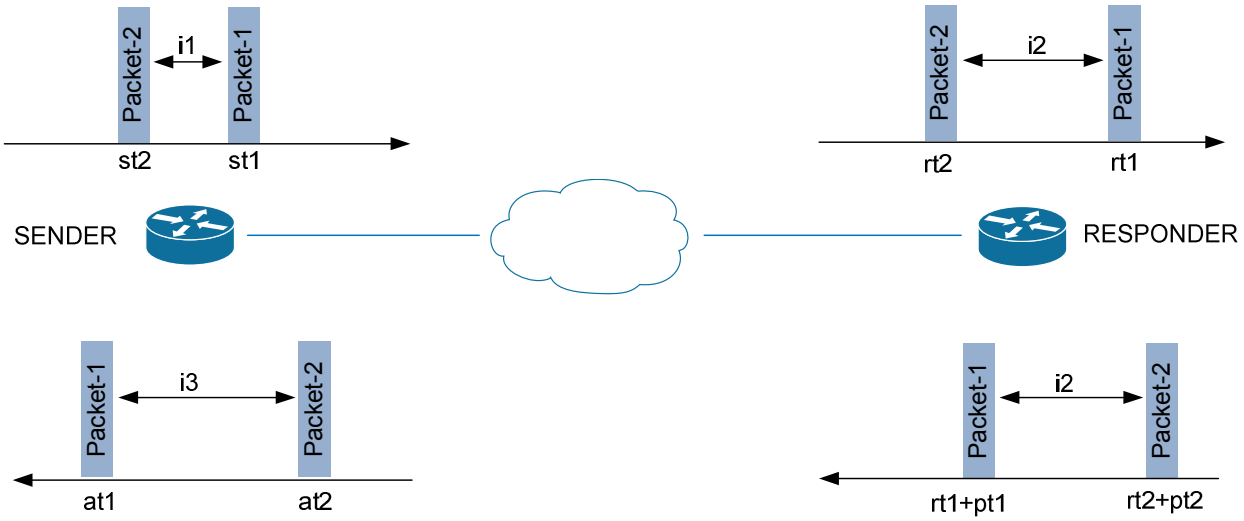


However, this kind of Measurement tells end-to-end. It is the same way as I outlined with PacketShaper on the previous page. Using a SNMP Tool can graph the results.



On the Jitter Graph (previous page), assuming packets are sent from the ShadowRouter with 20ms interval, Positive Jitter (blue spikes) means they have been received with more than 20ms interval. Negative Jitter (green spikes) means less than 20 ms interval.
Zero Jitter means, they are received with the same inter-packet delay (the variance is zero). Jitter should remain as low as possible for real-time traffic, such as Voice over IP.

Following example should help to understand the calculation of Jitter



- stx = send timestamp for packet x
- rtx = receive timestamp for packet x
- ptx = processing time spent between packet arrival and treatment
- atx = receive timestamp for packet x
- ix = inter packet delay

Jitter (Source to Destination) = (rt2-rt1)-(st2-st1) = i2-i1
Jitter (Destination to Source) = (at2-at1)-((rt2+pt2)-(rt1+pt1)) = i3-i2

If you want to report on IP SLA with your SNMP Tool, make sure you have required MIBs loaded.

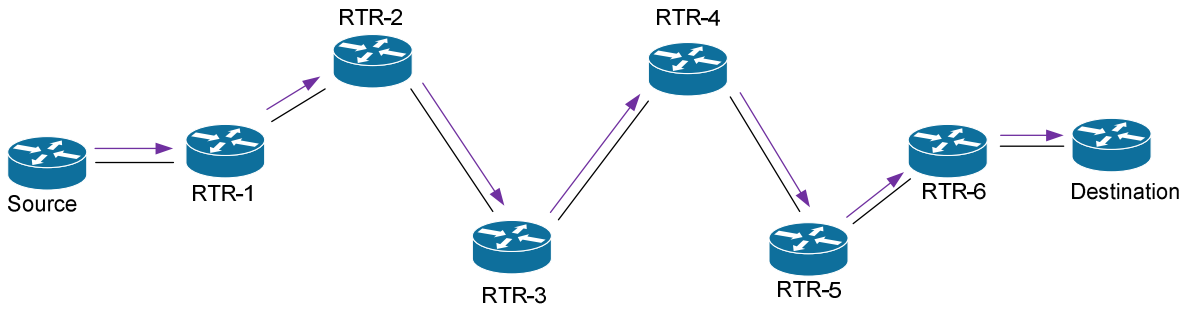
A great SNMP Reference guide can be found here:
http://www.cisco.com/en/US/tech/tk648/tk362/tk605/tsd_technology_support_sub-protocol_home.html

