



NETWORKERS 2004

ADVANCED PERFORMANCE MEASUREMENT WITH CISCO IOS SERVICE ASSURANCE AGENT

SESSION NMS-4043

NMS-4043
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Prerequisites

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- **Before attending this session, familiarities with the Cisco IOS® Service Assurance Agent (SA Agent) is essential**
- **Configuration and generic features will not be covered; this has been covered by NMS-1N04 online session**
- **Only new or advanced topics, as well as design recommendations will be covered**

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Objectives

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- **Understand the internals**
- **New features update**
- **Performance and scalability considerations**
- **How to get the most of SA Agent**
- **SA Agent's future and IP SLA strategic vision**

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This Is Not...

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- **An introduction to SA Agent**
- **Recommendations on QoS configuration**
- **A talk on backend network management applications**
- **A speculation on upcoming features**
- **...a Marketing document**

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Other Network Management Sessions

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- **NMS-1N01—Introduction to Network Management—Networkers On-Line**
- **NMS-1N02—Introduction to SNMP and MIBs—Networkers On-Line**
- **NMS-1N03—Accurate Time Synchronization – Networkers On-Line**
- **NMS-1N04—Introduction to Service Assurance Agent—Networkers On-Line**
- **NMS-1N41—Introduction to Performance Management—Networkers On-Line**
- **NMS-1011—Principles of Fault Management**
- **NMS-1101—Understanding DNS and DHCP**
- **NMS-2001—Network Troubleshooting Tools and Techniques**
- **NMS-2021—Large Scale Deployments of CiscoWorks**
- **NMS-2031—Traffic Accounting Scenarios**
- **NMS-2032—NetFlow for Accounting, Analysis and Attack**
- **NMS-2042—Performance Measurement with Cisco Devices**
- **NMS-2051—Securely Managing Your Network**
- **NMS-2102—Deploying and Troubleshooting NAT**
- **NMS-2101—DNS Deployment and Operation**
- **NMS-3011—Getting the Right Events from Network Elements**
- **NMS-4012—MPLS Embedded Management Tools**
- **NMS-2T00—Network Management Best Practices—Techtorial**

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Agenda

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- **Reminder**
- **SA Agent Accuracy**
- **Performance and Scalability**
- **New Features**
- **Design Recommendations**
- **Get the Most Out of SA Agent**
- **IP SLA Initiative**

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REMINDER ON SA AGENT



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Technical Overview

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- **Wide measurement capabilities (UDP, TCP, ICMP,...)**
- **Millisecond precision (do 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)—no additional cost**
- **Almost all interfaces supported, physical and logical**

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Reminder

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- **SAA 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**

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UDP Jitter Operation

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- **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 SAA responder**

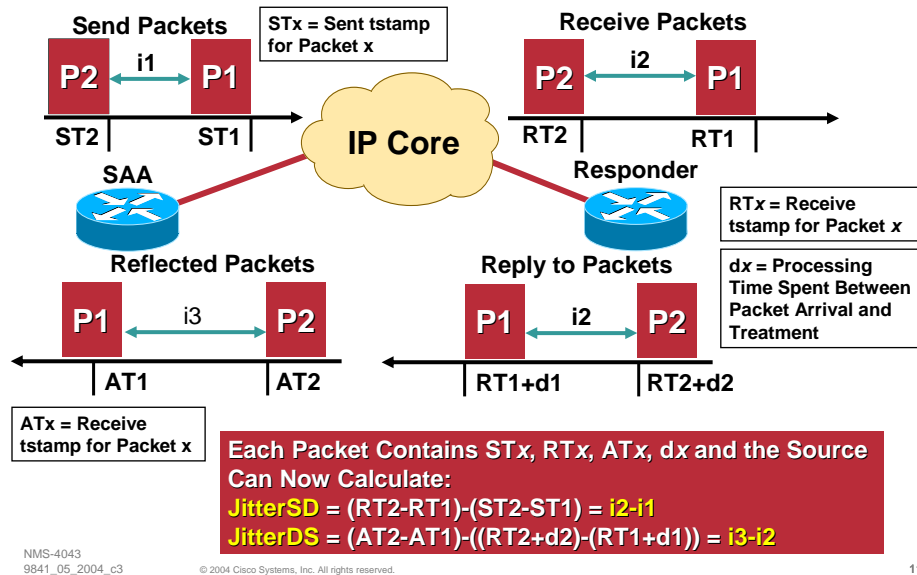
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UDP Jitter: Measurement Example

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UDP Jitter Operation Jitter Computation

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- 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

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UDP Jitter Operation One-Way Delay Computation

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- One-way delay measurement requires the clocks on source and target routers synchronized; the measurement accuracy will depend upon correct time synchronization
- Use a Global Positioning System (GPS) device connected on the auxiliary port of a 7200 like Trimble Acutime 2000; GPS requires clear-sky view: not always feasible
- NTP server with Reference Clock (stratum 1) on the same LAN as your router will do it too
- Other solutions exists, and there are corner cases; don't underestimate this problem! For more information on time synchronization techniques, check session NMS-1N03
- We recommend a maximum of 120 ms per direction for comfortable human to human voice communication

