



**NETWORKERS 2004**

**INTRODUCTION TO NETWORK  
PERFORMANCE MEASUREMENT  
WITH CISCO IOS SERVICE  
ASSURANCE AGENT**

**SESSION NMS-1N04**

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**OBJECTIVE OF THIS  
PRESENTATION**



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## Objective of This Presentation

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- **Present what is active measurement**
- **Give a clear understanding of Cisco SA Agent (SAA) features and capabilities**
- **Understand how SA Agent is working**
- **Be able to configure various operations**
- **Limitations and scalability issues**

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## This Presentation Is Not About...

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- **Designing your network to deploy Tight SLA services, QoS configuration or recommendations**
- **Applications, graphical interfaces, and other third party applications**
- **Marketing...**

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# Agenda

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- **SLA Concept**
- **Network Disturbance**
- **Active Measurement Overview**
- **Architecture**
- **Configuration**
- **Options**
- **Monitoring and Debugging**

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## THE SLA CONCEPT



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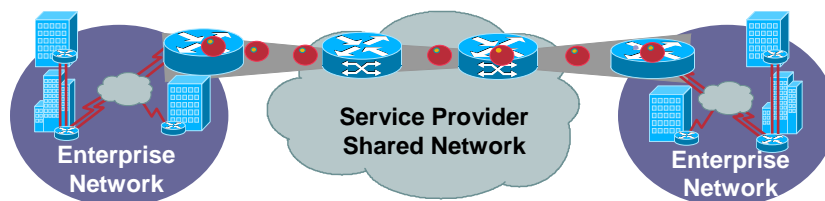
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## SA Agent (SAA) and Service Delivery

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### SLAs Are Becoming an Integral Part of Service Delivery

- Businesses are relying on them for mission critical applications (voice, clearing,...)
- SLA is cornerstone of carriers' differentiated service offerings



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## But What Is a SLA?

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- Stands for **S**ervice **L**evel **A**greement
- This is a contractual obligation between a provider and its clients, spelling out the details of service
- It may include downtime, bandwidth, latency, jitter, responsibilities,...
- Specify a means of measuring each party's compliance to the agreed terms

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## How SLAs Should Be?

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- **Easy to understand**
- **Simple and light to measure**
- **Attainable**
- **Meaningful**
- **Controllable**

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## SLA Components

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- **Delay**
- **Jitter**
- **Bandwidth**
- **Availability**
- **Packet loss**
- **Out of Sequence (OoS)**
- **[add your favourite here]**

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## NETWORK DISTURBANCE



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## Murphy's Law

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- If anything can go wrong, it will
- If anything just cannot go wrong, it will anyway
- Left to themselves, things tend to go from bad to worse
- If everything seems to be going well, you have obviously overlooked something



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## Latency: Delay

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- **Propagation delay**: the time it takes to the physical signal to traverse the path
- **Serialization delay** is the time it takes to actually transmit the packet; depends on the bit-rate
- **Queuing delay** is the time a packet spends in router queues; depends on queue length and type
- A maximum delay of 120 milliseconds is recommended for comfortable human-to-human audio

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## Jitter

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- **Jitter is delay variation**
- **It is caused by queue depth variation**
- **Jitter is bad for interactive voice like VoIP, generating pops and clicks**

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## Isolated Loss

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- **Loss of an isolated packet**
- **Possible causes:**
  - Because of a single CRC error**
  - Because of short duration full queue (tail-drop)**
  - ...**

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## Burst Loss

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- **Multiple consecutive packets are lost**
- **Possible causes:**
  - Because of a noise on the transmission media that kills all the packets**
  - A sudden route change in a transit device creates a temporary black hole**
  - Full transit interface queue**



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## Misordering

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- **This is not a rare situation...**
- **According to a study, roughly 25% of the hosts monitored exhibit reordering**
- **For the hosts that exhibited reordering on average 8 of the 50 packets were identified as being out of order**

**Results Are Based on "Packet Reordering Is Not Pathological Network Behavior", Jon C. R. Bennett, Craig Partridge and Nicholas Shectman, IEEE/ACM Transactions on Networking, Vol. 7, No. 6, December 1999, p789**

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## Misordering Causes

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- Load balancing through multiple paths having different latencies
- Inadequate QoS/queuing policy
- Typically happening on parallel architectures

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- **Active Measurement Overview**
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## SAA AND ACTIVE MEASUREMENTS OVERVIEW



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## Current Solutions to Measure SLAs?