With IOS 12.2(2)T or later, PathJitterOperations is available. This is a quite a simple way to gain visibility into the path.
For more information: /www.cisco.com/en/US/docs/ios/ipsla/configuration/guide/sla_icmp_pathjitter.html

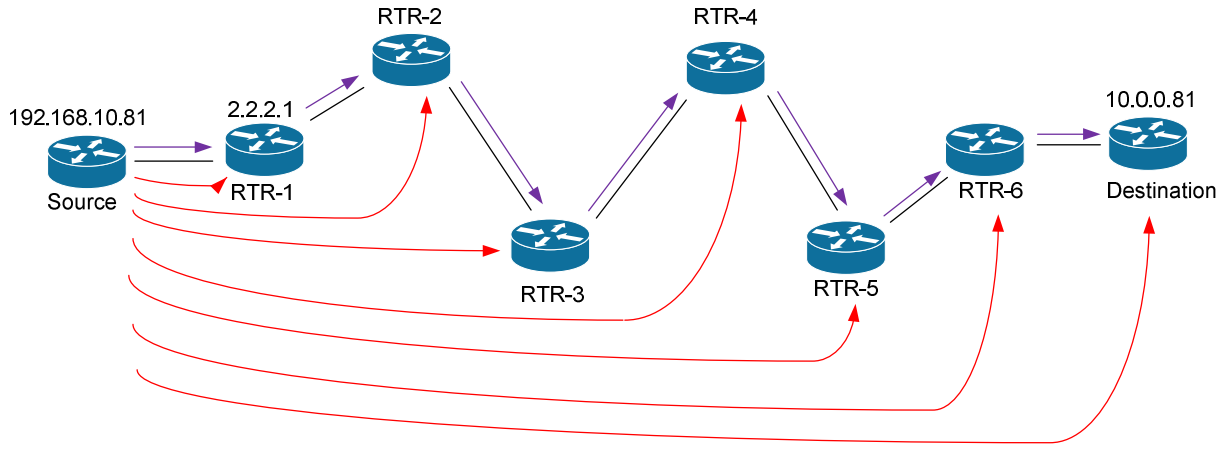
It runs in two phases:

- Route discovery
- Hops evaluation

During Route Discovery, the path will be discovered by a trace route from the source to destination



Once the route discovery has been completed the PathJitterOperation will evaluate each hop one by one for RTT, packet loss and round-trip total Jitter.