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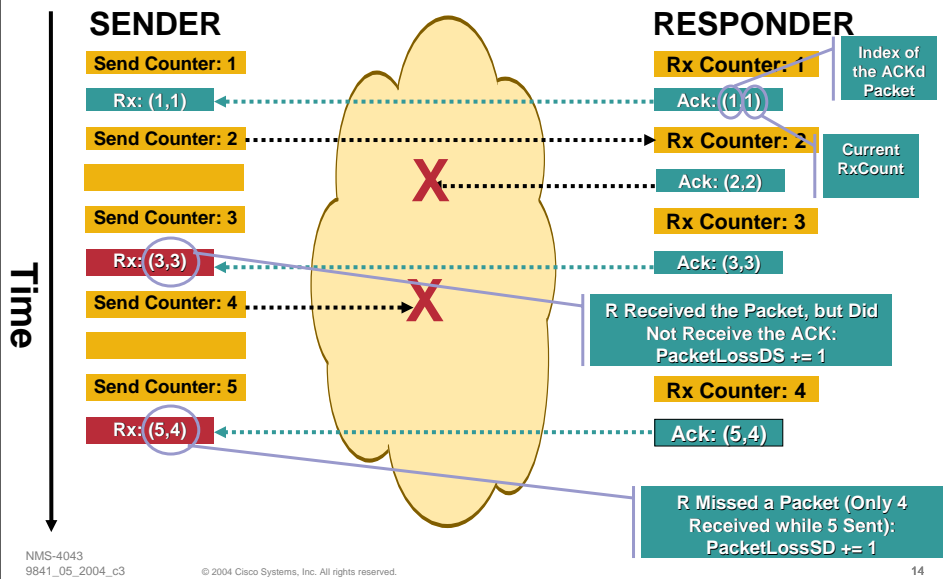
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UDP Jitter Operation Packet Loss

RESULT:
PacketLossSD = 1
PacketLossDS = 1

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UDP Jitter Operation (Example)

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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

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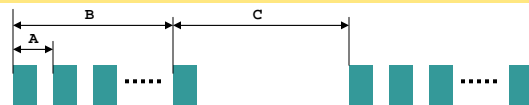
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UDP Jitter Operation (Example)

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- Simulating G.711 VoIP call
- Use RTP/UDP ports 16384 and above, the packet size is 200 bytes (160 bytes of payload + 40 bytes of header)
- 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 200
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)

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UDP Jitter Operation (Output) [1/3]

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```

etychon-vpn#sh rtr op 1
      Current Operational State
Entry Number: 1
      Latest Operation Time: 08:22:34.000 PDT Thu Aug 22 2002
3 Packets Lost S->D :
out of 1000 Sent      Entry 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
      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...)
  
```

Average RTT Was
 $458111/997 = 459\text{ms}$

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UDP Jitter Operation (Output) [2/3]

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```

(...cont)
Jitter Values:
MinOfPositivesSD: 1   MaxOfPositivesSD: 19
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
  
```

Source to
Destination Jitter

Destination to
Source Jitter

See Next Slide.

No Synchro Between
Clocks: All Zeroes

Follow RFC1889 (RTP) to
Measure Jitter with Noise
Reduction

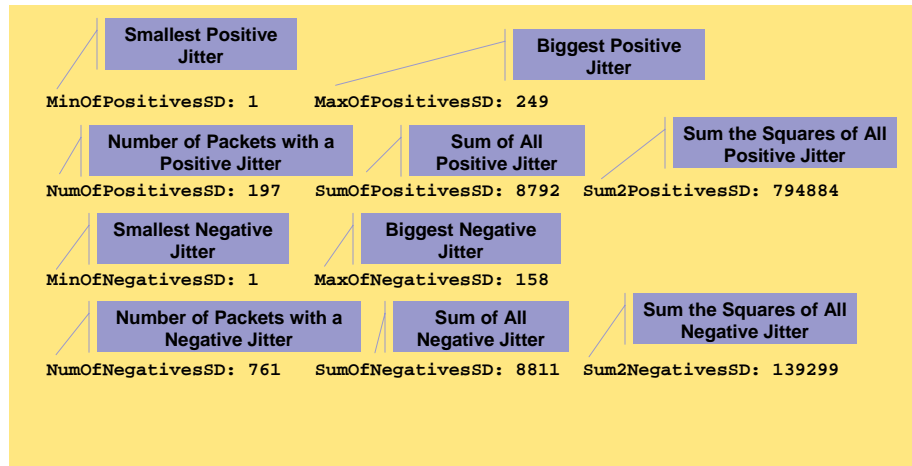
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UDP Jitter Operation (Output) [3/3]

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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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Agenda

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- Reminder
- **SA Agent Accuracy**
- Performance and Scalability
- New Features
- Design Recommendations
- Get the Most Out of SA Agent
- IP SLA Initiative

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SAA ACCURACY TESTS



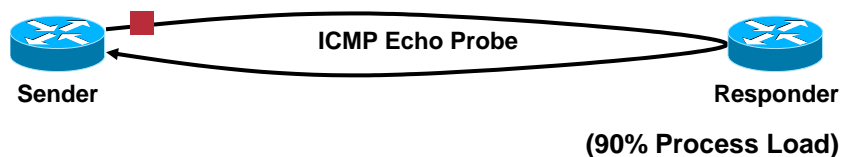
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SAA Accuracy...ICMP Echo Probe

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- With unloaded receiver, SAA 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...