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- **Wait for problem to happen, and customer to complain**  
**Reactive approach**
- **Manually**  
**Monkey approach**
- **Custom, home-made application**  
**The geeky approach**
- **Special hardware probes**  
**The expensive approach**

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## Current Solutions Drawbacks

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- Requires additional hardware
- New software, protocols
- Additional configuration skills
- Eventually adding a new vendor, support contract,...

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## The Idea Behind SAA

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- If you have a running Cisco IOS router, turn it into an active probing device
  - The smart approach**
- Reuse your current equipment and enhance existing network management applications
  - (CiscoWorks, VPNSC (ISC), Quallaby, Infovista, Concord eHealth, Agilent Firehunter...)

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## Positioning SA Agent

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Sampling Method	
Observed/Passive	<b>Synthetic/Active</b>
Collection Method	
<b>Embedded Agents</b>	External Probes
Scope of Measurement	
Device/Link	<b>End-to-End/Path</b>
Perspective of Measurement	
<b>User</b>	<b>Network</b>

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## Positioning SA Agent: Sampling Method

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Observed	<b>Synthetic</b>
<ul style="list-style-type: none"><li>• <b>Definition</b> Actual end-user network traffic where performance is measured by timing specific application traffic flows</li><li>• <b>Advantages</b> Most accurate for live application traffic on a specified link</li><li>• <b>Disadvantages</b> Limited to measuring: Existing traffic types, which may not be present on the network at all times Existing traffic patterns, which may not reflect patterns for new or future applications</li></ul>	<ul style="list-style-type: none"><li>• <b>Definition</b> Network traffic generated strictly for the purpose of measuring a network performance characteristic</li><li>• <b>Advantages</b> Measures performance: Between any two points in the network Controllable, on a continuous basis By traffic class based on IP Precedence marking</li><li>• <b>Disadvantages</b> Only an approximation for performance of live traffic Inject some traffic in the network</li></ul>

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## Positioning SA Agent: Collection Method

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### Embedded

- **Definition**  
Mechanisms for collection of network statistics are integrated into the network communication device (e.g., router or switch), itself
- **Advantages**
  - Follows network infrastructure
  - Gathers metrics that can not be observed externally
  - End-to-end monitoring
- **Disadvantages**
  - Performance monitoring has device-level performance implications

### External

- **Definition**  
Mechanisms for collection of network statistics are provided by a stand-alone device specifically designed to collect network performance statistics
- **Advantages**
  - Validation of performance performed independent of the devices that transmit network traffic
- **Disadvantages**
  - More hardware to administer
  - Observed statistics limited to points of deployment
  - Scale and distribution issues

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## Positioning SA Agent: Scope of Measurement

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### Device or Link Oriented

- **Definition**  
Performance measurement based on analysis of specific device or device interface, and typically based on utilization rates
- **Advantages**
  - Detailed application performance monitoring of critical network links
- **Disadvantages**
  - When network-wide performance problems exist, how does one select which device or link to evaluate?

### End-to-End

- **Definition**  
Performance measurement based on analysis of response time across two or more network devices, and typically based on latency
- **Advantages**
  - Starting point performance troubleshooting
  - Reflects end-user experience
- **Disadvantages**
  - Prior knowledge of relevant end-to-end paths is needed

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## Positioning SA Agent: Perspective of Measurement

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### User

- **Definition**  
Measurement based on performance statistics measured at the end-user workstation
- **Advantages**  
Accurate measurement of end-user experience
- **Disadvantages**  
Scale and distribution issues  
Intrusive on the desktop

### Network

- **Definition**  
Measurement based on performance statistics measured in network devices
- **Advantages**  
Easy to deploy, and non-intrusive to the desktop  
Identifies network performance issue
- **Disadvantages**  
Imperfect understanding of end-user experience

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## Benefits

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- **Flat learning curve (Cisco IOS technology)**
- **No additional equipment, vendor, or cost**
- **Can be deployed on customer site (CPE) and measure end-to-end SLAs**

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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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## CLI or SNMP

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- **All features are supported via CLI; only some are supported via SNMP**
- **We are working on extending the operations supported via SNMP**
- **SNMP requires the use of RTTMON MIB**