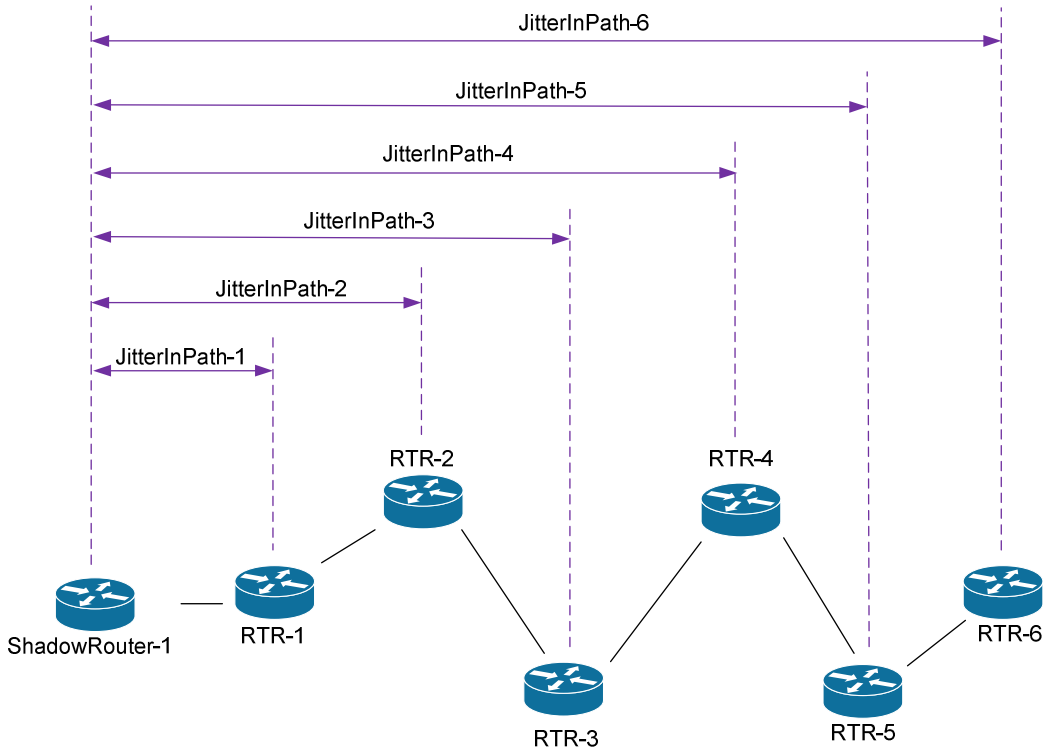
Path Jitter Statistics (Example)

```
Source IP                  - 192.168.10.81
Destination IP             - 10.0.0.81
Number of Echoes           - 10
Interval between Echoes    - 20 ms
Target Only                - Disabled (default)

Hop IP 2.2.2.1:
       RTT:1               PacketLoss:0        Jitter:0
       MinRTT:1            MaxRTT:2            SumRTT:19     Sun2RTT:37
       MinPosJitter:1      MaxPosJitter:1      SumPos:1      Sum2Pos:1
       MinNegJitter:0      MaxNegJitter:0      SumNeg:0      Sum2Neg:0
       OutOfSequence:0     DiscardedSamples:0
```

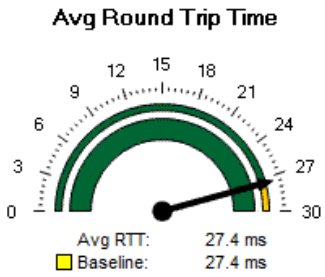
Another way to obtain Jitter in the Path would be a technique, I have used to implement during my time with Packeteer. It's called Synthetic Transactions by Hops. This is similar as PathJitterOperations, but can use different Operations, as well.

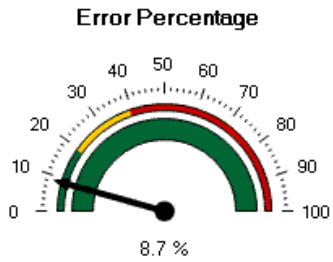
Check also: www.bemsel.com/TechTip/techiestuff/RBE-PKTR-SYNTRANS-HTTP.pdf