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Processing Time Measurement

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- 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 SA Agent, this mechanism is implemented for both UDP Echo and UDP Jitter probes

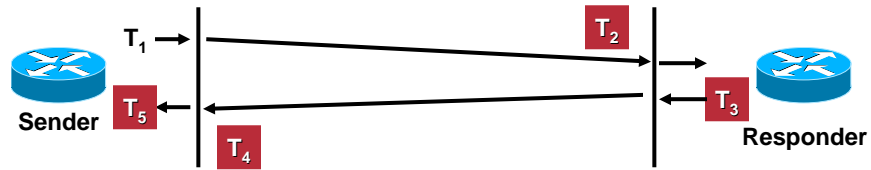
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UDP Echo Operation (With SAA Responder)

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Processing Delay on the Source: $T_{ps} = T_5 - T_4$

Processing Delay on the Destination: $T_{pd} = T_3 - T_2$

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

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

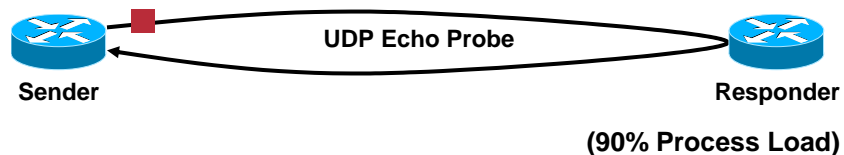
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SAA Accuracy: UDP Echo Probe

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

The SAA Responder Processing Delay Will Be Subtracted to the Final Results

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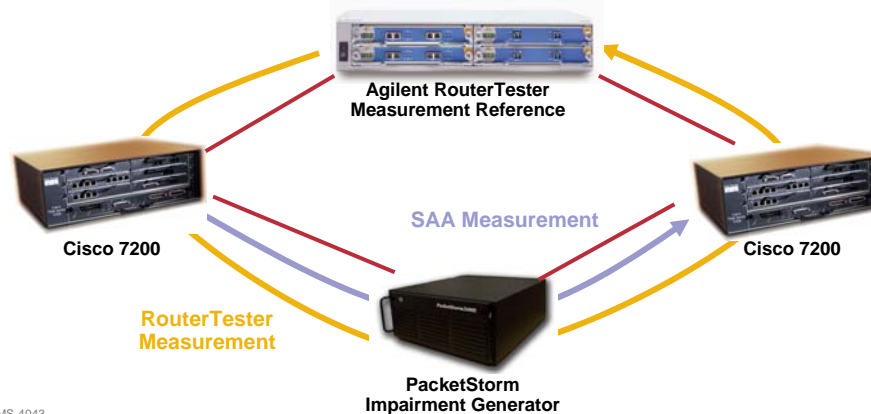
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Absolute Accuracy Tests

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



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Test Results

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- Release used: 12.3(7)T Advanced Enterprise on a Cisco 7200 VXR with NPE400
- RouterTester and SAA 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)

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SAA Accuracy: The Dilemma

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- A router is, basically, a forwarding machine
- SAA 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

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SAA Accuracy: ICMP vs. UDP

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- As seen before—for RTT accuracy, **always use UDP Echo or jitter with SAA 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...

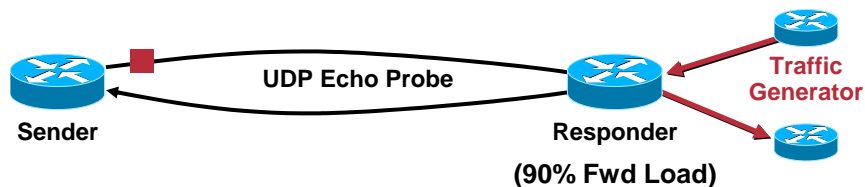
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SAA Accuracy: Forwarding

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

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SAA Accuracy: Forwarding Router

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

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SAA Accuracy: Test Results

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- 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

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Accuracy with TOS-Marked Packets

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- SAA 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...

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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 SA Agent 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 SAA 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

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Accuracy: Time on Distributed Platforms

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- **Distributed platform are having various components like route processor (RP) and line cards (LC)**
- **Each of these components is having its own clock,**
- **With Cisco SA Agent, 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**

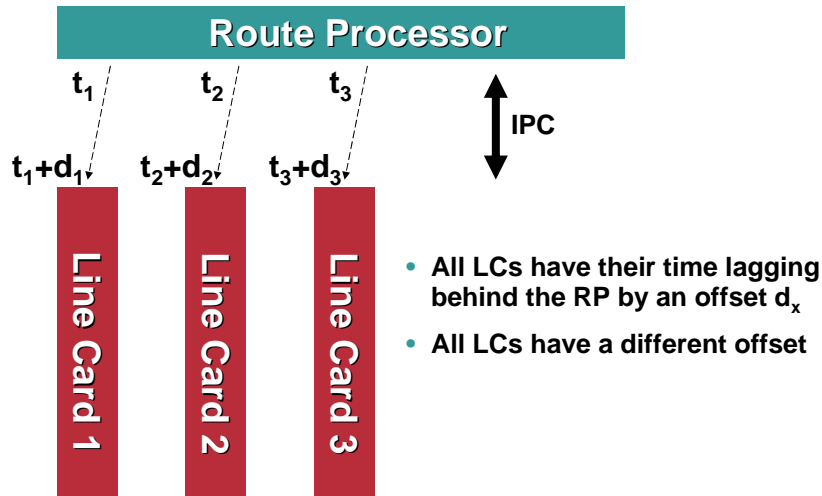
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Example