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## Proactive Notification

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- Can send SNMP traps when certain “triggering” events occur (e.g. when rising and falling thresholds are passed)
- Can trigger another SAA operation for further analysis (e.g. when ping fails, a path echo operation starts)

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## Historical Data Storage

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- Stores previous results
- Not supported on all operations
- New **enhanced history** in SAA phase 2 (with the new enhanced history feature, a user or an application can configure SAA to store aggregated measurements in “buckets”)

E.g. store 48 buckets, and each bucket maintains 15 minutes of the aggregated measurements; with this configuration, it can store 12 hours of performance information

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## Availability

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- Cisco IOS routers: Available on all platforms from the small 800 up to the 12000
- Catalyst® switches: 2900, 3500, 3700, 4000 (SUP4), 6000 (MSFC or MWAM)
- Included in IP feature set since 11.3 and up to 12.2, and 12.3M (included)
- Starting release 12.3T and all 12.4, the IP voice or upper feature set will be required
- The responder will still remain in IP base

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## Supported Cisco IOS Version

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Feature/Release	11.2	12.0(3)T	12.0(5)T 12.0(8)S	12.1(1)T 12.2	12.2(2)T	12.2(11)T (Eng2)
ICMP Echo	X	X	X	X	X	X
ICMP Echo Path	X	X	X	X	X	X
SSCP(SNA)	X	X	X	X	X	
UDP Echo		X	X	X	X	X
TCP Connect		X	X	X	X	X
UDP Jitter			X	X	X	X
HTTP			X	X	X	X
DNS			X	X	X	X
DHCP			X	X	X	X
DLSw+			X	X	X	X
SNMP Support			X	X	X	X
UDP Jitter with One Way Latency				X	X	X
FTP Get				X	X	X
MPLS/VPN Aware					X	X
Frame Relay (CLI)					X	X
ICMP Path Jitter					X	X
APM					X	X

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## SA Agent History

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- Used to be called RTR, renamed SAA in 12.0(5)T; we call it “Engine 1”
- New “Engine 2” introduced initially in 12.2(11)T, and now present in all 12.3 trains
- New name for 12.4 release: IP SLA

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## SAA “Engine Two”

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- Introduced in 12.2(11)T
- Major rewrite of the SAA code base
- Faster and more scalable
- Memory usage dramatically reduced
- ATM and Frame Relay L2 operations
- Enhanced history

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## Summary

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- Cisco IOS feature
- Provides real-time performance metrics on a wide range of protocols
- Already in Cisco IOS and available on most platforms and interfaces
- Millisecond accuracy

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# SAA ARCHITECTURE



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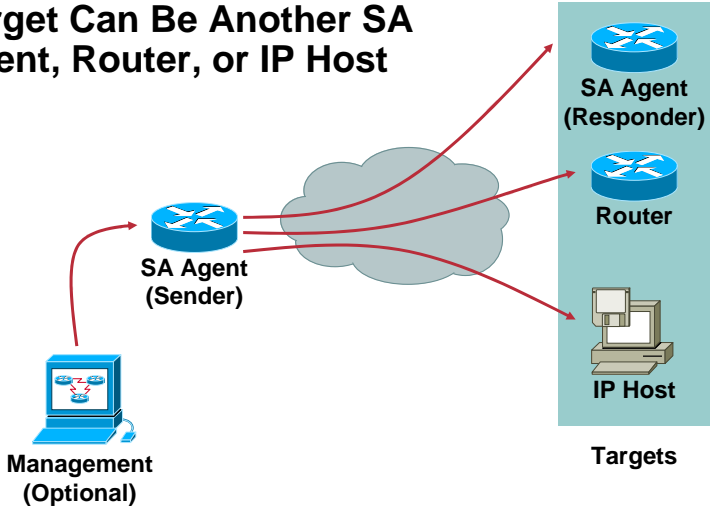
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## Architecture Overview

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### Target Can Be Another SA Agent, Router, or IP Host



Management (Optional)

SA Agent (Sender)

SA Agent (Responder)

Router

IP Host

Targets

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## SAA Sender

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- Cisco IOS box that sends probe packets
- Target might be another entity (running Cisco IOS or not)
- Some operations **require** the target to run the SAA responder (jitter for instance)

