ADVANCED PERFORMANCE MEASUREMENT WITH CISCO IOS IPSLA

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Session Number
Presentation_ID

Recuerde siempre:

- Apagar su teléfono móvil/pager, o usar el modo "silencioso".
- Completar la evaluación de esta sesión y entregarla a los asistentes de sala.
- Ser puntual para asistir a todas las actividades de entrenamiento, almuerzos y eventos sociales para un desarrollo óptimo de la agenda.
- Completar la evaluación general incluida en su mochila y entregarla el miércoles 8 de Junio en los mostradores de registración. Al entregarla recibirá un regalo recordatorio del evento.

Prerequisites

- Before attending this session, familiarities with Cisco IOS® IP Service Level Assurance (IPSLA) is essential.
- Configuration and generic features will not be covered; this has been covered by NMS-1204.
- Only new or advanced topics, as well as design recommendations will be covered

Objectives

- Understand the internals
- New features update
- Performance and scalability considerations
- How to get the most of IPSLA
- Future and IPSLA strategic vision

This Is Not…

- An introduction to IPSLA
- Recommendations on QoS configuration
- A talk on backend network management applications
- A speculation on upcoming features
- …a Marketing document

Agenda

- Reminder
- IPSLA Accuracy
- Performance and Scalability
- New Features
- Design Recommendations
- Get the Most Out of IPSLA
- IPSLA Initiative

Technical Overview

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- Wide measurement capabilities (UDP, TCP, ICMP,…)
- Millisecond precision (does not use Cisco IOS timers)
- Accessible using CLI and SNMP
- Proactive notification
- Historical data storage
- Flexible scheduling options
- Already in Cisco IOS® (available on most platforms)
- Almost all interfaces supported, physical and logical

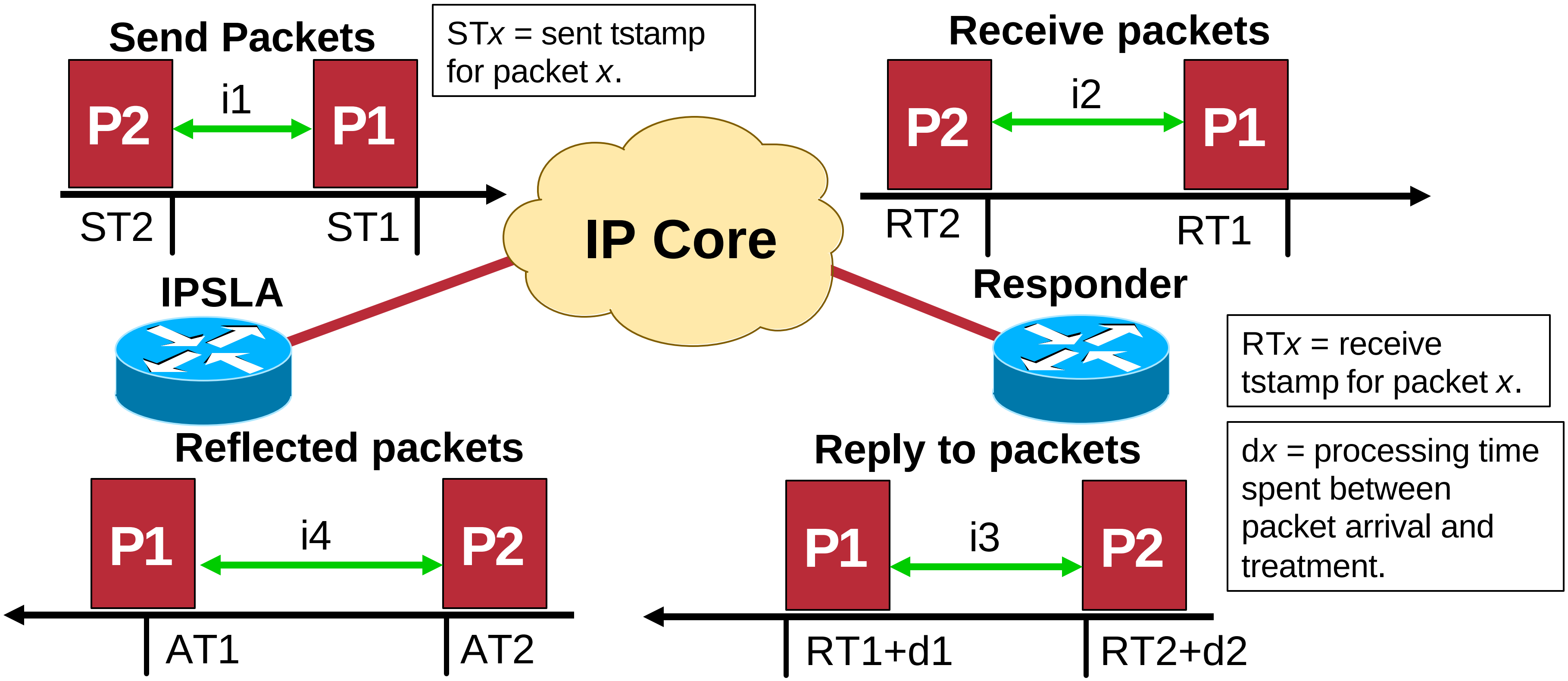
Reminder

- **IPSLA in an active probing and monitoring feature in Cisco IOS**
- **Wide protocol and applications coverage: UDP, TCP, ICMP, HTTP, DNS, DHCP, FTP,…**
- **ICMP or UDP operation for connectivity**
- **Jitter operation is most appropriate for network measurements**

UDP Jitter Operation

- **Measures the delay, delay variance (jitter) and packet loss by generating periodic UDP traffic**
- **Measures: per-direction jitter, per-direction packet-loss and round trip time**
- **Detect and report out-of-sequence and corrupted packets**
- **One-way delay requires Cisco IOS® 12.2(2)T or later and clock synchronization between source and destination**
- **Always requires IPSLA responder**

UDP Jitter - Measurement Example



ATx = receive tstamp for packet *x*.

Each packet contains ST*x*, RT*x*, AT*x*, d*x* and the source can now calculate:

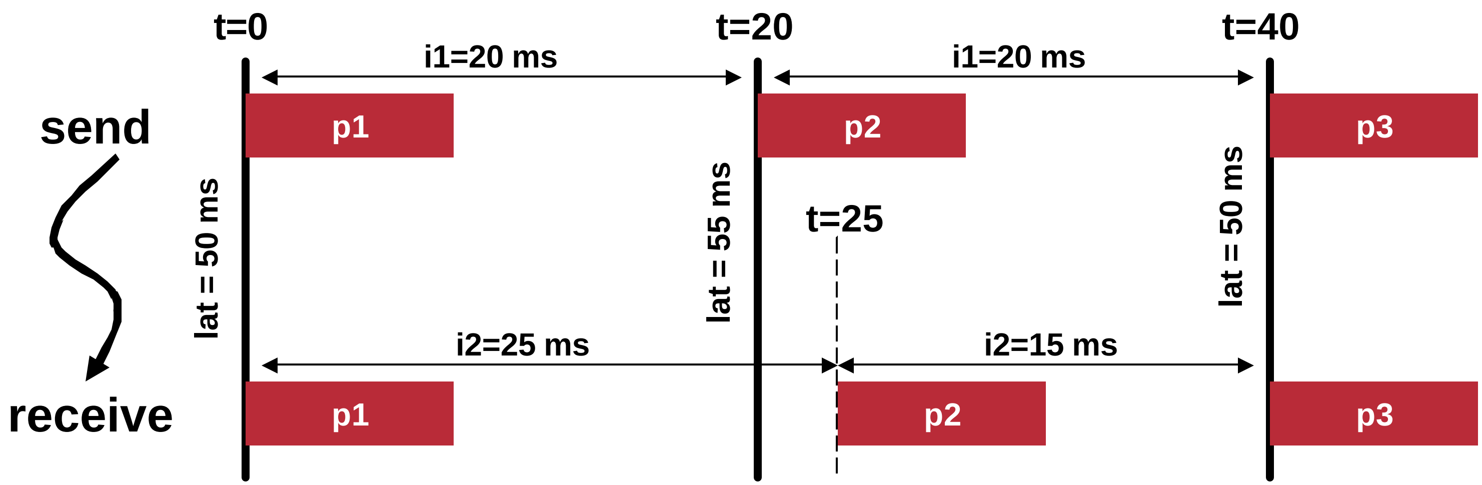
JitterSD = (RT2-RT1)-(ST2-ST1) = i2-i1

JitterDS = (AT2-AT1)-((RT2+d2)-(RT1+d1)) = i4-i3

UDP Jitter Operation
Jitter Computation

- If packets are sent with 10ms interval, positive jitter means they have been received with more than 10ms interval
- Negative jitter means less than 10ms 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; a general estimate is that jitter shall not exceed 30 ms end-to-end
- No need to have clocks synchronized

Jitter Calculation – beware!



IPSLA Jitter	i2-i1 = +5 ms	i2-i1 = -5 ms
RTP Stream Jitter	Packet too late: 5 ms	Packet on-time: 0 ms

If you count positive AND negative jitter, you are penalized twice. Counting only positive jitter is enough.

UDP Jitter Operation (Example)

Simple Example:

```
rtr 1
 type jitter dest-ipaddr 10.52.130.68 \
       dest-port 3456 num-packets 20

rtr schedule 1 start-time now
```

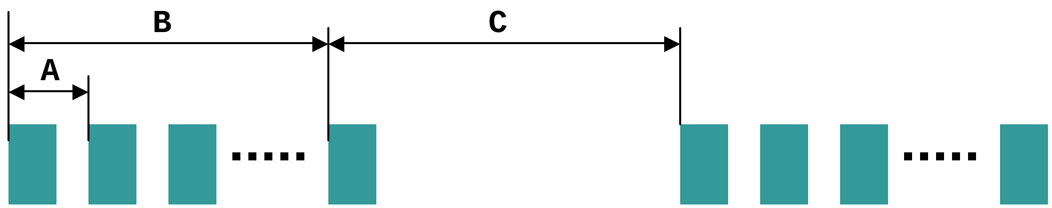
UDP Jitter Probe to 10.52.130.68, port 3456

Send 20 packets each time

UDP Jitter Operation (Example)

- Simulating G.711 VoIP call
- Use RTP/UDP ports 16384 and above, the packet size is 172 bytes (160 bytes of payload + 12 bytes for RTP)
- Packets are sent every 20 milliseconds
- Marked with DSCP value of 8 (TOS equivalent 0x20)

```
rtr 1
 type jitter dest-ipaddr 10.52.130.68 dest-port 16384 \
      num-packets 1000 interval 20
 tos 0x20
 frequency 60
 request-data-size 172
rtr schedule 1 life forever start-time now
```



A = 20 ms
B = 20 s (1000 x 20 ms)
C = 40 s (60 s – 20 s)

UDP Jitter Example (new CLI)

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- **Same configuration with the new and old CLI:**

```
ip sla 1
 udp-jitter 10.52.130.68 16384 num-packets 1000 \
       interval 20
 request-data-size 172
 tos 20
 frequency 60
ip sla schedule 1 start-time now
```

```
rtr 1
 type jitter dest-ipaddr 10.52.130.68 dest-port 16384 \
       num-packets 1000 interval 20
 request-data-size 172
 tos 0x20
 frequency 60
rtr schedule 1 life forever start-time now
```

UDP Jitter Operation (Output) [1/3]


```
etychon-vpn#sh rtr op 1
        Current Operational State
Entry Number: 1
Modification Time: 08:22:34.000 PDT Thu Aug 22 2002
                :
                ntry was Reset: Never
Number of Octets in use by this Entry: 1594
Number of Operations Attempted: 1
Current Seconds Left in Life: 574
Operational State of Entry: active
Latest Operation Start Time: 08:22:34.0                        2
Latest Oper Sense: ok
RTT Values:
NumOfRTT: 997   RTTSum: 458111  RTTSum2: 238135973
Packet Loss Values:
PacketLossSD: 3 PacketLossDS: 0
PacketOutOfSequence: 0  PacketMIA: 0    PacketLateArrival: 0
InternalError: 0        Busies: 0
(cont…)
```

3 Packets Lost S->D out of 1000 Sent

Average RTT Was 458111/997 = 459ms

UDP Jitter Operation (Output) [2/3]

Source to Destination Jitter

Destination to Source Jitter

```
(…cont)
Jitter Values:
MinOfPositivesSD: 1      MaxOfPositivesSD: 149
NumOfPositivesSD: 197    SumOfPositivesSD: 8792   Sum2PositivesSD: 794884
MinOfNegativesSD: 1      MaxOfNegativesSD: 158
NumOfNegativesSD: 761    SumOfNegativesSD: 8811   Sum2NegativesSD: 139299
MinOfPositivesDS: 1      MaxOfPositivesDS: 273
NumOfPositivesDS: 317    SumOfPositivesDS: 7544   Sum2PositivesDS: 581458
MinOfNegativesDS: 1      MaxOfNegativesDS: 183
NumOfNegativesDS: 603    SumOfNegativesDS: 6967   Sum2NegativesDS: 336135
Interarrival jitterout: 16       Interarrival jitterin: 35
One Way Values:
NumOfOW: 0
OWMinSD: 0       OWMaxSD: 0       OWSumSD: 0       OWSum2SD: 0
OWMinDS: 0       OWMaxDS: 0       OWSumDS: 0       OWSum2DS: 0
```

See Next Slide.