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Summary

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- SA Agent uses a special timestamping mechanism at interrupt level
- Thanks to this, SA Agent 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, SA Agent may lose some accuracy

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Agenda

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- Reminder
- SA Agent Accuracy
- **Performance and Scalability**
- **New Features**
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- **IP SLA Initiative**

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PERFORMANCE AND SCALABILITY CONSIDERATIONS



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SAA Performance with Engine 1: CPU Load by Platform

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(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

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SAA 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

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Relation between Probes and Frequency

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

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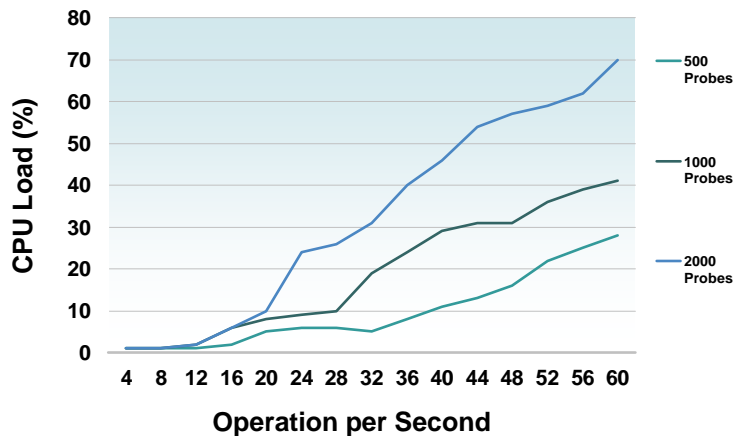
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Probes/Frequency: Graphical View

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



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SAA Memory Usage

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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

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Summary

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- Under reasonable operation it is unlikely to hit a performance issue with SA Agent
- Memory usage is reasonable
- Compared to Engine 1, both performance and memory usage have been improved on SA Agent Engine 2

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NEW FEATURES UPDATE



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SAA VoIP: Impairment Factors

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- 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



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VoIP Operation

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- 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)

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What Is ICPIF?

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- 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: SAA uses a simplified formula which is also used by Cisco Gateways to calculate the ICPIF for received VoIP data streams

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ICPIF Scores Meaning

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

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What Is MOS?

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

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MOS Scores Meaning

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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

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SAA VoIP: Codec Simulation

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- By specifying the codec, SAA 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 mu-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

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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 G711u codec
- 1000 packets, interval 20 ms, frequency 1 minute