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## SAA Responder

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- Runs on Cisco IOS
- Configure 'rtr responder', or set rttMonApplResponder.0=1 with SNMP
- Sender uses the SAA control protocol to communicate with responder before sending the test packets
- Responder knows the type of operation, the port used, the duration
- Communication can be authenticated with MD5, not encrypted

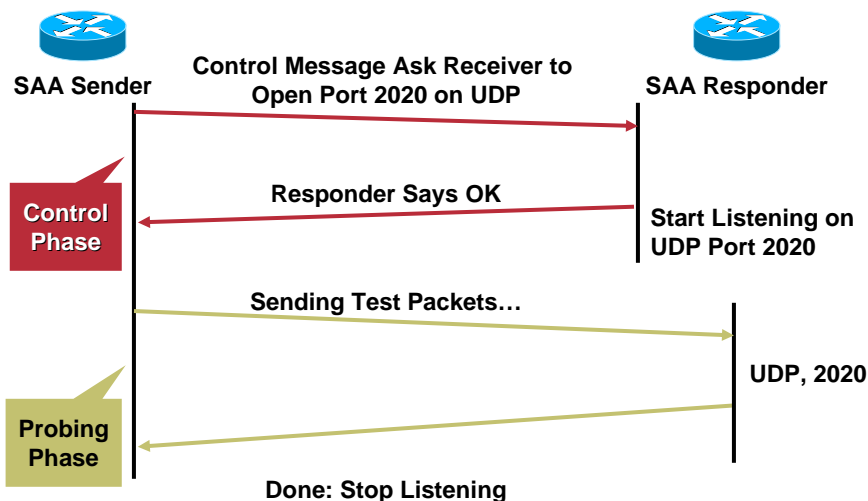
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## SAA Operation with Responder: 1/2

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## SAA Operation with Responder: 2/2

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- Sender computes all the response times
- The responder, based on the type of operation, may insert in/out timestamps in the packet's payload
- Processing time spend on the responder can therefore be calculated and deduced

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## SA AGENT CONFIGURATION COMMAND LINE INTERFACE (CLI)



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## Configuring an Operation

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```
c26f7-12(config)#rtr 1
c26f7-12(config-rtr)#type ?
    dhcp          Perform DHCP Operation
    dlsw          Perform DLSw Keepalive Operation
    dns           Perform DNS Query
    echo          Perform Point to Point Echo Operations
    ftp           Perform ftp operation
    http          Perform HTTP Operations
    jitter        Perform Jitter Operation
    pathEcho      Perform Path Discovered Echo Operations
    tcpConnect    Perform TCP Connect Operations
    udpEcho       Perform UDP Echo Operations
```

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## Parameters

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```
router (config-rtr)#?
frequency          Operation Frequency Value in Seconds
lsr-path           Loose Source Routing Path
owner              Owner of Entry
request-data-size  Requested Request Payload Size
response-data-size Requested Response Payload Size
tag                User Defined Tag
threshold          Operation Threshold in msec
timeout            Operation Timeout Value in msec
tos                Type Of Service
verify-data        Verify Data
```

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## ICMP Echo Operation

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- Target can be any IP host
- Response time is computed by measuring the time taken between sending an ICMP echo request message to the destination and receiving an ICMP echo reply
- Processing delays on the source router is subtracted

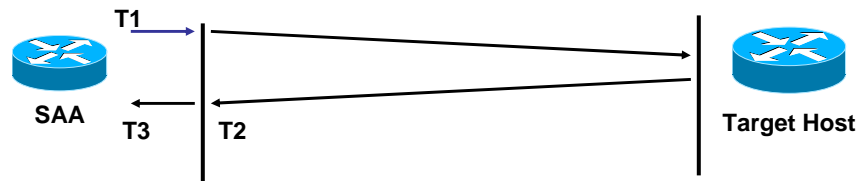
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## ICMP Echo Operation: Measurement

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Processing Time on the Sender:  $T_{proc} = T3 - T2$

Round Trip Time:

$$T = T3 - T1 - T_{proc}$$

$$T = T3 - T1 - (T3 - T2)$$

$$T = T3 - T1 - T3 + T2$$

$$T = T2 - T1$$

- Locally an SAA packet will perceive the same scheduling latency as any packet from its class
- Remember that this type of operation will include the processing time on the target host; (see later to avoid this)