No Synchro Between Clocks: All Zeroes

Follow RFC1889 (RTP) to Measure Jitter with Noise Reduction

UDP Jitter Operation (Output) [3/3]

Smallest Positive Jitter | Biggest Positive Jitter

```
MinOfPositivesSD: 1     MaxOfPositivesSD: 249
```

Number of Packets with a Positive Jitter | Sum of All Positive Jitter | Sum the Squares of All Positive Jitter

```
NumOfPositivesSD: 197   SumOfPositivesSD: 8792  Sum2PositivesSD: 794884
```

Smallest Negative Jitter | Biggest Negative Jitter

```
MinOfNegativesSD: 1     MaxOfNegativesSD: 158
```

Number of Packets with a Negative Jitter | Sum of All Negative Jitter | Sum the Squares of All Negative Jitter

```
NumOfNegativesSD: 761   SumOfNegativesSD: 8811  Sum2NegativesSD: 139299
```

UDP Jitter Output (new CLI)

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```
r1#sh ip sla stat 1

Round Trip Time (RTT) for       Index 1
        Latest RTT: 2 milliseconds
Latest operation start time: *12:48:43.823 PST Fri Apr 15 2005
Latest operation return code: OK
RTT Values:
        Number Of RTT: 100              RTT Min/Avg/Max: 1/2/54 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 Jitter Samples: 99
        Source to Destination Jitter Min/Avg/Max: 4/6/48 milliseconds
        Destination to Source Jitter Min/Avg/Max: 4/4/8 milliseconds
Packet Loss Values:
        Loss Source to Destination: 0           Loss Destination to Source: 0
        Out Of Sequence: 0      Tail Drop: 0    Packet Late Arrival: 0
Total Packet Loss: 0
Min/Max of Loss Period Length: 0/0
Min/Max of Inter Loss Period Length: 0/0
Num of Loss Periods: 0
Voice Score Values:
        Calculated Planning Impairment Factor (ICPIF): 0
        Mean Opinion Score (MOS): 0
Number of successes: 1
Number of failures: 2
Operation time to live: Forever
```

Summary

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- Cisco IOS Feature
- Active monitoring with synthetic operations
- Detailed results like delay, loss, and jitter per direction
- Easy to use, available on all platforms

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IPSLA Accuracy...ICMP Echo Probe

(90% Process Load)

- **With unloaded receiver, IPSLA measures 15.0 ms**
- **With high CPU load on the receiver: 58.5 ms!!**

Any System Will Report Wrong Results when Excessive CPU Time Is Spent on the Receiver Between the ICMP Echo Request and Echo Reply

Fortunately, We Have a Solution…

Processing Time Measurement

- **When running the responder, we have a clear advantage, because…**
- **There is a mechanism to evaluate the processing time spend on the receiving router**
- **Insert a timestamp when the responder receives the packet, and when it replies**
- **Receive timestamp done at interrupt level, as soon as the packet is dequeued from the interface driver; absolute priority over everything else**
- **With IPSLA, this mechanism is implemented for both UDP Echo and UDP Jitter probes**

UDP Echo Operation (With IPSLA Responder)

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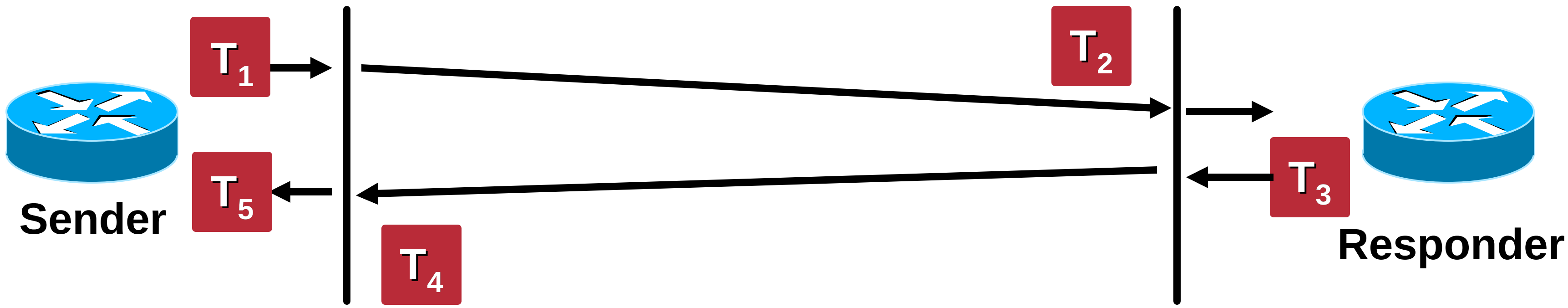


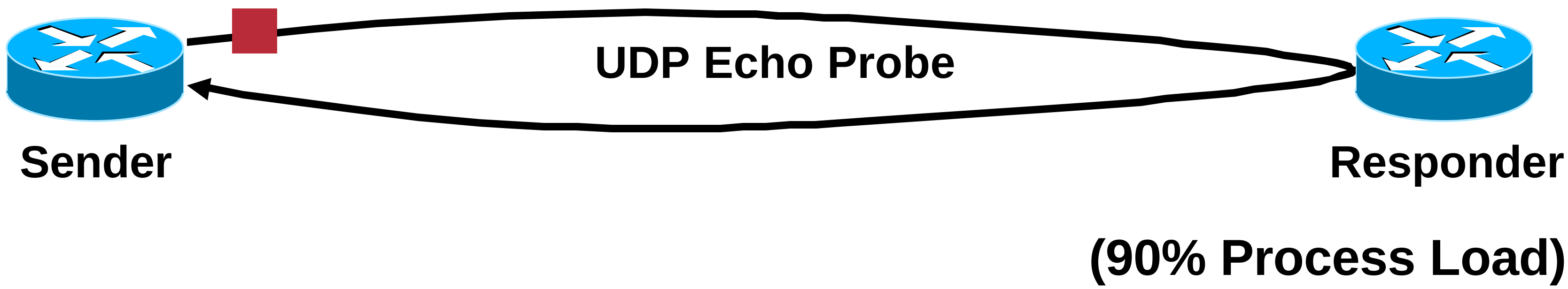
Processing Delay on the Source: Tps = T_5-T_4

Processing Delay on the Destination: Tpd = T_3-T_2

Round Trip Time Delay: T = […] = T_2 - T_1 + T_4 - T_3

- **We have no control of queuing delay on the source and destination, but this is experienced by real traffic too, and must be accounted as such**

IPSLA Accuracy: UDP Echo Probe

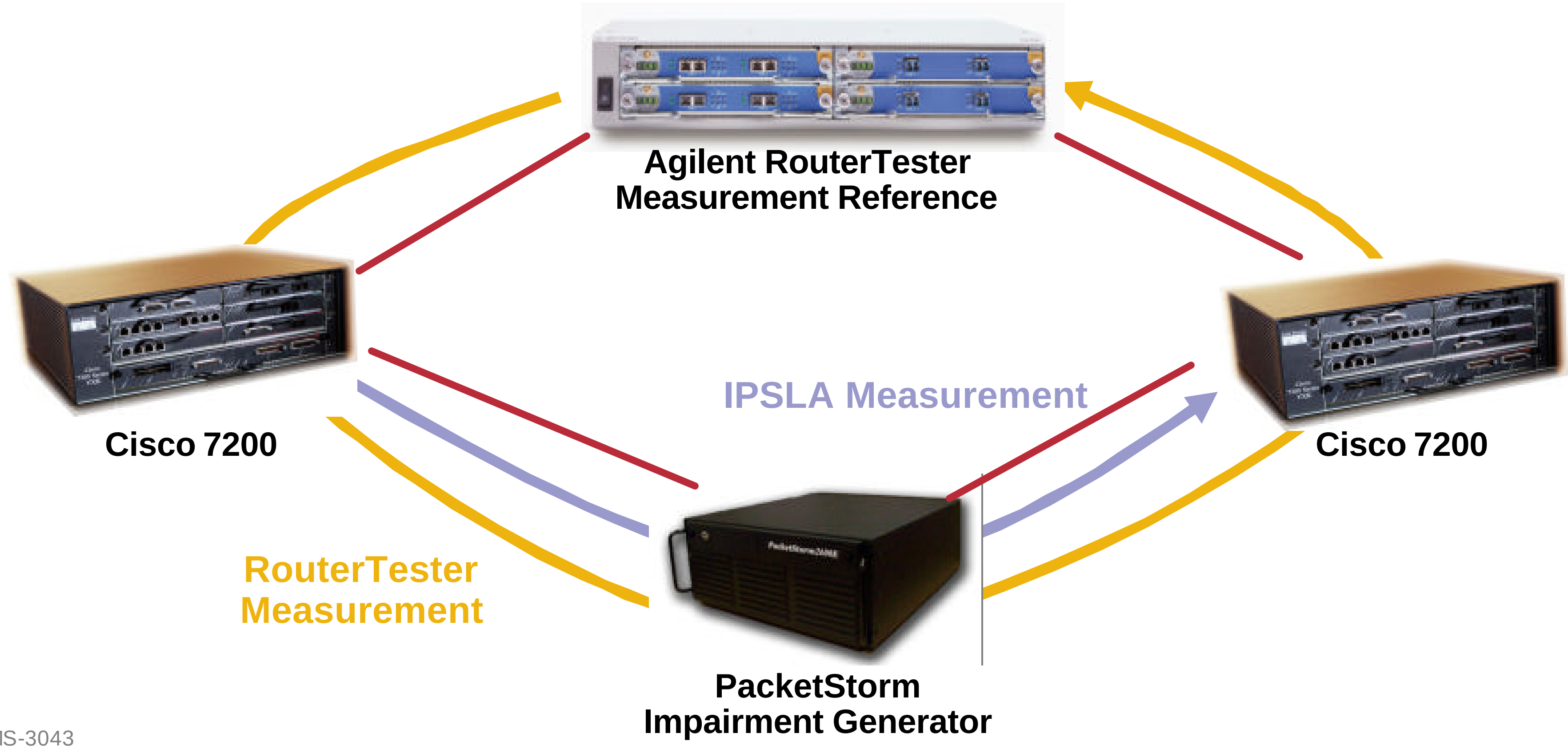


- **With unloaded receiver: 15.0 ms**
- **With 90% CPU receiver: 15.3 ms**

The IPSLA Responder Processing Delay Will Be Subtracted from the Final Results

Absolute Accuracy Tests

- To validate IPSLA's accuracy, we wanted to compare its results with another measurement device
- We've used the following topology:



Test Results

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- **Release used: 12.3(7)T Advanced Enterprise on a Cisco 7200 VXR with NPE400**
- **RouterTester and IPSLA sending packets at the same rate**
- **All results obtained for delay and jitter are in sync with Agilent's result at +- 1 ms**
- **This was expected: it's the Cisco IOS timer granularity**
- **Spikes may happen during high-frequency interrupt events, like writing to NVRAM (write memory)**

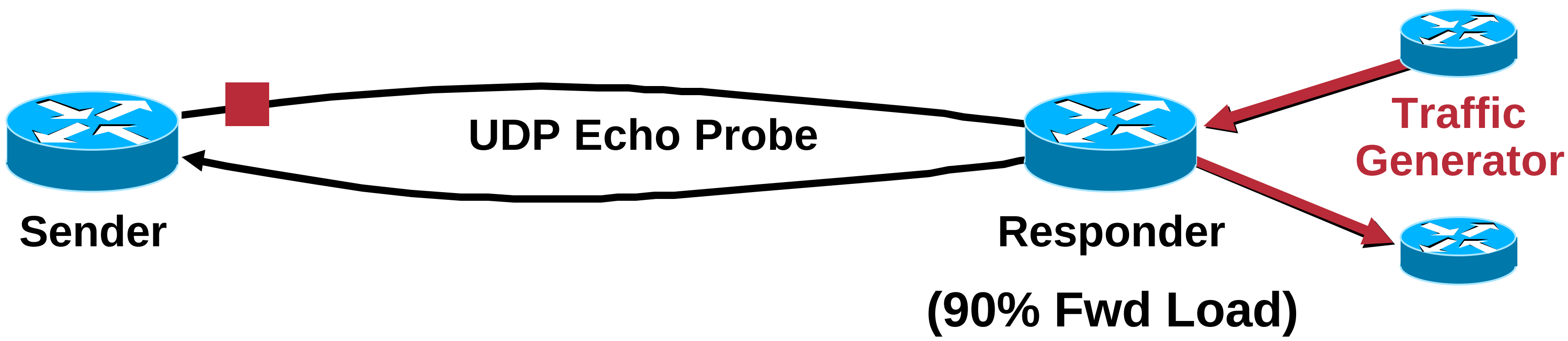
IPSLA Accuracy: The Dilemma

- **A router is, basically, a forwarding machine**
- **IPSLA is a time sensitive application running on a forwarding machine**
- **Cisco IOS uses a non pre-emptive process scheduler**
- **This creates potential issues…**
  but we have solutions

IPSLA Accuracy: ICMP vs. UDP

- As seen before—for RTT accuracy, always use UDP Echo or jitter with IPSLA responder
- Only in this case, processing time spent on the sender and responder routers will be subtracted
- Results more accurate regardless of the sender and receiver CPU process load
- But…if we have a high CPU interrupt load, like packet forwarding on centralized platforms, things may change…

IPSLA Accuracy: Forwarding



- **With unloaded receiver: 100 ms**
- **With 90% CPU receiver, loaded by forwarded traffic: 110 ms**
- **IPSLA timestamping routines are in competition with the forwarded traffic done at Interrupt level**

IPSLA Accuracy: Forwarding Router

- IPSLA may be inaccurate on a router loaded with forwarded traffic
- Reason is that interrupt level code (i.e.: interface) is in competition with IPSLA
- Actual solution: use a dedicated, non forwarding router (called shadow router)

IPSLA Accuracy: Test Results

- Tests have shown good accuracy if the router's forwarding CPU load is below 30%; this is Cisco's recommendation
- Results become unrealistic when the forwarding CPU load reach the 60% utilization
- Process load has a negligible effect on UDP probes; remaining under 60% process load is a comfortable value

Accuracy with TOS-Marked Packets

- **IPSLA probes can be sent with a specific Type of Service (TOS) value**
- **The right precedence will be applied when routing the packet, but what about the sending router?**
- **It depends…**

Accuracy: Per Platform TOS Queuing