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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 Buses: 0
```

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Number of Operations

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- 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

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Agenda

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- Reminder
- SA Agent Accuracy
- Performance and Scalability
- New Features
- **Design Recommendations**
- **Get the Most Out of SA Agent**
- **IP SLA Initiative**

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DESIGN RECOMMENDATIONS



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Class of Service

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- One operation per class of service
- Traffic coloring from within SAA 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)



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Why Using a Shadow Router?

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- If your Provider Edge (PE) router is already overloaded
- If your PE lacks memory
- If your PE is a distributed platform
- If you want to isolate SAA and routing
- If you want to be able to upgrade the SAA engine without disturbing the network, then...
- Use a **shadow router (router dedicated to SAA)**

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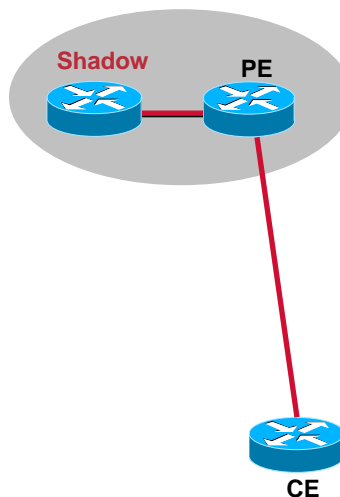
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Shadow Router Configuration

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- 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,...



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Shadow-CE

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

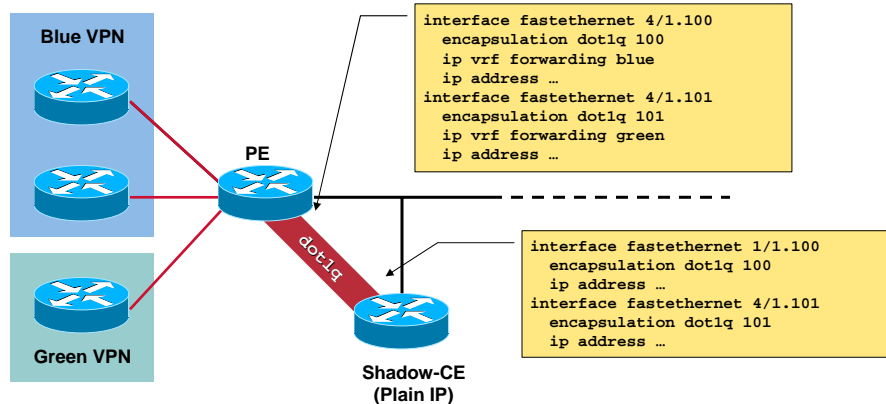
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Shadow-CE: Example

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

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Shadow-PE

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- The shadow-PE is having the knowledge about multiple VRFs
- Full MPLS/VPN with EGP/IGP, but it's better to leverage the Multi-VRF/VRF-Lite feature
- SAA 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

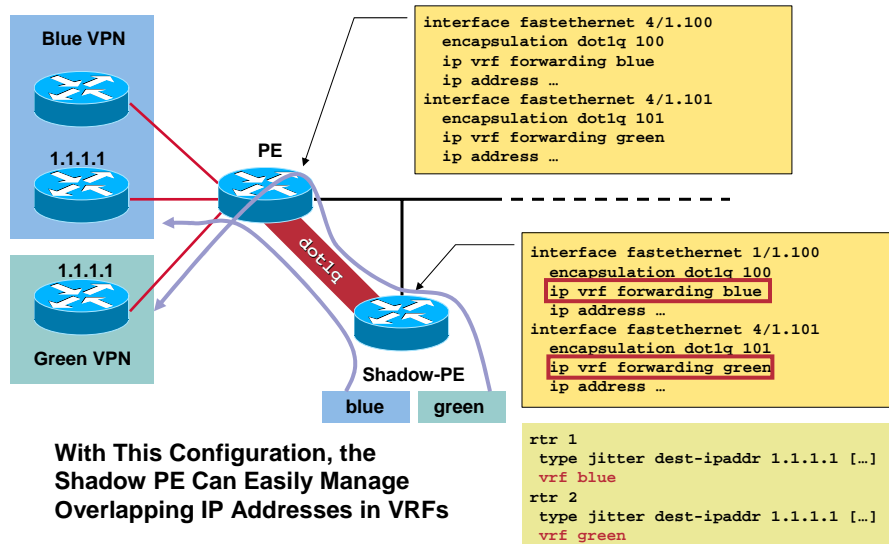
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Shadow-PE: Example

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How to Probe?

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- Full mesh
- Partial mesh
- Composite SLAs