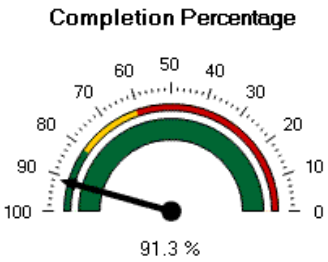


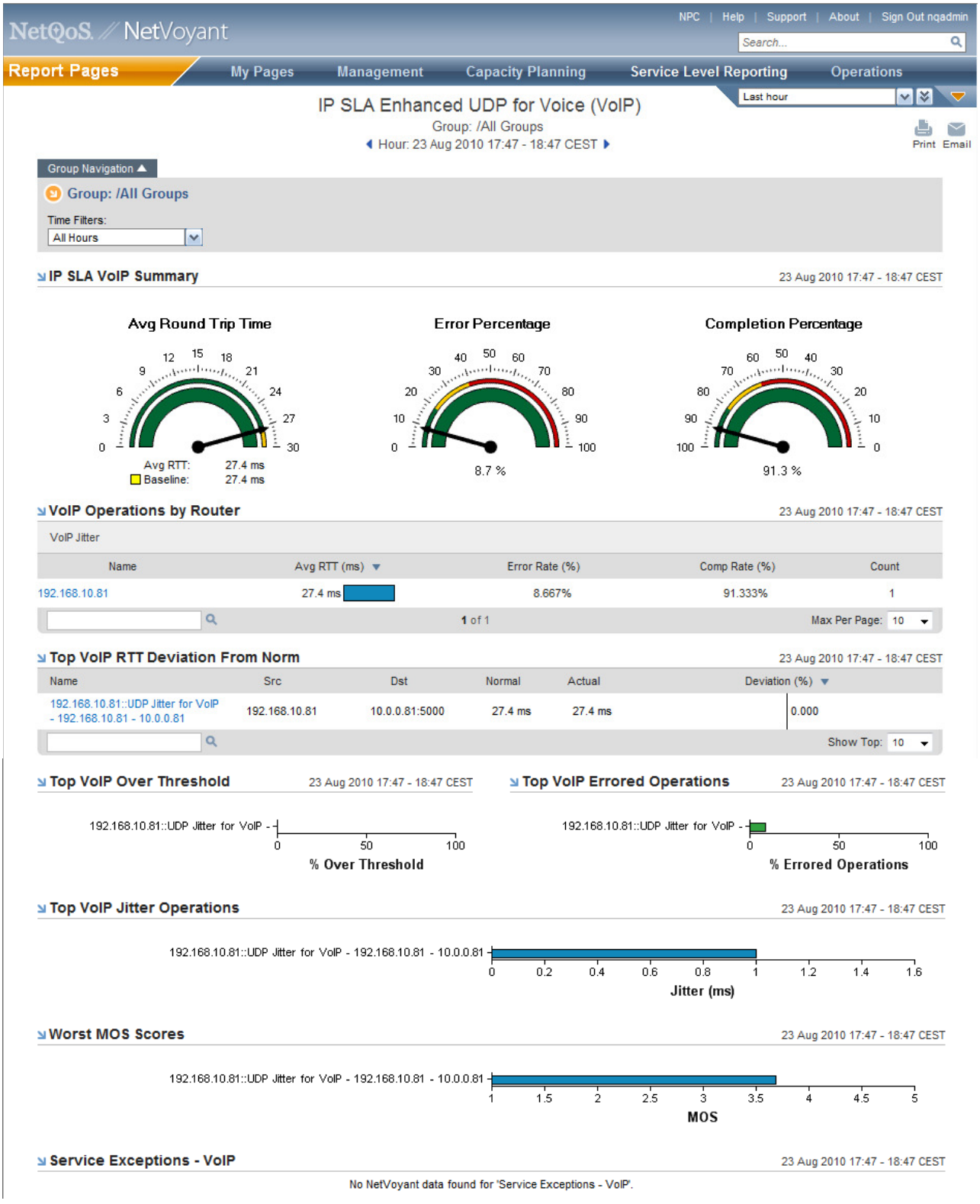
I use one ShadowRouter to run UDP Jitter for VoIP (see also Appendix - IP SLA Visual Configuration at the end of this document)

It will gather statistics for each Hop and prepare a visual of different metrics.









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Where Am I?