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- **Non-distributed platforms and 7500:**

  Locally originated packets with proper TOS marking will go through the same outgoing queuing treatment; so IPSLA packets go through the corresponding WFQ queues

- **For the Cisco 12K (GSR) and 10K (ESR):**

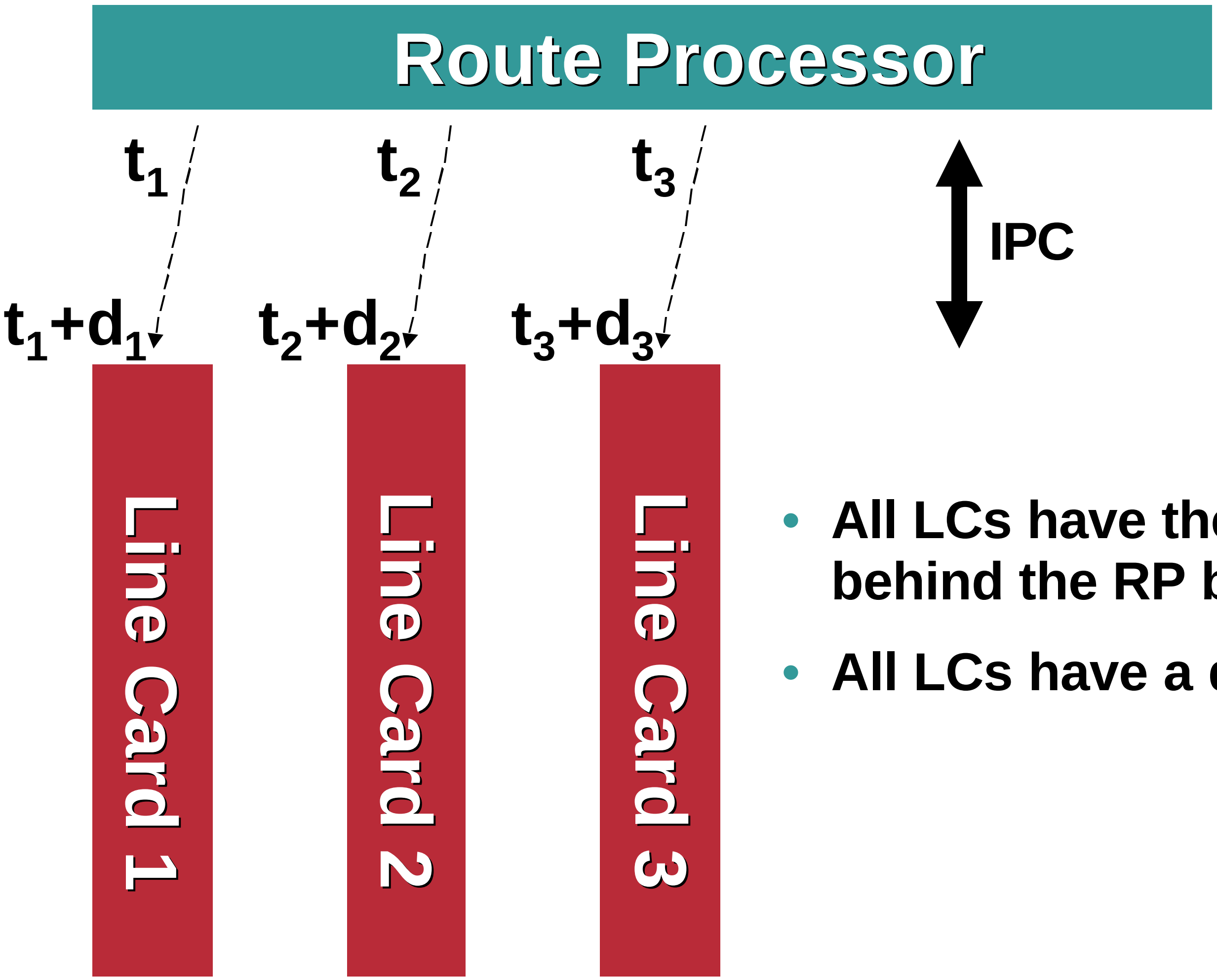
  Queuing is done on the line cards; locally originated packets, like IPSLA probes, are all going to the default queue regardless of their original precedence; the default queue is typically slower

NOTE: On the 12K, This Problem Has Been Fixed in 12.0(28)S

Accuracy: Time on Distributed Platforms

- **Distributed platform have various components like route processor (RP) and line cards (LC)**
- **Each component has its own clock,**
- **With Cisco IPSLA, transmit timestamps are given by the RP, while the receive timestamps are given by the LC**
- **This will potentially create inaccurate results on platforms where the time is distributed**

Example



- All LCs have their time lagging behind the RP by an offset d_x
- All LCs have a different offset

Summary

- **IPSLA uses a special timestamping mechanism at interrupt level**
- **Thanks to this, IPSLA is immune to high CPU load**
- **The absolute tested accuracy is +- 1 ms**
- **If the device is under high forwarding rate, or if it's a distributed platform, IPSLA may lose some accuracy**

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- Performance and Scalability
- New Features
- Design Recommendations
- Get the Most Out of IPSLA
- IPSLA Initiative

IPSLA Performance with Engine 1: CPU Load by Platform

(Jitter Probe Running Eng 1—500 Active Jitter Oper—Cisco IOS 12.2(8)T5)

Oper/ Second	Oper/ Minute	2600	2650XM	3640	3725	7200VXR NPE225
4	240	8	8	8	1	1
8	480	20	7	12	1	1
12	720	34	13	21	3	2
16	960	46	27	28	4	3
20	1200	57	32	35	6	4
24	1440	66	39	42	9	5
28	1680	77	45	49	16	6
32	1920	88	52	56	25	7
36	2160	96	59	58	29	10
40	2400		65	64	34	15
44	2640		71	70	40	21
48	2880		77	76	41	23
52	3120		82	81	45	27
56	3360		96	95	56	31
60	3600				57	35

IPSLA Performance with Engine 2: CPU Load by Platform

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(Jitter Probe Running Eng 2—2000 Active Jitter Oper—Cisco IOS 12.3(3))

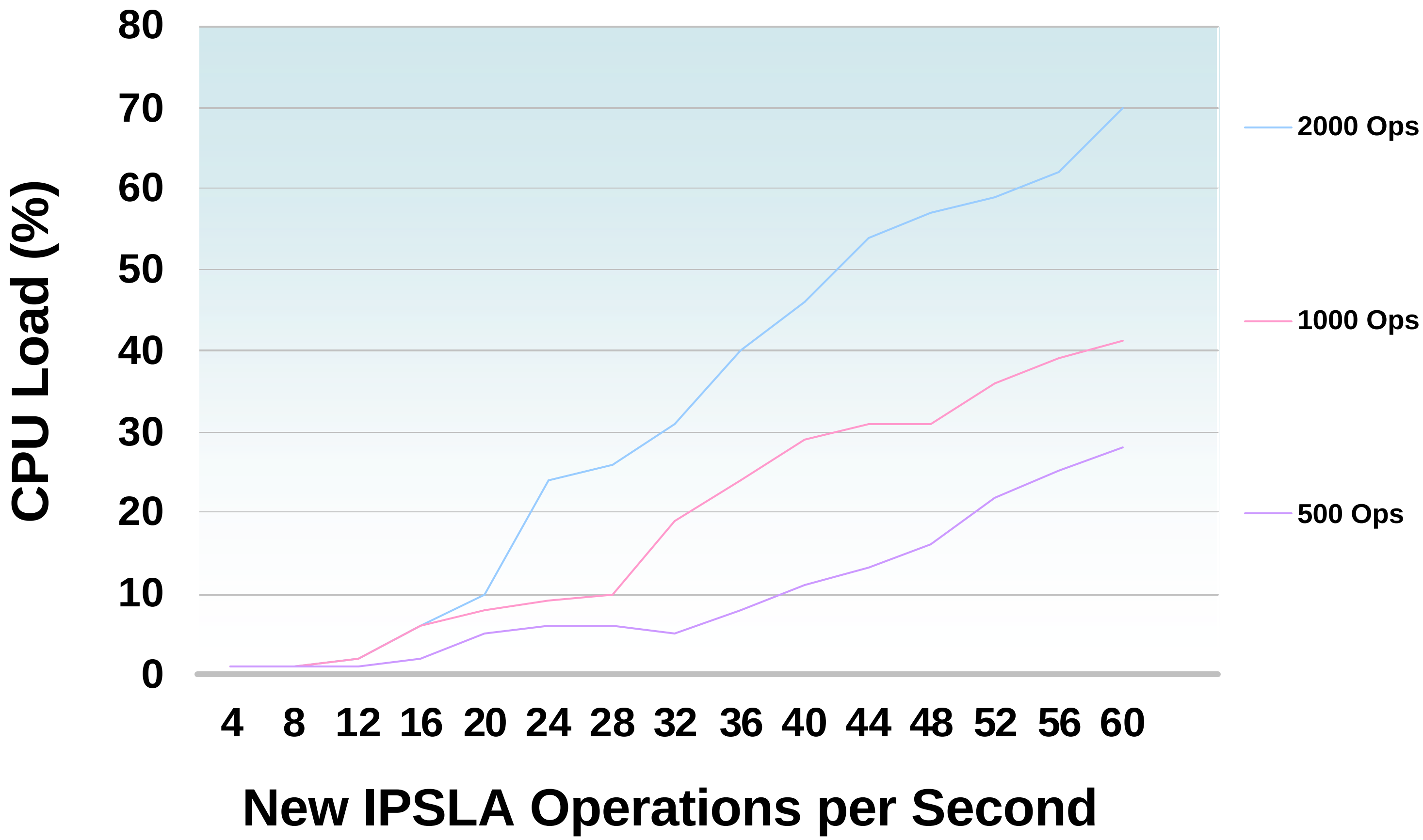
Oper/ Second	Oper/ Minute	2600	2620XM	3640	3725	7200VXR NPE225
4	240	14	7	6	2	4
8	480	20	8	9	3	3
12	720	29	12	13	2	3
16	960	35	15	17	3	3
20	1200	41	19	22	2	3
24	1440	48	24	25	3	3
28	1680	56	27	28	3	3
32	1920	63	28	31	2	4
36	2160	67	31	35	2	3
40	2400		34	38	3	7
44	2640		38	43	4	8
48	2880		42	47	5	8
52	3120		46	49	5	10
56	3360		48	43	6	11
60	3600		52	58	6	11

Relation between Probes and Frequency

- Each operation's results have to be stored into a hierarchical structure
- So, the processing time increases with the number of configured probes
- With the same number of probes starting every second, the higher the configured probes, the higher the CPU

Probes/Frequency: Graphical View

Cisco 7200VXR /NPE-225 Running Eng1 12.2(8)T5



IPSLA Memory Usage

Engine 2 Reduce the Memory Usage by a Factor 2 to 5

	Eng1 12.2(8)T5	Eng2 12.2(13)T
UDP Jitter	< 24 KB	< 12KB
UDP Echo	< 19 KB	< 3.5KB
ICMP Echo	< 17 KB	< 3.2 KB

Summary

- Under normal, a a performance issue with IPSLA is unlikely
- Memory usage is reasonable
- Compared to Engine 1, both performance and memory usage have been improved on IPSLA Engine 2

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IPSLA VoIP: Impairment Factors

- The VoIP Operation will look at various network metrics to calculate a “voice score”
- **Delay** impair the communication interactivity and is extremely annoying
- **Jitter** affects voice quality by causing uneven gaps in the speech pattern of the person talking
- **Packet Loss** causes the receiving codec to either replay the last received packet, or to send white noise

VoIP Operation

- **Newly introduced in Cisco IOS 12.3(4)T—IP VOICE feature set**
- **Modified jitter operation**
- **Reports both Mean Opinion Score (MOS) and Calculated Planning Impairment Factor (ICPIF)**
- **Those results are estimates and should be used for comparison only and should not be interpreted as reflecting actual customer opinions**
- **Supported Codecs:**

  G.711 A Law (g711alaw: 64 kbps PCM compression method)

  G.711 mu Law (g711ulaw: 64 kbps PCM compression method)

  G.729A (g729a: 8 kbps CS-ACELP compression method)

What Is ICPIF?

- Stands for "Impairment Calculated Planning Impairment Factor"
- The ICPIF attempts to quantify, for comparison and planning purposes, the key impairments to voice quality that are encountered in the network
- ICPIF values are expressed in a typical range of 5 (very low impairment) to 55 (very high impairment) ICPIF values numerically less than 20 are generally considered "adequate"
- Note: IPSLA uses a simplified formula which is also used by Cisco Gateways to calculate the ICPIF for received VoIP data streams

ICPIF Scores Meaning

Score	Quality
5	Very Good
10	Good
20	Adequate
30	Limiting Case
45	Exceptional Limiting Case
55	Unacceptable

What Is MOS?

- **IPSLA calculates an estimated value designated as MOS-CQE (Mean Opinion Score; Conversational Quality, Estimated) by the ITU-T in order to distinguish it from objective or subjective MOS values**

MOS Scores Meaning

Score	Quality	Description of Quality Impairment
5	Excellent	Imperceptible
4	Good	Just Perceptible, but Not Annoying
3	Fair	Perceptible and Slightly Annoying
2	Poor	Annoying but Not Objectionable
1	Bad	Very Annoying and Objectionable

IPSLA VoIP: Codec Simulation

- By specifying the codec, IPSLA selects for you a set of default parameters; any default value can be over written

Codec	Packet Payload	Interval	Number of Packets	Frequency
G.711 µ-Law (g711ulaw)	160 + 12 RTP bytes	20 ms	1000	Every minute
G.711 A-Law (g711alaw)	160 + 12 RTP bytes	20 ms	1000	Every minute
G.729A (g729a)	20 + 12 RTP bytes	20 ms	1000	Every minute

VoIP Operation: Sample Configuration

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```
rtr 2
 type jitter dest-ipaddr 10.52.132.71 \
 dest-port 16001 codec g711alaw
rtr schedule 2 life forever start-time now
```