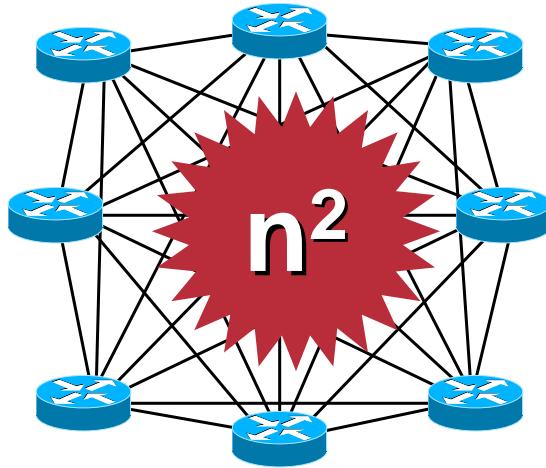
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Full Mesh

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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

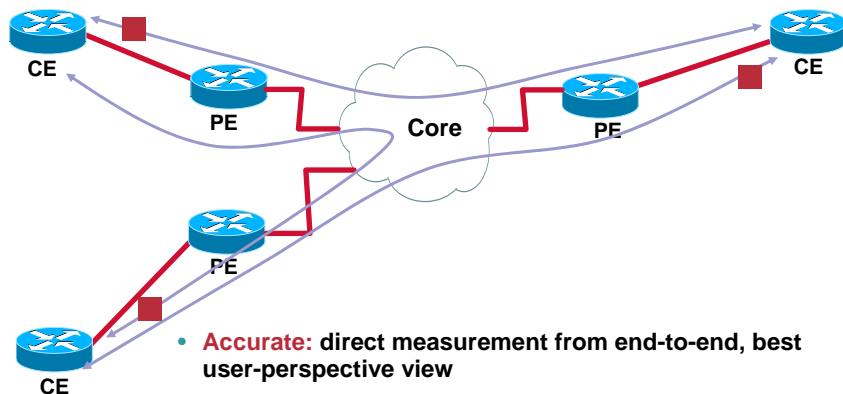
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Full Mesh CE-to-CE [Example]

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- **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

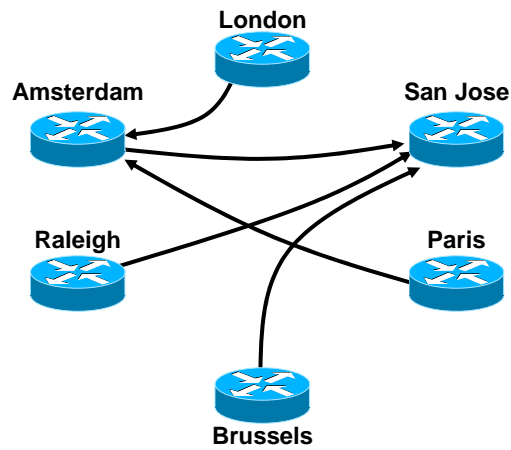
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Partial Mesh

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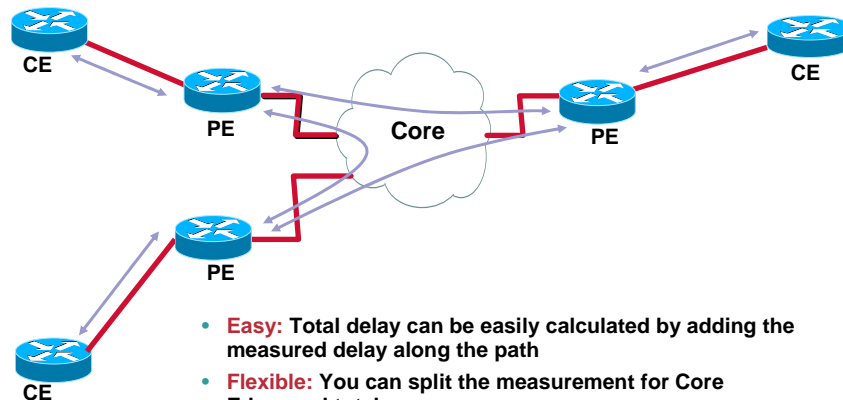
- Full mesh is not always desirable
- Select only critical path, like branch offices to headquarters
- Dramatically reduces the number of probes

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Composite SLA for Delay [Example]

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- **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)

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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:

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

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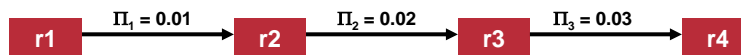
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Composite SLA for Packet Drop [2/2]

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Example: We Have Three Sections with Various Drop Probabilities:



- **First solution:**
 $0.01 + 0.02 + 0.03 = 0.06$ (6%)
- **Second solution:**
 $1 - [(1 - 0.01) \cdot (1 - 0.02) \cdot (1 - 0.03)] = 0.058906$ (5.8%)

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Composite SLA for Jitter

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- 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

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Load Balancing Scenario

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- For performance measurement: configure the operation **on the balancing router** and force the source IP address to the outgoing interface
- For connectivity and monitoring: you can use loose source routing

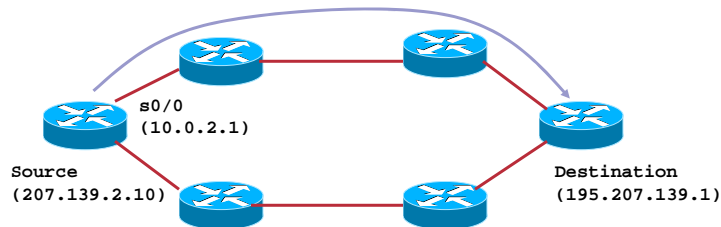
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Load Balancing Scenario (Force Source)

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Solution 1: Force the Source IP Address to Egress Interface

Drawback: Need to Be Configured on the Balancing Router, and No Guarantee That the Return Path Will Be the Same Unless You Policy-Route

Example:

```
rtr 3
type echo protocol ipIcmpEcho 195.207.139.1 \
source-ipaddr 10.0.2.1
rtr schedule 3 start-time now
```

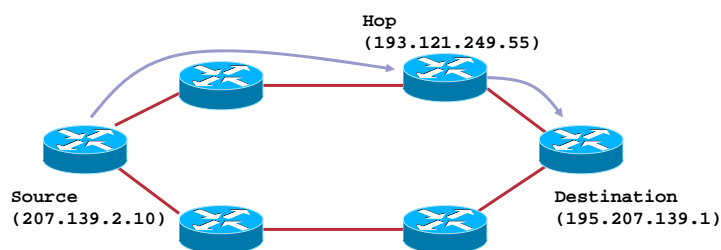
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Load Balancing Scenario (LSR)

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Solution 2: Specify An Intermediate Hop with Loose Source Routing (LSR)

Drawback: LSR packets Are Process Switched, Not for Measurement But Only for Connectivity; Return Path Will Be the Same (IP feature)

Example:

```
rtr 3
type echo protocol ipIcmpEcho 195.207.139.1
lsr-path 193.121.249.55
rtr schedule 3 start-time now
```

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Summary

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- PE-PE, PE-CE or CE-CE, full-mesh or partial-mesh is all your decision!
- SA Agent can run on almost any existing 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

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Agenda

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- Reminder
- SA Agent Accuracy
- Performance and Scalability
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- Design Recommendations
- **Get the Most Out of SA Agent**
- IP SLA Initiative

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HOW TO GET THE MOST OUT OF SA AGENT?



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Common Questions...

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- **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?**

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Spectrum of Test

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

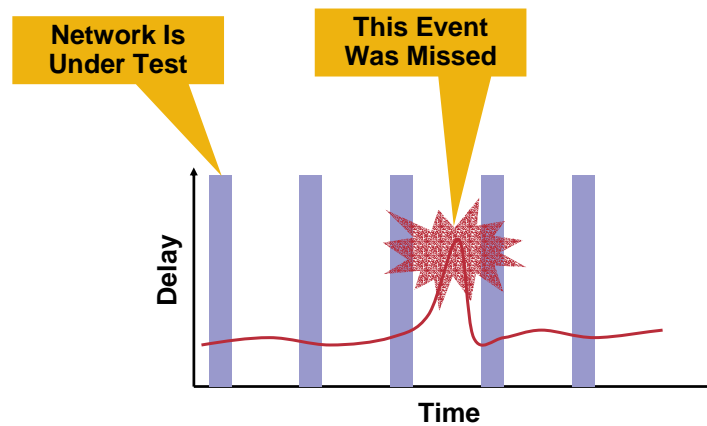
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Spectrum of Test

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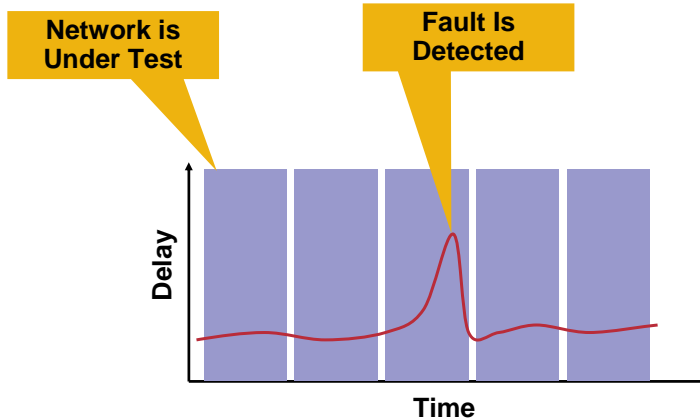
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Spectrum of Test

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Number of Packets

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- The more packets sent, the larger the population
- The more diluted are the results (looking more to an “average” or “trend”)
- At identical frequency, the longer the operation, and the wider the test spectrum

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Frequency

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- 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, increased the bandwidth consumed but will not change the accuracy

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Interval

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- 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

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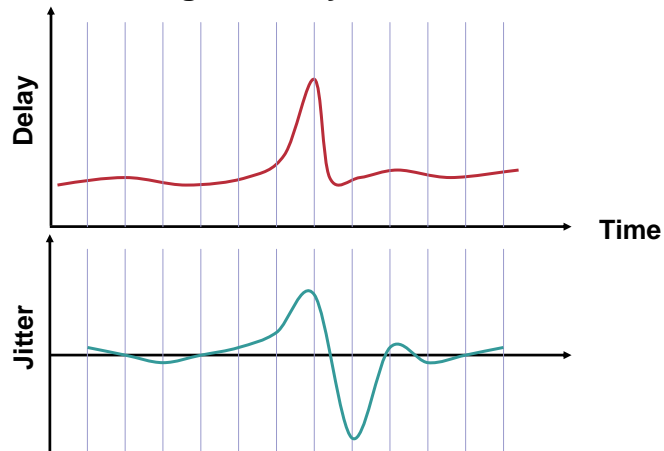
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Interval Effect of Jitter

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



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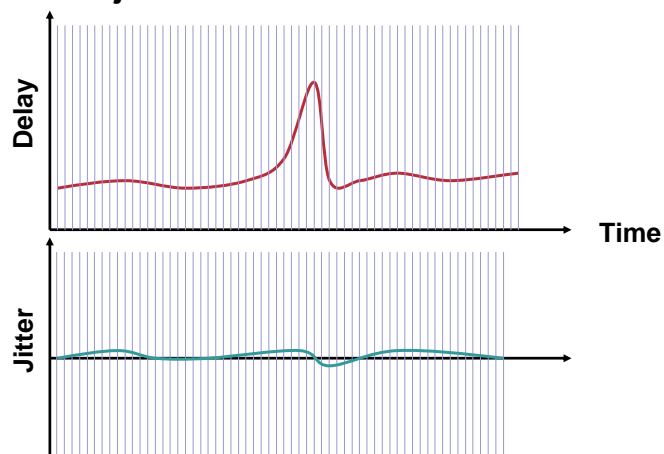
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Interval Effect of Jitter

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- Shorter intervals measures more granular, and hence smaller jitter



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Interval and Jitter

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- 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

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Packet Size

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- 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 core network
- Use realistic packets for low-speed access links, where the serialization delay is a factor we need to count

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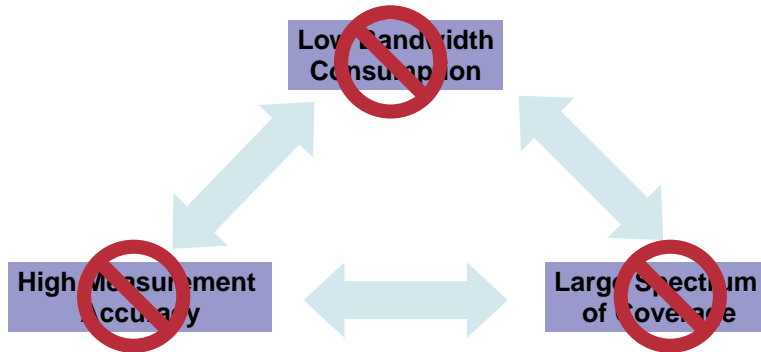