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## ICMP Echo Operation: Example

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```
rtr 1
  type echo protocol ipIcmpEcho 10.32.130.2
  tos 0x20
  frequency 120

rtr schedule 1 life forever start-time now
```

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## ICMP Echo Operation: Output

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```
c26f7-12#sh rtr op 1
  Current Operational State
Entry Number: 1
Modification Time: 11:28:21.000 CET Thu Aug 22 2002
Diagnostics Text:
Last Time this Entry was Reset: Never
Number of Octets in use by this Entry: 1490
Connection Loss Occurred: FALSE
Timeout Occurred: FALSE
Over Thresholds Occurred: FALSE
Number of Operations Attempted: 1
Current Seconds Left in Life: infinite - runs forever
Operational State of Entry: active
Latest Completion Time (milliseconds): 2
Latest Operation Start Time: 11:28:21.000 CET Thu Aug 22 2002
Latest Operation Return Code: ok
Latest 10.52.130.2
```

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## UDP Echo Operation

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- Uses either well-known UDP port 7 (echo service)—or any other custom port
- Requires responder for more accurate results: processing delays subtracted on both source and destination

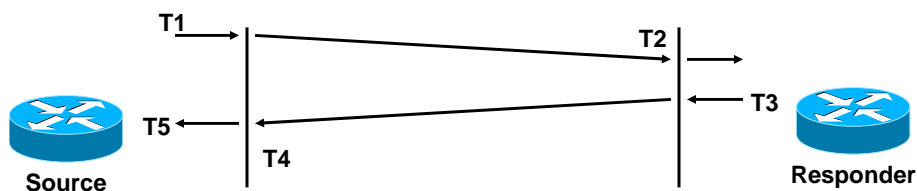
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## UDP Echo Operation: with SAA Responder

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Processing Delay on the Source:  $T_{ps} = T5 - T4$

Processing Delay on the Destination:  $T_{pd} = T3 - T2$

Total delay:

$T = T5 - T1 - T_{ps} - T_{pd}$

$T = T5 - T1 - (T5 - T4) - (T3 - T2)$

$T = T5 - T1 - T5 + T4 - T3 + T2$

$T = T2 + T4 - T1 - T3$

- We have no control on the queuing delay on both the source and destination
- Queuing delay is usually negligible, but might become a problem on loaded interfaces

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## UDP Echo Operation: Example

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```
rtr 1
  type udpEcho dest-ipaddr 10.52.132.68 dest-port 7
  threshold 200

rtr schedule 1 start-time now
```

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## UDP Echo Operation: Output

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```
c26f7-12#sh rtr op 1
      Current Operational State
Entry Number: 1
Modification Time: 13:55:05.000 CET Thu Aug 22 2002
Diagnostics Text:
Last Time this Entry was Reset: Never
Number of Octets in use by this Entry: 1490
Connection Loss Occurred: FALSE
Timeout Occurred: FALSE
Over Thresholds Occurred: FALSE
Number of Operations Attempted: 1
Current Seconds Left in Life: 3595
Operational State of Entry: active
Latest Completion Time (milliseconds): 2
Latest Operation Start Time: 13:55:05.000 CET Thu Aug 22 2002
Latest Operation Return Code: ok
Latest 10.52.132.68
```

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## TCP Connect Operation

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- TCP connect operation measure the time taken by the source to perform a TCP connect operation to the destination device
- Target can be normal host or SAA responder
- Useful in simulating Telnet, SSH, SQL... connection time

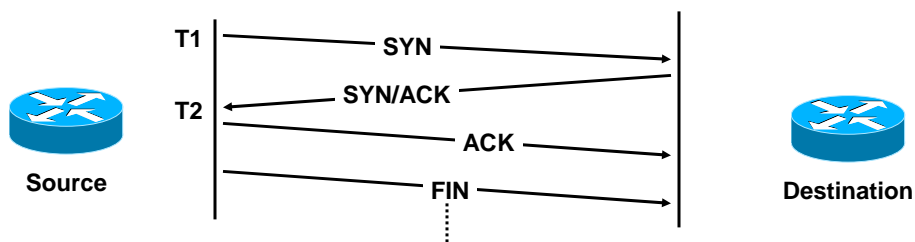
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## TCP Connect Operation: Measurement