- **Autoconfigured to simulate a G711a codec**
- **1000 packets, interval 20 ms, frequency 1 minute**

VoIP Operation Output

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```
c26f7-15#sh rtr op 2
Entry number: 2
Modification time: 05:39:46.741 UTC Wed Apr 28 2004
Number of operations attempted: 1
Number of operations skipped: 0
Current seconds left in Life: Forever
Operational state of entry: Active
Last time this entry was reset: Never
Connection loss occurred: FALSE
Timeout occurred: FALSE
Over thresholds occurred: FALSE
Latest RTT (milliseconds): 1
Latest operation start time: 05:39:46.744 UTC Wed Apr 28 2004
Latest operation return code: OK
Voice Scores:
ICPIF Value: 0  MOS score: 5.0
RTT Values:
NumOfRTT: 1000  RTTAvg: 1       RTTMin: 1       RTTMax: 3
RTTSum: 1982    RTTSum2: 4018
Packet Loss Values:
PacketLossSD: 0 PacketLossDS: 0
PacketOutOfSequence: 0  PacketMIA: 0    PacketLateArrival: 0
InternalError: 0        Busies: 0
```

Number of Operations

- **Previously, the number of configurable operations on a device was limited to 500 for Engine 1, and 2000 for Engine 2**
- **Now, the number is limited only by the available router memory**
- **Feature committed in 12.3(2)T, 12.3(2) and 12.3(3)B**

Multi-Operation Scheduler

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- Start many operations at once, with automatic smooth “start-time”.
- Introduced 12.3(8)T.
- Example, start operations 1 to 10 within 10 seconds:

```
r1(config)#ip sla group schedule 1 1-10 schedule-period 10 \
             start-time now
r1#sh ip sla op | i start
Latest operation start time: *12:50:51.599 PST Mon Apr 18 2005
Latest operation start time: *12:50:52.599 PST Mon Apr 18 2005
Latest operation start time: *12:50:53.599 PST Mon Apr 18 2005
Latest operation start time: *12:50:34.579 PST Mon Apr 18 2005
Latest operation start time: *12:50:35.579 PST Mon Apr 18 2005
Latest operation start time: *12:50:36.579 PST Mon Apr 18 2005
Latest operation start time: *12:50:37.579 PST Mon Apr 18 2005
Latest operation start time: *12:50:38.579 PST Mon Apr 18 2005
Latest operation start time: *12:50:39.579 PST Mon Apr 18 2005
Latest operation start time: *12:50:40.591 PST Mon Apr 18 2005
```

Improved Accuracy

- New, more accurate, time stamping procedures with microsecond accuracy (compared to millisecond before)
- Requires to configure “precision microseconds” for each operation.
- Introduced in Cisco IOS 12.3(12)T.