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Summary

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- The design will have to accommodate with some tradeoffs, mainly those three affirmations will never be true at the same time:



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Agenda

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- Reminder
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- Performance and Scalability
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- **IP SLA Initiative**

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SAA PARTNERS AND IP SLA INITIATIVE



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Cisco IOS IP SLA Strategic NMS Partners and Applications

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- **Cisco Applications**

CiscoWorks Internetwork Performance Monitor (IPM)

ISC—MPLS/VPN and IPsec VPN

Tunnel Builder-Pro—MPLS Traffic Engineering

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SLA Challenges

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- **Delivering service levels is an increasingly complex task**
- **Today's SLAs may not guarantee services**
 - Lack of strict SLA metrics means decreased service differentiation and service quality
- **No clear understanding of what metrics need monitoring in multiservice networks**
 - Standardized jitter measurement is not established
 - Best practices for measurement parameters not fully established: Packet size, packet spacing, measurement frequency...

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“THE MISSION FOR CISCO IP SLA—PROVIDE EMBEDDED IOS FUNCTIONALITY TO ASSURE IP SERVICE LEVELS, PROACTIVELY VERIFY NETWORK OPERATION AND ACCURATELY MEASURE NETWORK PERFORMANCE.”

TOM ZINGALE, IP SLA PRODUCT MANAGER

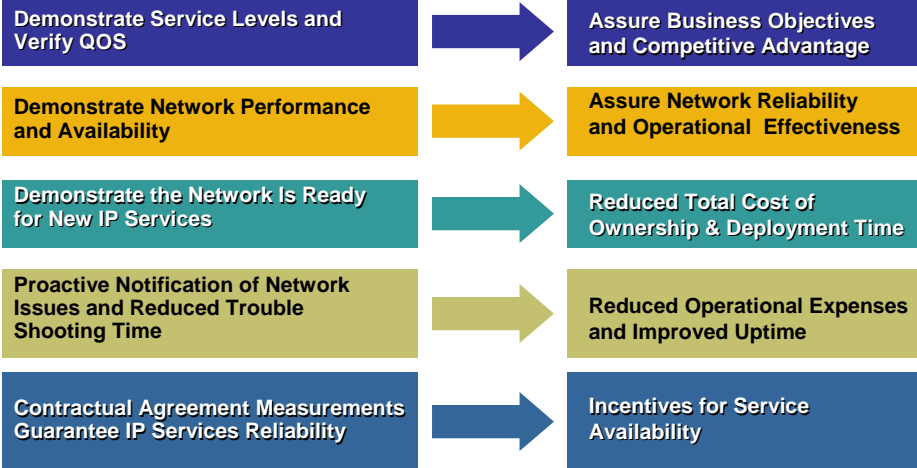
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Benefits of IP SLA Monitoring with SAA

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Cisco "IP SLA" Goals

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- Automate SLA measurements for IP Services, MPLS, VPN, VoIP and Video
- Define SLA metrics and methodology
 - Standardized jitter measurement
 - Best practices for measurement parameters
 - Packet size, packet spacing, measurement frequency...
 - NTP designs for unidirectional measurements
- Standardize how to measure the SLA metrics
 - New research for SLA metrics including work in IETF (IPPM WG)
- High accuracy and highly granular measurements

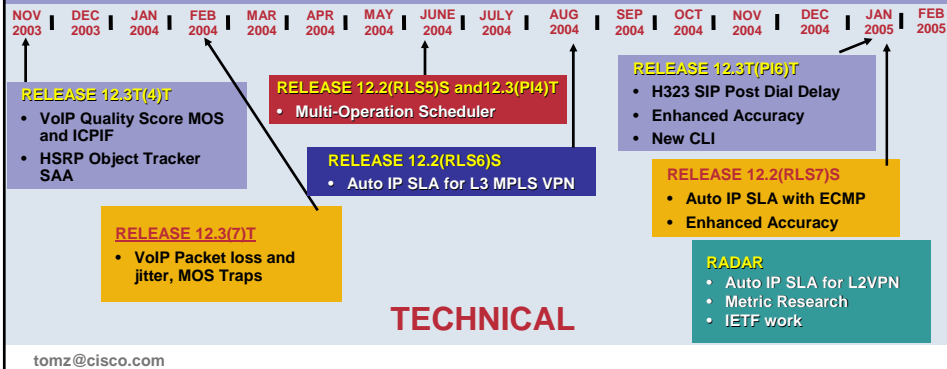
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Cisco IOS SA Agent Roadmap

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References

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- Cisco IOS SAA home page
<http://www.cisco.com/go/saa>
- For questions related to SA Agent, feel free to write an email to:
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Q AND A



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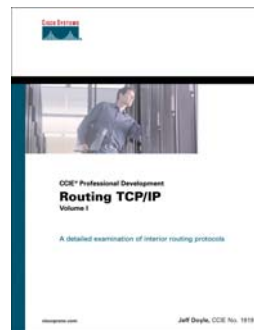
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- **Continue your Networkers learning experience with further reading for this session from Cisco Press.**
- **Check the Recommended Reading flyer for suggested books.**



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- WHAT:** Complete an online session evaluation and your name will be entered into a daily drawing
- WHY:** Win fabulous prizes! Give us your feedback!
- WHERE:** Go to the Internet stations located throughout the Convention Center
- HOW:** Winners will be posted on the onsite Networkers Website; four winners per day

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