Last hour

Enhanced UDP For Voice (VoIP)

IPSLA Jitter: 192.168.10.81::UDP Jitter for VoIP - 192.168.10.81 - 10.0.0.81

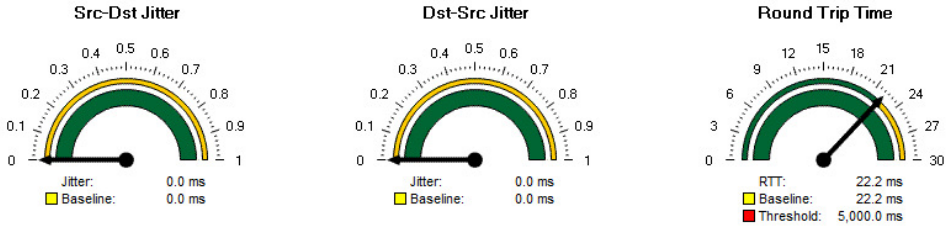
Hour: 23 Aug 2010 17:50 - 18:50 CEST

Print Email

VoIP Jitter/Round Trip Time

23 Aug 2010 17:50 - 18:50 CEST

IPSLA Jitter: 192.168.10.81::UDP Jitter for VoIP - 192.168.10.81 - 10.0.0.81
Destination: 10.0.0.81:5000

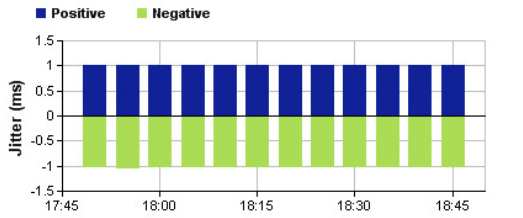


Index: 1, Frequency: 60, Codec: G.711 A Law, Codec Packets: 30, Inter-packet delay: 20ms, Request Size: 200 bytes, Precision: Milliseconds, ToS: 160

Jitter: Source to Destination

23 Aug 2010 17:50 - 18:50 CEST

IPSLA Jitter: 192.168.10.81::UDP Jitter for VoIP - 192.168.10.81 - 10.0.0.81
Destination: 10.0.0.81:5000

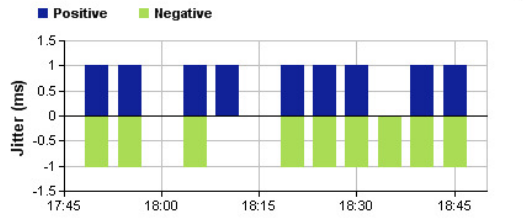


Resolution: 5 min

Jitter: Destination to Source

23 Aug 2010 17:50 - 18:50 CEST

IPSLA Jitter: 192.168.10.81::UDP Jitter for VoIP - 192.168.10.81 - 10.0.0.81
Destination: 10.0.0.81:5000

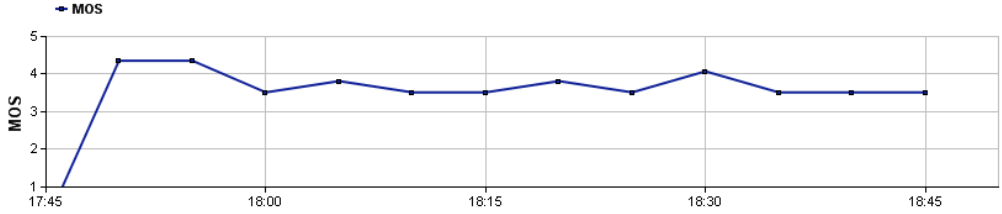


Resolution: 5 min

Mean Opinion Score

23 Aug 2010 17:50 - 18:50 CEST

IPSLA Jitter: 192.168.10.81::UDP Jitter for VoIP - 192.168.10.81 - 10.0.0.81
Destination: 10.0.0.81:5000