```
ip sla 11
 udp-jitter 10.0.0.1 5556
 precision microseconds
ip sla schedule 11 start-time now
```

New CLI

- **Will be introduced in three phases starting with Cisco IOS 12.3(12)T.**
- **Basically a replacement of "rtr" by "ip sla".**
- **Some simplifications for the configuration.**
- **Much better statistics.**

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Class of Service

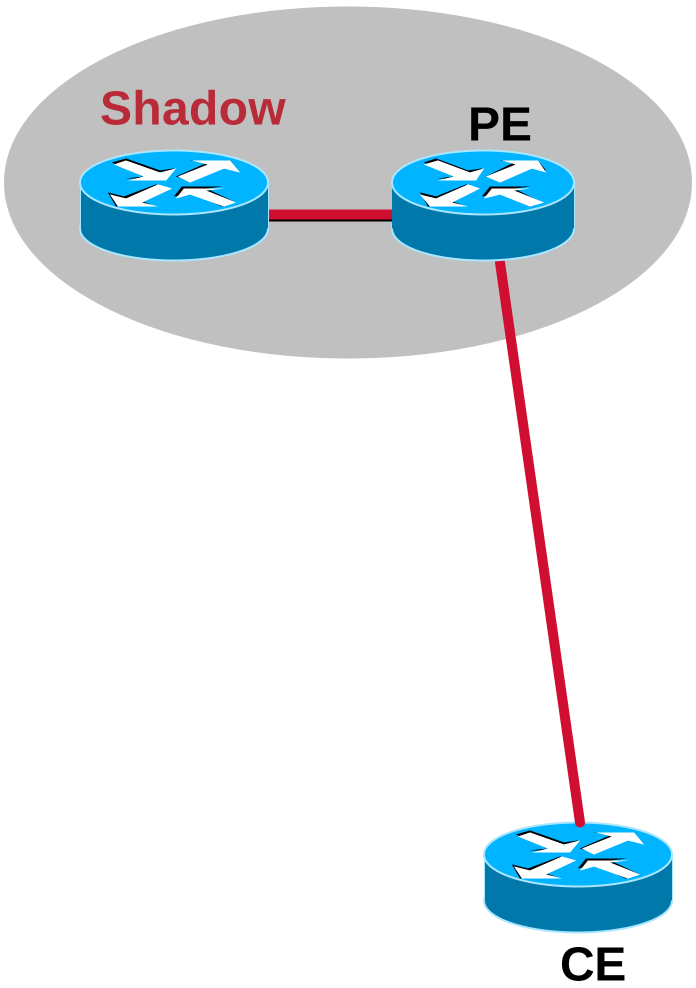
- One operation per class of service
- Traffic coloring from within IPSLA with TOS/DSCP configuration
- Bear in mind the corner case with locally generated and colored traffic on some distributed platforms
- Workaround is to use a Shadow Router (see later)

Why Using a Shadow Router?

- If your Provider Edge (PE) router is already overloaded (> 60% CPU at interrupt level)
- If your PE lacks memory
- If your PE is a distributed platform
- If you want to isolate IPSLA and routing
- If you want to be able to upgrade the IPSLA engine without disturbing the network, then…
- Use a shadow router (router dedicated to IPSLA)

Shadow Router Configuration

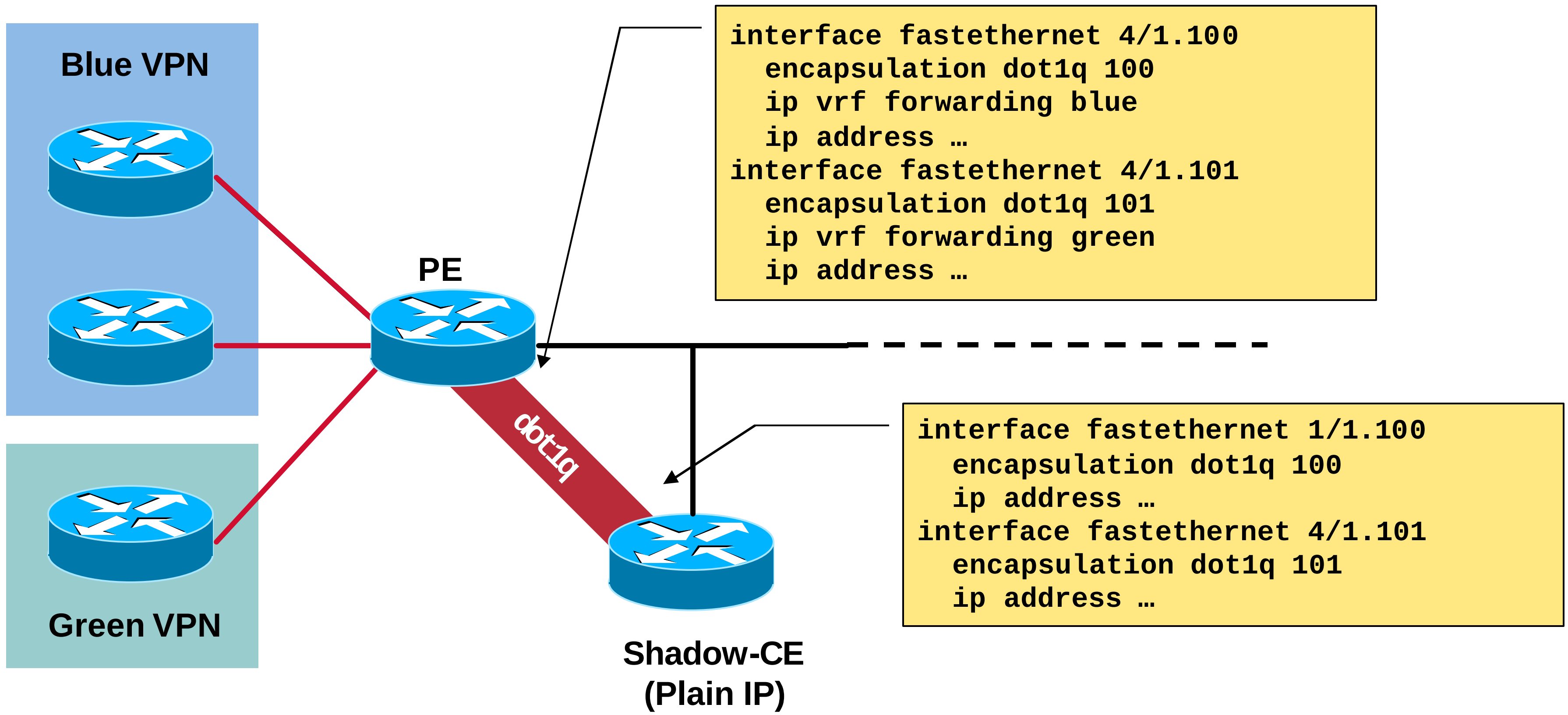
- A shadow router is typically a dedicated router located in the POP who acts like a Customer Edge (CE) device
- It can be connected to the PE via different methods: tunnels, dot1q,…



Shadow-CE

- No VRF notion—only one global routing table
- One plain IP interface per VPN toward the CE device; is there is no VPN, one plain IP connection is sufficient
- Pros: Low-end routers can do it
- Cons: Unable to deal with overlapping IP addresses in multiple VPN

Shadow-CE: Example

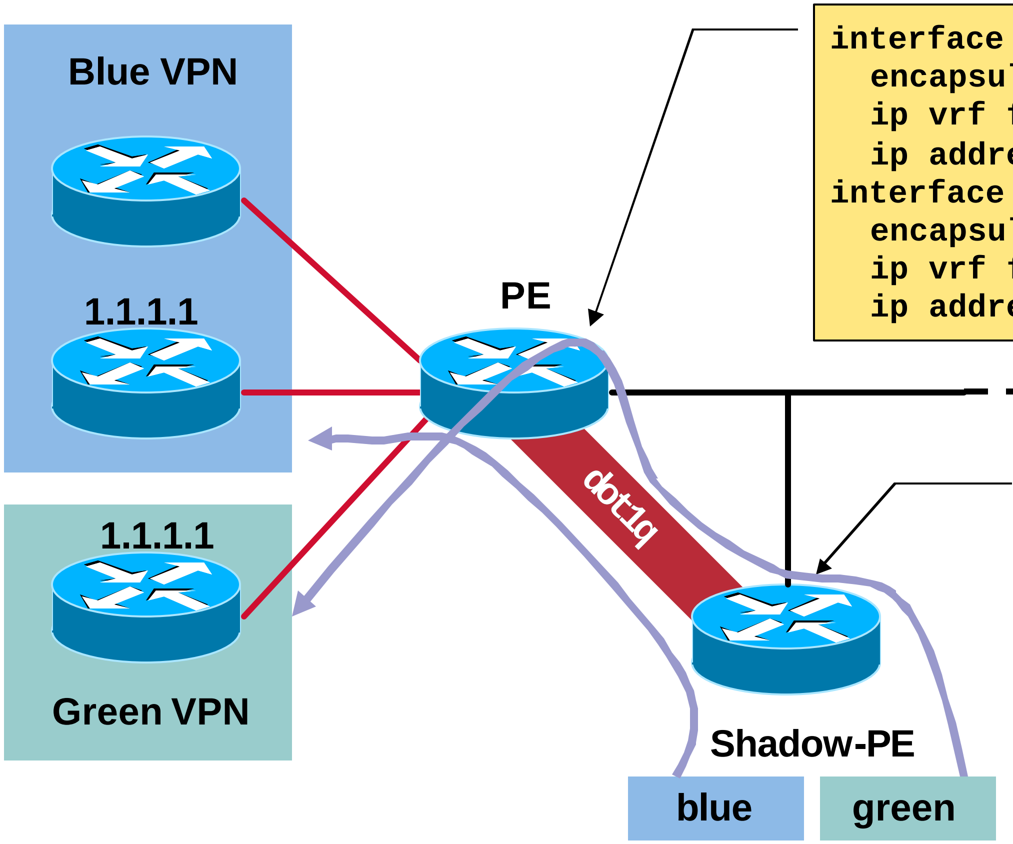


The Shadow-CE Is Using Plain IP To Send Packets
Overlapping IP Addresses Is An Issue In This Case

Shadow-PE

- **The shadow-PE knows multiple VRFs**
- **Full MPLS/VPN with EGP/IGP, or leverage the Multi-VRF/VRF-Lite feature**
- **IPSLA operations are vrf-aware since 12.2(2)T, 12.2(6)S, 12.0(26)S and up**
- **Supported on ICMP Echo, ICMP Path Echo, UDP Echo, UDP Jitter and VoIP operations**
- **Allows separate PE-PE and PE-CE measurements**
- **To configure, use *`vrf vrf-name`* option**

Shadow-PE: Example




```
interface fastethernet 4/1.100
  encapsulation dot1q 100
  ip vrf forwarding blue
  ip address …
interface fastethernet 4/1.101
  encapsulation dot1q 101
  ip vrf forwarding green
  ip address …
```