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**The Measured Connection Time Is the Difference Between the Time We Sent the ACK and We Sent the Initial SYN, In This Case T2-T1**

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## TCP Connect Operation: Example

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```
rtr 1
  type tcpConnect dest-ipaddr 10.52.132.68 \
    dest-port 9 control disable
rtr schedule 1 start-time now
```

Tries a TCP Connection to 10.52.132.68 on Port 9

If the Target Host is Not Running SA Agent, Disable  
the Control Protocol

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## TCP Connect Operation: Output

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```
c26f7-12#sh rtr op 1
  Current Operational State
Entry Number: 1
Modification Time: 14:17:10.000 CET Thu Aug 22 2002
Diagnostics Text:
Last Time this Entry was Reset: Never
Number of Octets in use by this Entry: 1490
Connection Loss Occurred: FALSE
Timeout Occurred: FALSE
Over Thresholds Occurred: FALSE
Number of Operations Attempted: 17
Current Seconds Left in Life: 2603
Operational State of Entry: active
Latest Completion Time (milliseconds): 6
Latest Operation Start Time: 14:33:10.000 CET Thu Aug 22 2002
Latest Operation Return Code: ok
Latest 10.52.132.68
```

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## UDP Jitter Operation

Cisco.com

- 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

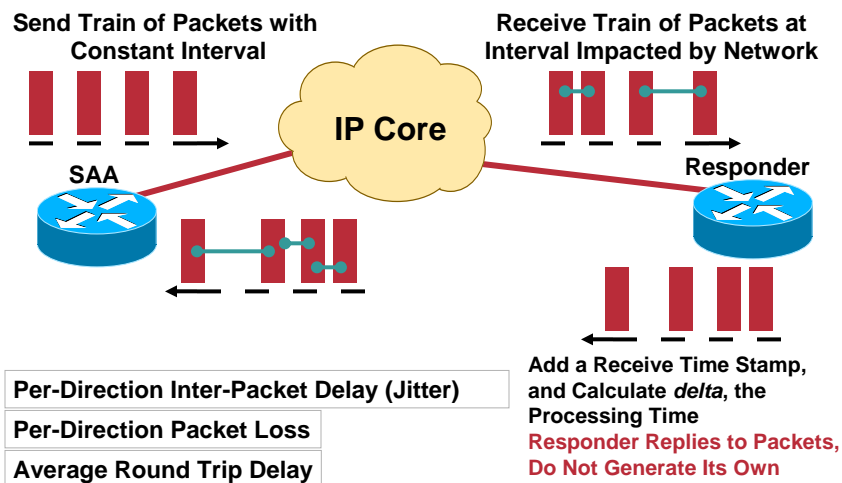
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## UDP Jitter: Packet Stream

Cisco.com



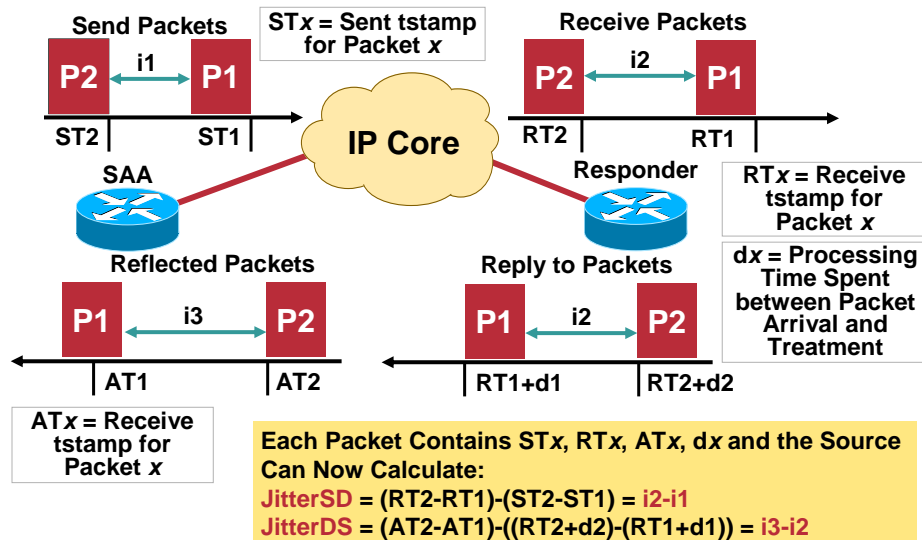
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## UDP Jitter: Measurement Example