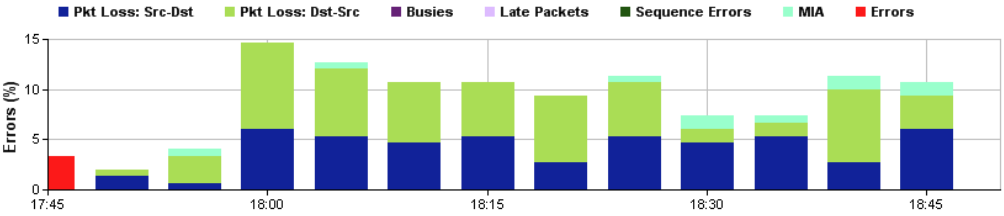


1=Bad, 2=Poor, 3=Fair, 4=Good, 5=Excellent; Resolution: 5 min

VoIP Errors

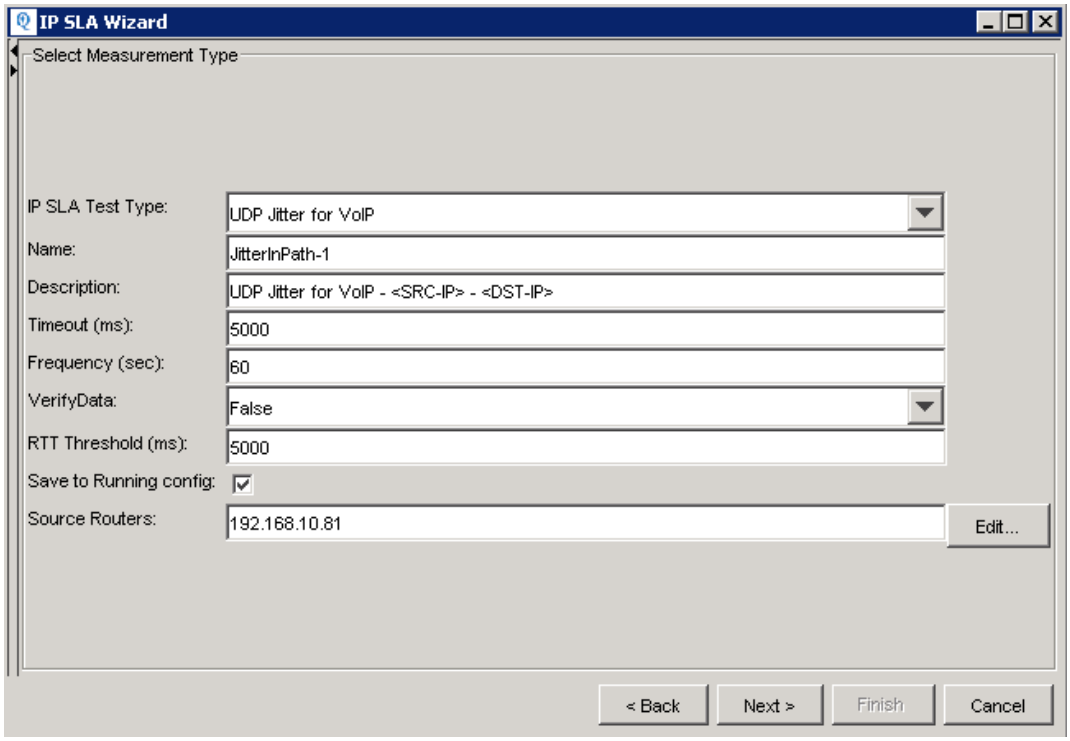
23 Aug 2010 17:50 - 18:50 CEST

IPSLA Jitter: 192.168.10.81::UDP Jitter for VoIP - 192.168.10.81 - 10.0.0.81
Destination: 10.0.0.81:5000