```
interface fastethernet 1/1.100
  encapsulation dot1q 100
  ip vrf forwarding blue
  ip address …
interface fastethernet 4/1.101
  encapsulation dot1q 101
  ip vrf forwarding green
  ip address …
```

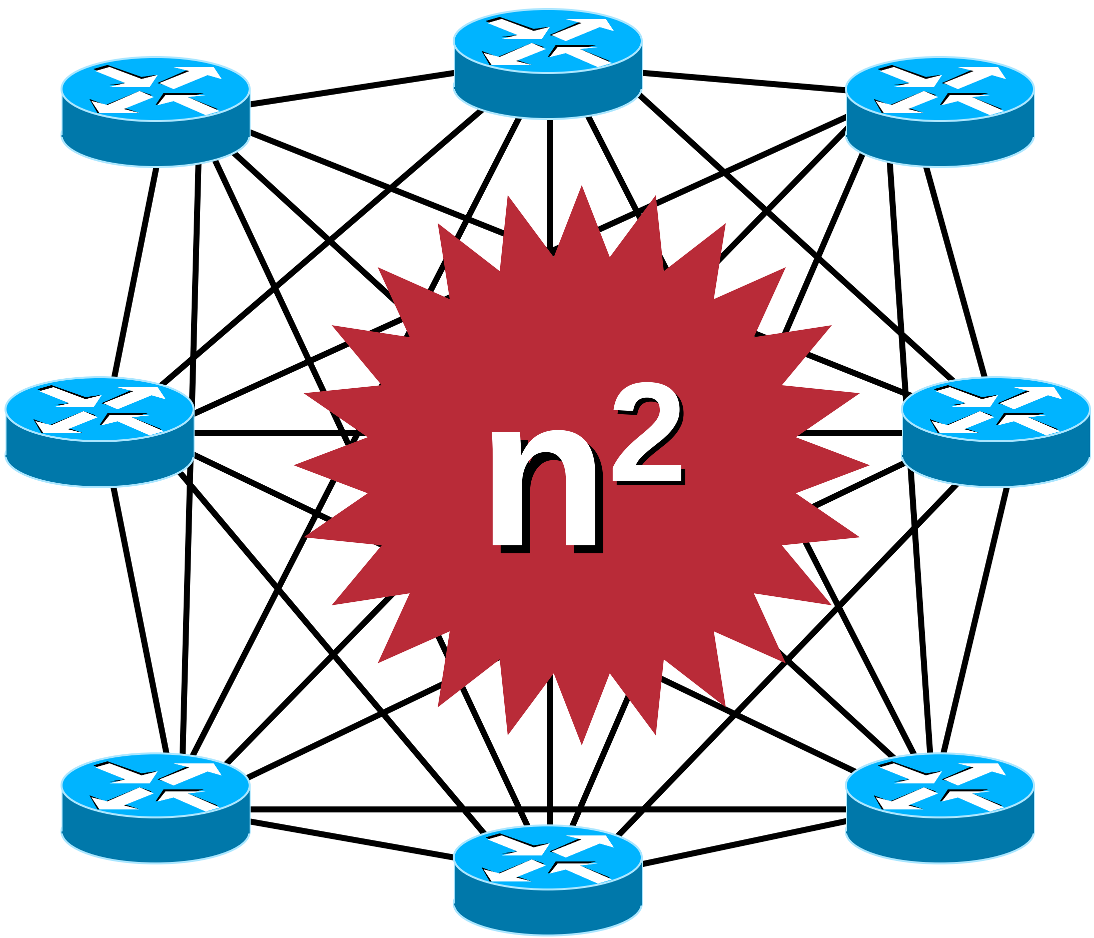
```
rtr 1
 type jitter dest-ipaddr 1.1.1.1 […]
 vrf blue
rtr 2
 type jitter dest-ipaddr 1.1.1.1 […]
 vrf green
```

With This Configuration, the Shadow PE Can Easily Manage Overlapping IP Addresses in VRFs

How to Probe?

- **Full mesh**
- **Partial mesh**
- **Composite SLAs**

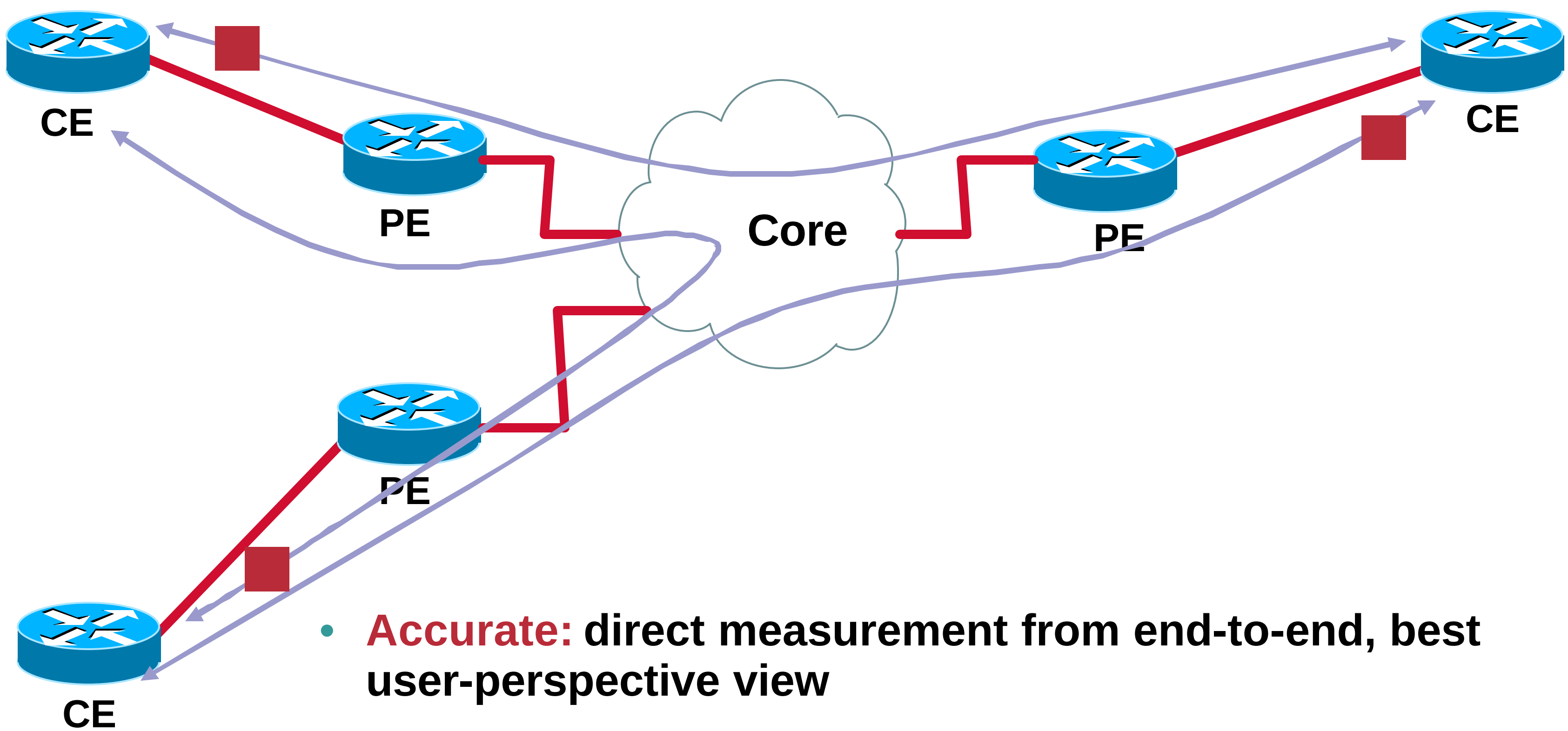
Full Mesh



Nodes	Operation
2	1
3	3
4	6
5	10
6	15
7	21
8	28
…	…
100	4950

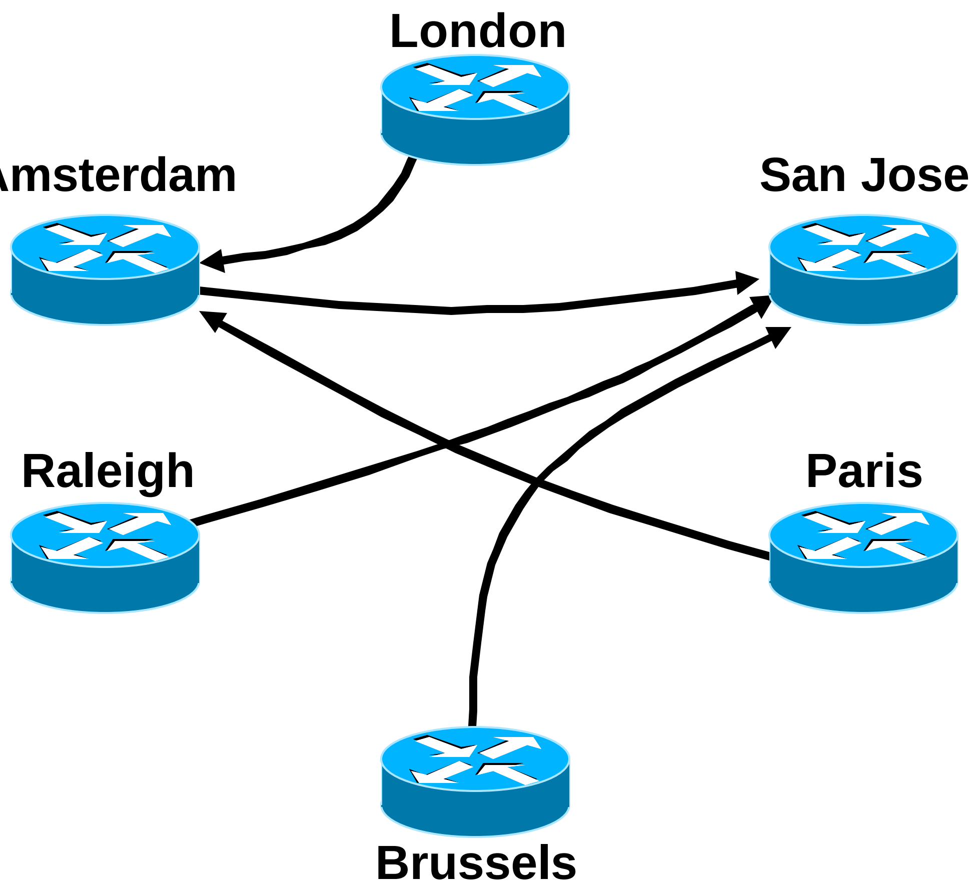
- **Number of operations is proportional to the square of the number of nodes**
- **Does not scale**

Full Mesh CE-to-CE [Example]



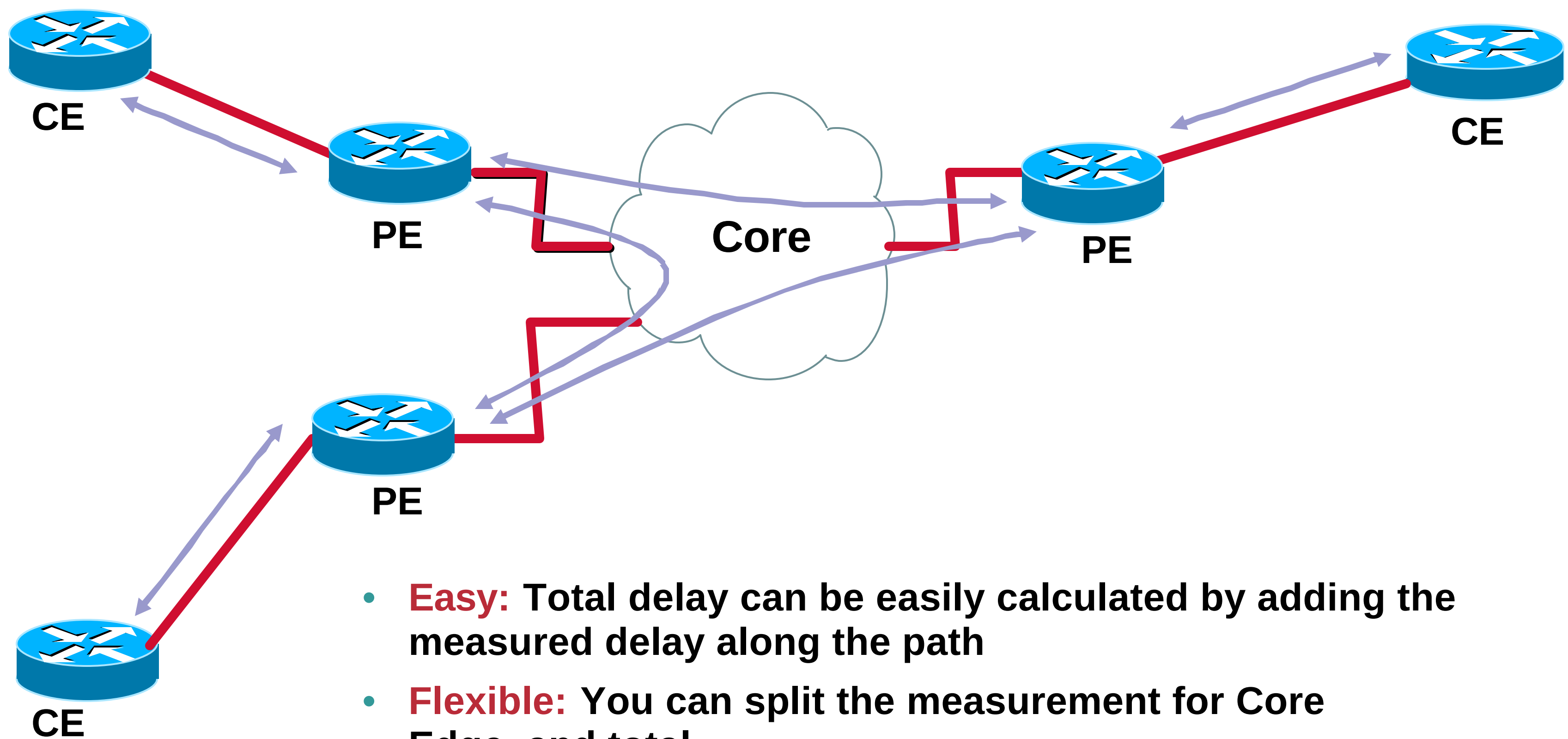
- **Accurate:** **direct measurement from end-to-end, best user-perspective view**
- **Expensive:** **for n nodes, requires n(n-1)/2 operations**
- **In certain cases, it might be difficult to poll the results with SNMP on the CE**

Partial Mesh



- Full mesh is not always desirable
- Select only critical path, like branch offices to headquarters
- Dramatically reduces the number of probes

Composite SLA for Delay [Example]



- **Easy: Total delay can be easily calculated by adding the measured delay along the path**
- **Flexible: You can split the measurement for Core Edge, and total**
- **Measurements are less accurate, as each measurement carry its own error tolerance (typically ± 1 ms per measurement)**

Composite SLA for Packet Drop [1/2]

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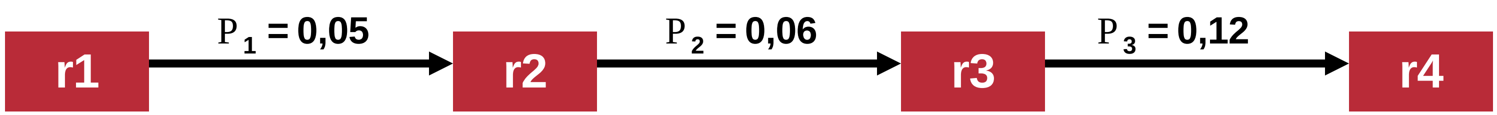
- **A trivial solution might is to consider the sum of drop probabilities; this is conservative**
- **A more accurate approach is to invert the probability of a successful packet delivery**
- **If Π_x is the loss probability across section x, then the total loss probability is:**

$$\Pi_{1\ldots x} = 1 - [(1-\Pi_1).(1-\Pi_2)\cdots(1-\Pi_n)]$$

Composite SLA for Packet Drop [2/2]

Example: We Have Three Sections with Various Drop Probabilities:



- **First solution (approximation):**
  0,05+0,06+0,12=0,23 (23%)
- **Second solution (exact):**
  1-[(1-0,05)x(1-0,06)x(1-0,12)]=0,21416 (21,4%)

Composite SLA for Jitter

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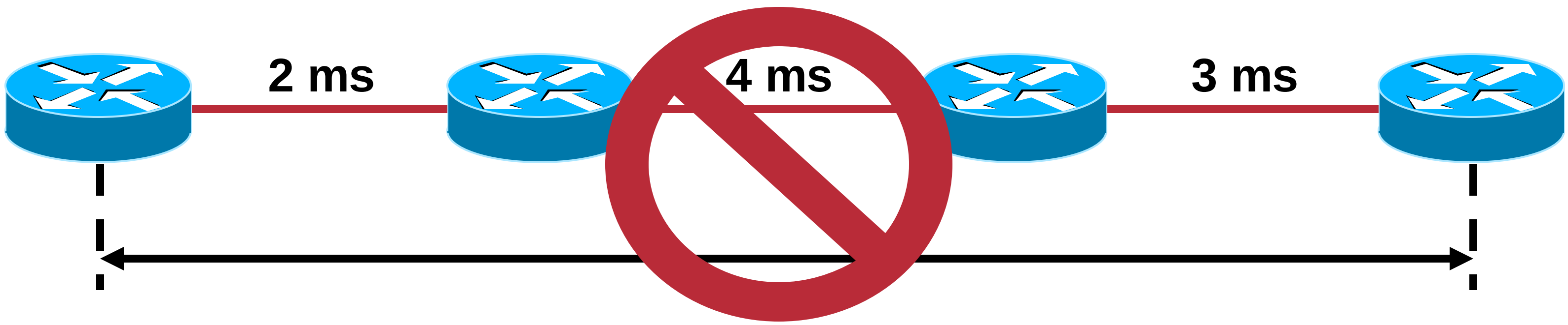

Can We Add a Jitter Value to a Jitter Value?

- **Short answer: NO!**
- **This is not a valid approach to calculate total jitter based on measured jitter, because we don't know how to do it… (jitter is not additive)**
- **Too many factors: positive jitter, negative jitter, percentile-95 of jitter, average jitter,…**