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## UDP Jitter Operation Jitter Computation

Cisco.com

- 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
- No need to have clocks synchronized

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# UDP Jitter Operation One-Way Delay Computation

Cisco.com

- One-way delay measurement requires the clocks on source and target routers synchronized
- Use Network Time Protocol (NTP) server, eventually with GPS device as reference
- Use a GPS device on the auxiliary port of a 7200 (ex: Trimble Palisade GPS)
- If the time is not synchronized, SAA ignores the measurement by filling in 0's

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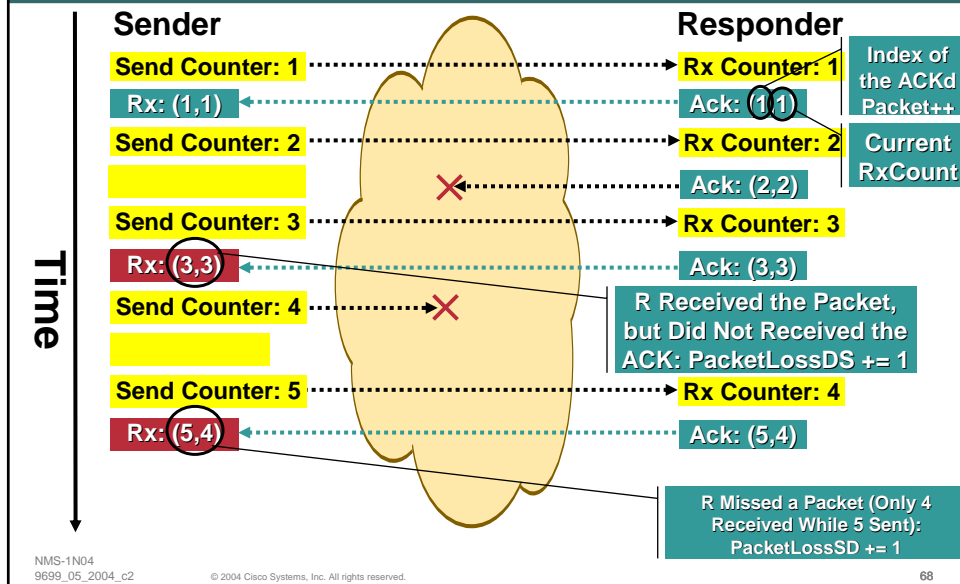
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# UDP Jitter Operation Packet Loss

Result:  
PacketLossSD = 1  
PacketLossDS = 1

Cisco.com



## UDP Jitter Operation: Example

Cisco.com

- 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 Operation to 10.52.130.68, Port 3456

Send 20 Packets Each Time

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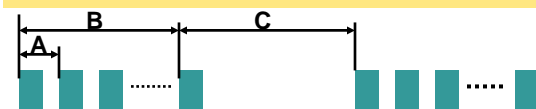
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## UDP Jitter Operation: Example

Cisco.com

- 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
```



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# UDP Jitter Operation: Output: 1/3

Cisco.com

```

etychon-vpn#sh rtr op 1
Current Operational State
Entry Number: 1
Modification Time: 08:22:34.000 PDT Thu Aug 22 2002
was Reset: Never
Number of Objects 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...)
    
```

**3 Packets Lost S->D  
Out of 1000 Sent**

**Average RTT Was  
458111/997 = 459ms**

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# UDP Jitter Operation: Output: 2/3

Cisco.com

```

(...cont)
Jitter Values:
MinOfPositivesSD: 1 MaxOfPositivesSD: 249
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 OWMMaxSD: 0 OWSumSD: 0 OWSum2SD: 0
OWMinDS: 0 OWMMaxDS: 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**