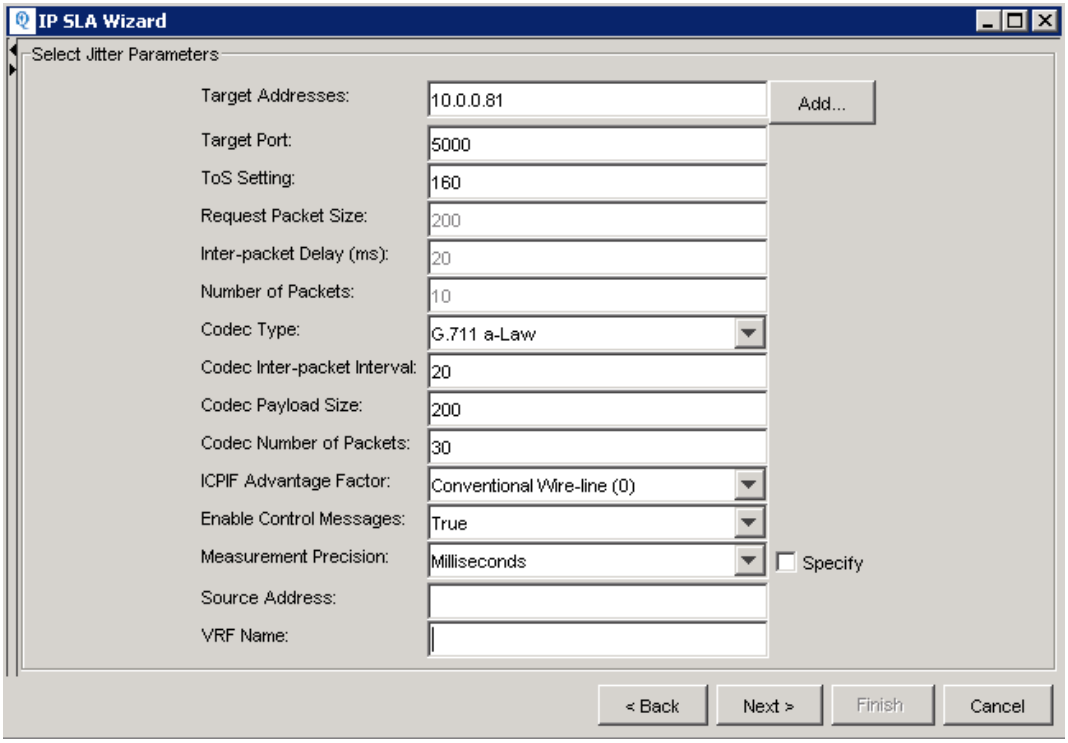
Appendix – IP SLA Visual Configuration

If you have NetVoyant from NetQoS, you can use the IP SLA Wizard to build the configuration. You will need to have Write Access via SNMP to the source router. Also, to mention, destination router needs to be configured as Responder (via CLI)



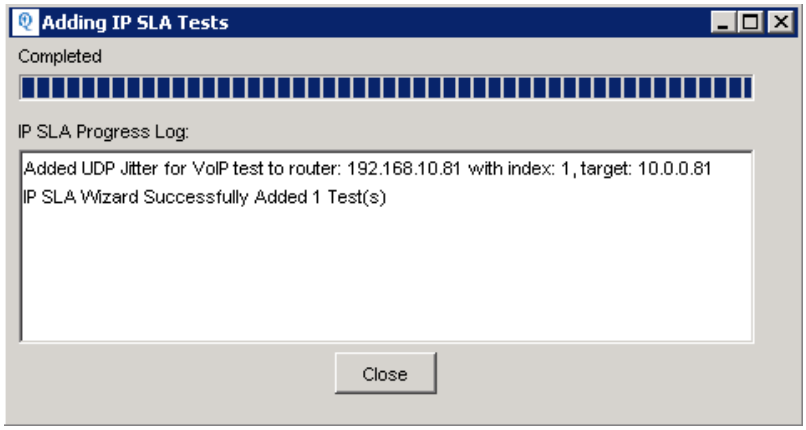
Name:	Enter a name to help you identify the IP SLA operation.	
Description	Enter a description to help you identify what the IP SLA operation measures.	
Timeout (ms)	Timeout Enter the amount of time in milliseconds that the IP SLA operation waits for a response from a request packet.	
Frequency (sec)	Enter the rate in seconds at which the IP SLA operation repeats.	
VerifyData:	Select True to configure the IP SLA operation to check each reply packet for data corruption. Select False to not use this option.	
RTT Threshold (ms)	Enter the upper threshold value in milliseconds for calculating network monitoring statistics created by the IP SLA operation.	
Save to Running config	Select this check box to save the IP SLA operation to the router's configuration. This feature allows the IP SLA test to be seen in the router's running configuration, making it possible to save the test (an additional procedure) to the	When this check box is not selected, the test cannot be seen in the running configuration or saved to the startup configuration. If the router reboots, the test is lost and the NetVoyant

	startup configuration.	product generates a polling alarm for the IP SLA test until re-discovery disables the poll instance.
Source Routers:	Enter the IP address for the Cisco devices on which you want to configure the IP SLA operation, and use commas to separate multiple IP addresses.	