- **You'd better measure it, not calculate it**

Summary

- PE-PE, PE-CE or CE-CE, full-mesh or partial-mesh is all your decision!
- IPSLA can run on almost any existing Cisco router. When this is not possible/desirable then a shadow router is recommended
- Composite SLAs are a good idea while end-to-end jitter results are not required

Agenda

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- Reminder
- IPSLA Accuracy
- Performance and Scalability
- New Features
- Design Recommendations
- **Get the Most Out of IPSLA**
- **IPSLA Initiative**

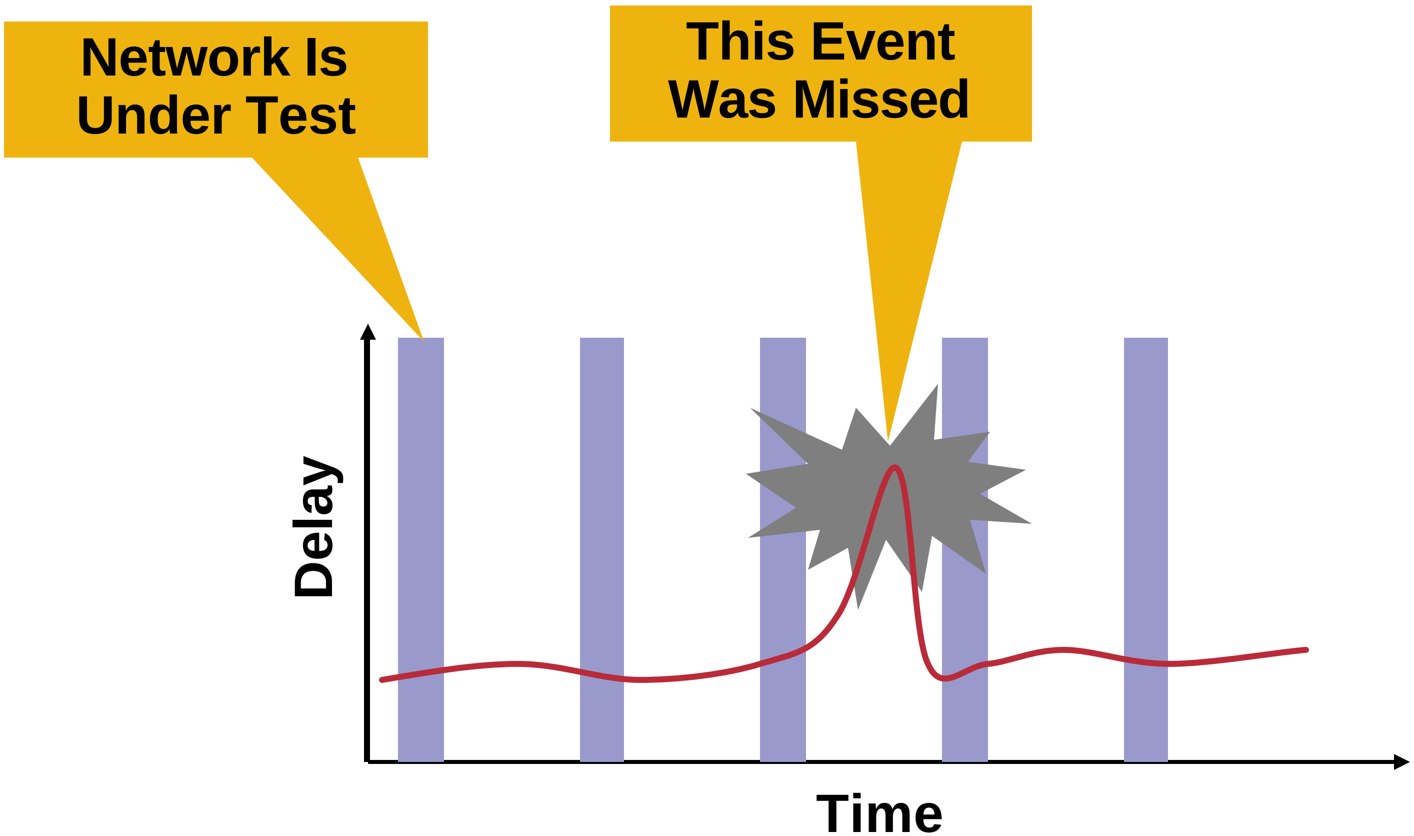
Common Questions…

- How should I configure my operations to accurately measure jitter/delay/packet loss?
- How many packets should be sent per operation?
- How frequently?
- What percentage of by bandwidth should be dedicated for measurement?

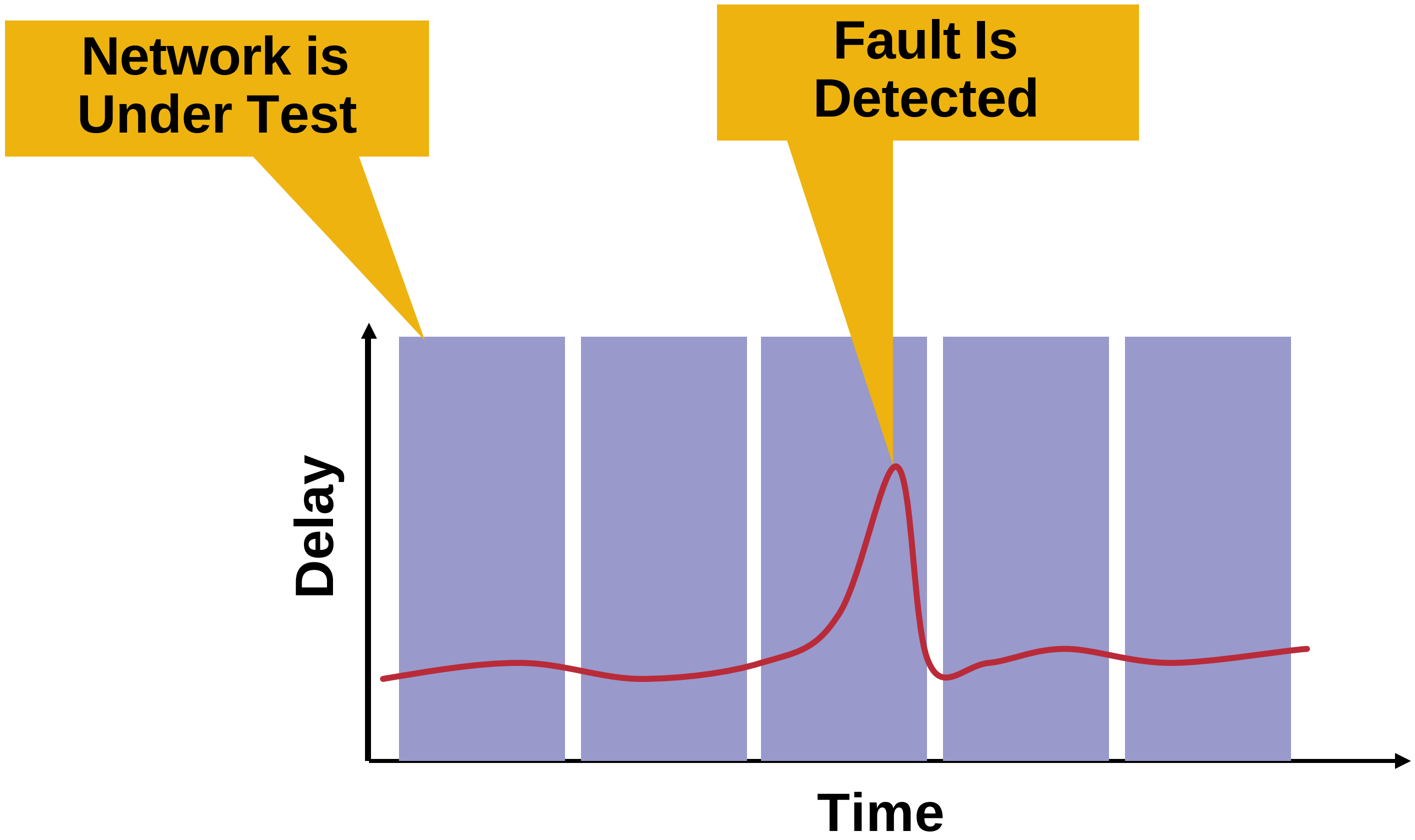
Spectrum of Test

- This is the proportion of time during which the network is under test
- A small spectrum of test means a small probability of catching an event
- For example: running a test for 20 seconds every 60 seconds is equivalent to a 33% spectrum of test

Spectrum of Test



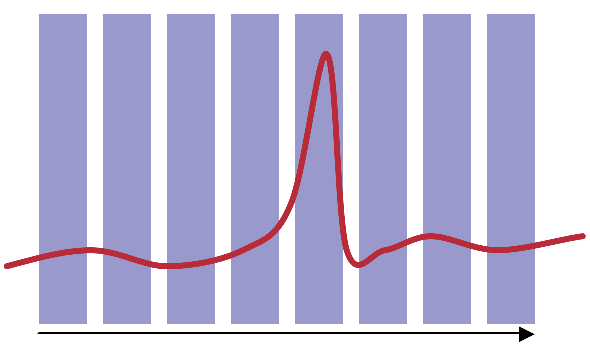
Spectrum of Test



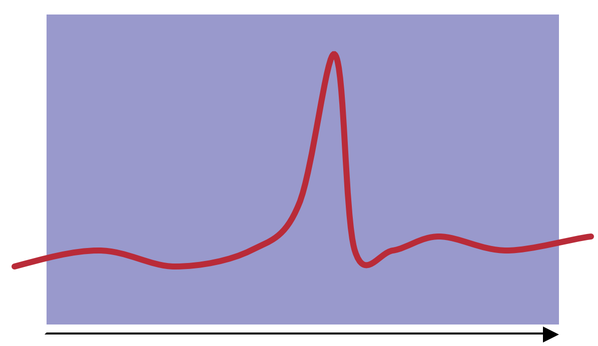
Number of Packets

- **The more packets sent:**
  - **The larger the population**
  - **The more diluted are the results**
- **At identical frequency, the longer the operation, and the wider the test spectrum.**
- **Example of result dilution with the same spectrum, but a bigger number of packets per operation.**

Non-diluted:



Diluted:



Frequency

- **The operation frequency, as well as operation duration, have a direct impact on the SPECTRUM OF COVERAGE**
- **Increasing the frequency will increase your spectrum of coverage, and increase the bandwidth consumed but will not change the accuracy**

Interval

- **The interval is the space between two consecutive probe packets**
- **Long intervals (hundreds of ms) are for trends, and will lead to higher jitter results**
- **Short intervals (low tens of ms) are for very precise measurement, limited in time; the jitter is expected to be smaller in that case**

Interval Effect of Jitter

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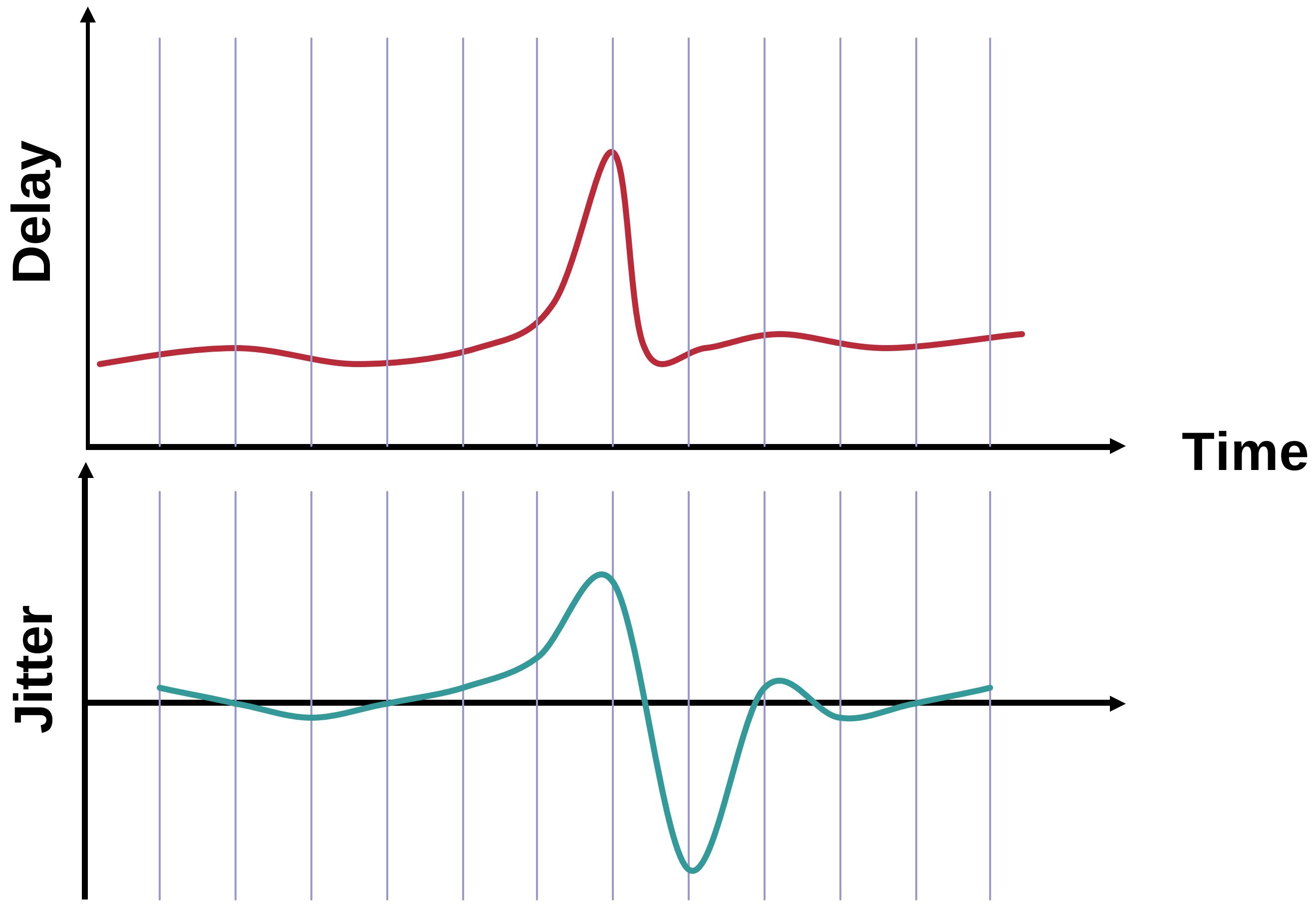
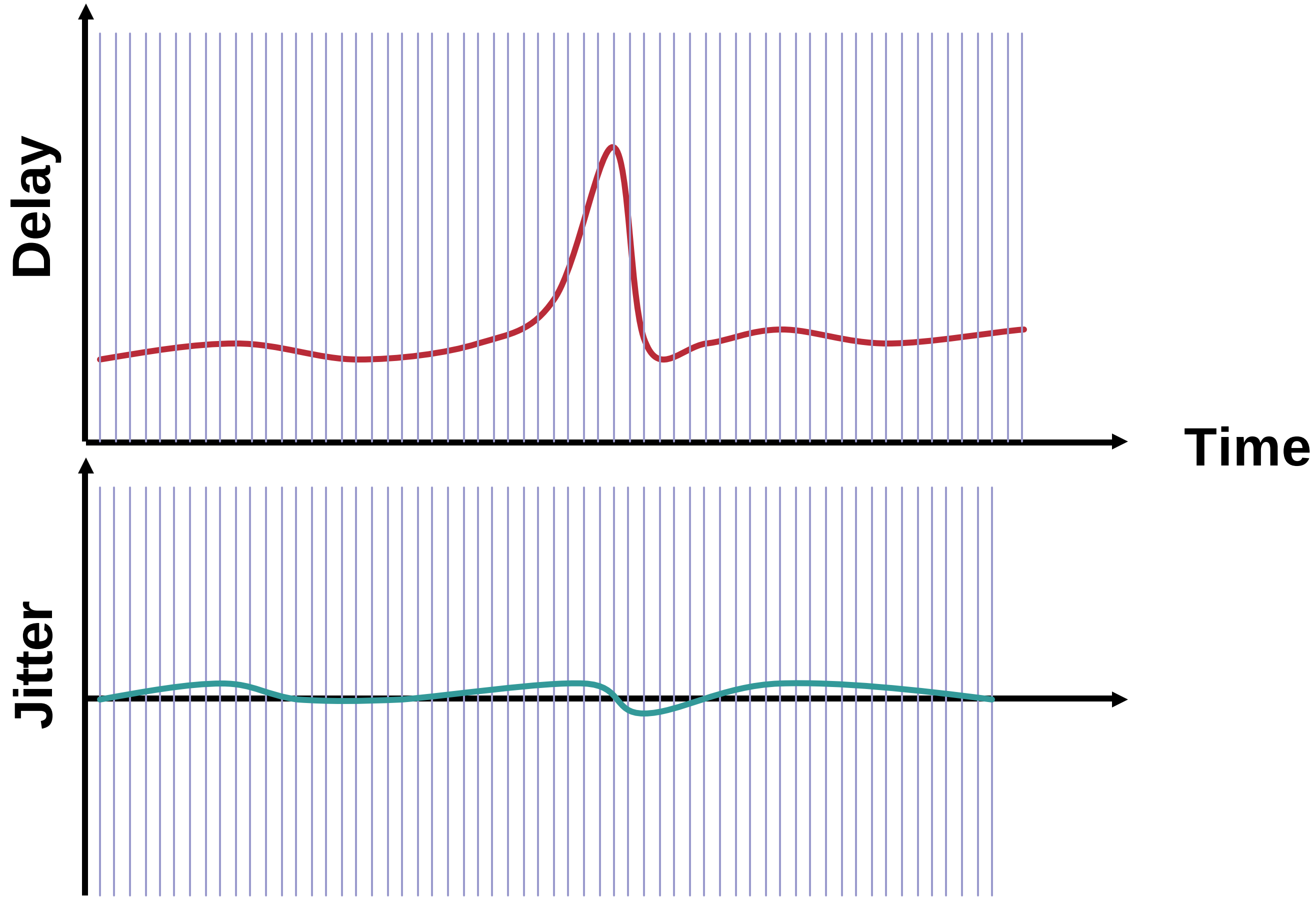
- **Longer intervals ultimately measures bigger jitter, because of coarse granularity:**



Interval Effect of Jitter

- **Shorter intervals measurements are more granular, and hence give less jitter:**



Interval and Jitter

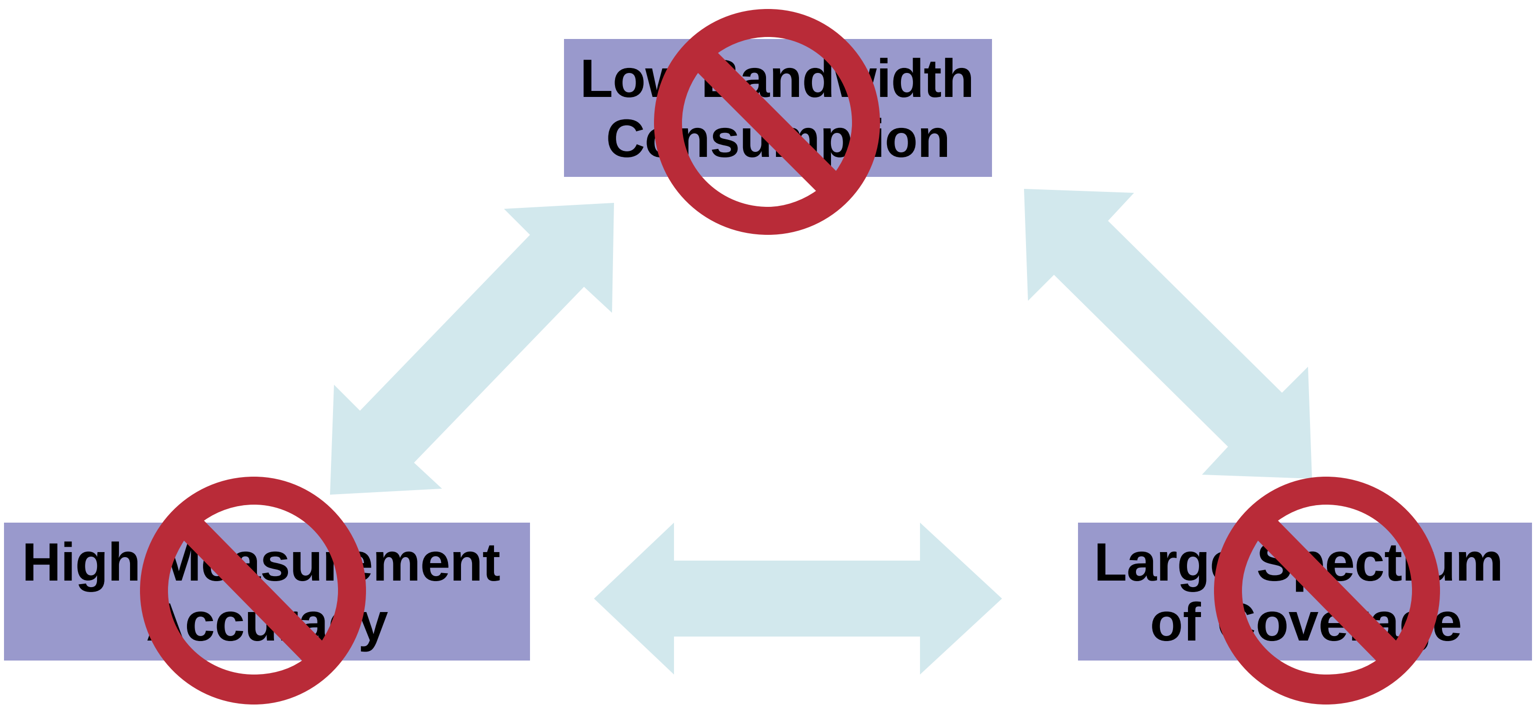
- Compare different jitter measurements ONLY if the measurement intervals are identical