Target Addresses:	You can enter one or more IP addresses (separated by commas or spaces) or click the Edit button to search for and select IP addresses.	(remember to configure as responder)
Target Port	Target Port The port over which requests are directed as part of the IP SLA operation	Port max =65535 5000 (default)
ToS Setting	The ToS setting enables you to identify the ToS bits of the packets to send. This is especially important in validating service levels as well as obtaining an accurate measure of voice quality.	
Request Packet Size	The protocol data size in the payload of the IP SLA operation's request packet.	200 (default)
Codec Type	Select the type of codec to be used for voice simulation as part of the IP SLA operation. The codec enables the operation to generate VoIP scores in addition to latency, jitter, and packet loss statistics.	• G.711 a-Law (default) • 64 kbps PCM compression method • G.711 u-Law - 64 kbps PCM Compression method • G729a – 8 kbps CSACELP Compression method

Codec Interpacket Interval	The time, in milliseconds, between the packets sent as part of the IP SLA operation.	20 ms (default)
Codec Payload Size	The size of data payload sent in each packet as part of the IP SLA operation	
Codec Number of Packets	Enter the number of packets to send as part of the IP SLA operation.	
ICPIF Advantage Factor	Select the ICPIF Advantage Factor that best represents the level of voice-quality expected for the voice test. The value you specify is subtracted from the measured impairment values. You can use this option to correct the ICPIF and MOS values for network conditions. Conventional	• Conventional Wire Line (0) • Mobility within Building (5) • Mobility within Geographic • Area (10) • Access to Hard to Reach • Location (20)
Enable Control Messages	Set this to True when the target is also configured as a Responder. This provides for better timing measurements during the RTT test.	
Measurement Precision	The unit of measurement used for the operation if Specify is selected.	
Specify	Indicates whether the operation uses the Measurement Precision command. * Select the check box to turn on the Measurement Precision command. * Clear the check box to turn off the Measurement Precision command.	
Source Address	Enter the source address on the router for greater accuracy	
VRF Name	Allows monitoring of MPLS VPNs by specifying a VPN routing/forwarding (VRF) name to which the operation belongs.	



Note: Most screenshots have been taken from NetQoS NetVoyant and Packeteer PacketShaper

Appendix - Configure Responder

For the Jitter Test - in global configuration

```
10.0.0.81# conf t
10.0.0.81(config)#ip sla responder
10.0.0.81(config)#exit
10.0.0.81# write t
```

Appendix - IP SLA CLI Statistics

```
192.168.10.81#sho ip sla stat 1
IPSLAs Latest Operation Statistics

IPSLA operation id: 1
        Latest RTT: 27 milliseconds
Latest operation start time: *16:49:55.298 UTC Mon Aug 23 2010
Latest operation return code: OK
RTT Values:
        Number Of RTT: 26               RTT Min/Avg/Max: 27/27/28 milliseconds
Latency one-way time:
        Number of Latency one-way Samples: 0
        Source to Destination Latency one way Min/Avg/Max: 0/0/0 milliseconds
        Destination to Source Latency one way Min/Avg/Max: 0/0/0 milliseconds
Jitter Time:
        Number of SD Jitter Samples: 23
        Number of DS Jitter Samples: 24
        Source to Destination Jitter Min/Avg/Max: 0/1/1 milliseconds
        Destination to Source Jitter Min/Avg/Max: 0/0/0 milliseconds
Packet Loss Values:
        Loss Source to Destination: 2           Loss Destination to Source: 2
        Out Of Sequence: 0      Tail Drop: 0
        Packet Late Arrival: 0  Packet Skipped: 0
Voice Score Values:
        Calculated Planning Impairment Factor (ICPIF): 25
MOS score: 3.50
Number of successes: 48
Number of failures: 0
Operation time to live: Forever
```