- Short interval is more accurate, but more expensive: use it occasionally to have a true application-like jitter
- Long interval is less accurate, but consumes less bandwidth: use it to expand your test spectrum and keep an eye on your jitter trends

Packet Size

- The main effect of packet size is to modify the SERIALIZATION DELAY
- On fast links, this is negligible compared to the propagation delay, so the packet size has little or not effect but to consume bandwidth
- Use small packets of fast links, like on core network
- Use realistic packets for low-speed access links, where the serialization delay is a factor we need to count

Summary

- **The design will have to accommodate some tradeoffs, you can choose two out of three:**



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Cisco IOS IPSLA Strategic NMS Partners and Applications

- **Cisco Applications**

  CiscoWorks Internetwork Performance Monitor (IPM)

  Cisco IP Solution Center (ISC) — MPLS/VPN

  Cisco InfoCenter (with ISM Module from MicroMuse)

References

Cisco.com

- **Cisco IOS IPSLA home page**

  http://www.cisco.com/go/ipsla

- **For questions related to IPSLA, feel free to write an email to:**

  cs-ipsla@cisco.com

Summary & Conclusion

- IPSLA is a Cisco IOS feature available today to actively measure and report many network metrics.
- It is easy to use, and is supported by many existing network management applications.
- Stay tuned… We have an ambitious roadmap for new features like MPLS integration, better voice measurements and we're always listening your suggestions!

Other Network Management Sessions

- **NMS-1011 - Principles of Fault Management**
- **NMS-1101 - Introduction to SNMP and MIBs**
- **NMS-1204 - Introduction to Network Performance Measurement with Cisco IOS IPSLA**
- **NMS-1601 - Zero Touch Image and Configuration Management**
- **NMS-2042 - Performance Measurement with Cisco Devices**
- **NMS-2051 - Securely Managing Your Network and SNMPv3**
- **NMS-2132 - Cisco Accounting Techniques**
- **NMS-2621 - Cisco IOS XR Software Management for the Cisco CRS-1**
- **NMS-3011 - Getting the Right Events from Network Elements**
- **NMS-3043 - Advanced Network Performance Measurement with Cisco IOS IP SLA**
- **NMS-3108 - DNS Operations**
- **NMS-3132 - Advanced NetFlow Usage**
- **NMS-3301 - Advanced IOS Management Tools**
- **NMS-3601 - Managing your MPLS Core**
- **NMS-3611 - Intelligent Edge Networking**
- **TECNMS103 - MPLS Operations and Management: A Practical Guide (Techtorial)**
- **TECNMS104 - Network Management Best Practices (Techtorial)**
- **BoF-09 - Network Management**

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Muchas gracias.

Session ID: NMS-3043

Advanced Performance Measurements w/Cisco IOS IP SLAs.

Questions?