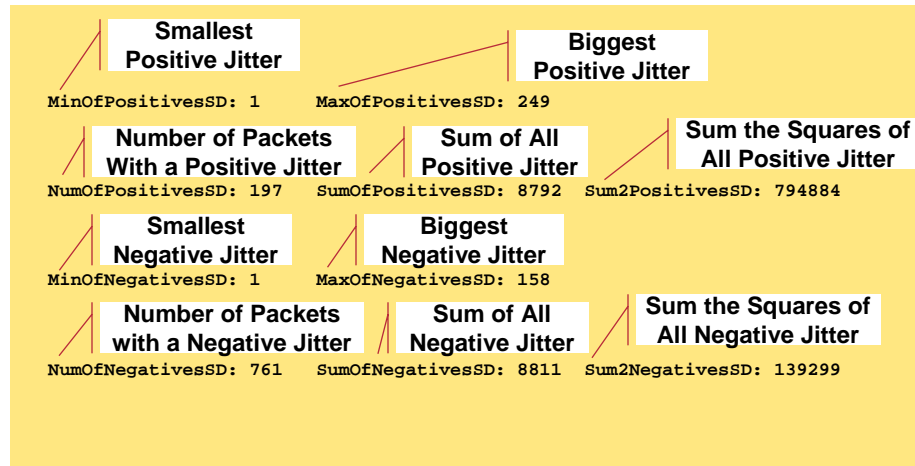
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## UDP Jitter Operation: Output: 3/3

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## UDP Jitter Operation: Calculate Jitter

Cisco.com

- SAA provides no average jitter
- You can calculate an average with:

$$AvgJit = \frac{\sum \text{SumOf}\{\text{Positive} | \text{Negative}\}\{\text{SD} | \text{DS}\}}{\text{NumOfRTT}}$$

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## DHCP Operation

Cisco.com

- Good for cable/DSL providers that uses DHCP for dynamic address allocation
- Measures the time taken to discover a DHCP Server and obtain a lease from it
- SAA releases the leased IP address after the operation

```
rtr 1
  type dhcp
rtr schedule 1 start-time now
```

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## DNS Operation

Cisco.com

- Difference between the time taken to send a DNS request and the time a reply is received
- Check your DNS performance, a critical element for surfers' speed feeling
- The SAA DNS operation queries for an IP address if the user specifies hostname (forward), or queries for a hostname if the user specifies an IP address (reverse)
- Do not revert back to TCP if the DNS UDP query fails

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## DNS Operation: Example

Cisco.com

```
rtr 1
type dns target-addr drop.cisco.com \
name-server 10.52.128.30
rtr schedule 1 start-time now
```

Resolve drop.cisco.com to an IP Address...

...Against the DNS Server 10.52.128.30.

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## HTTP Operation

Cisco.com

- Measures HTTP server responsiveness: DNS request, TCP connection, time to first byte, HTTP transaction time...
- Normal GET requests or custom RAW requests supported
- HTTP proxy servers supported
- SA responder cannot be used

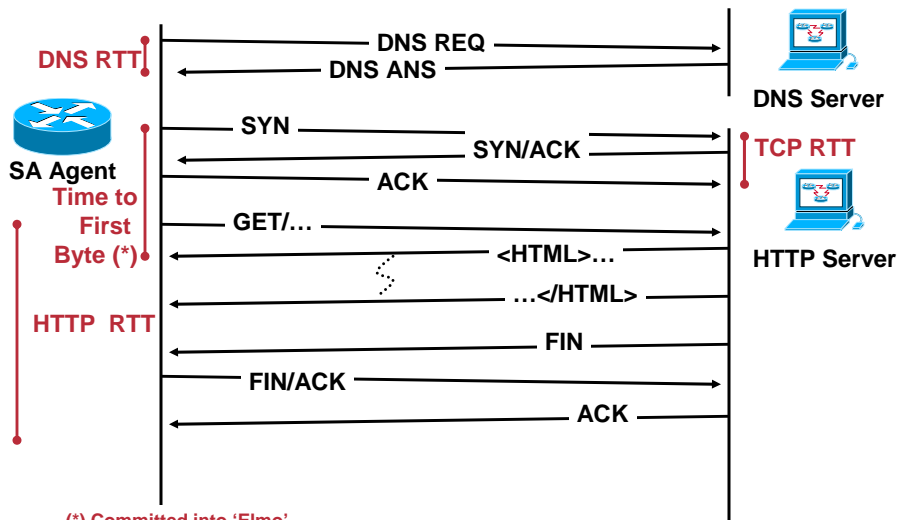
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## HTTP Operation (Measurement)

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## HTTP Operation (GET vs. RAW)

Cisco.com

- **GET** request—SAA will format the request based on the URL specified
- **RAW**—one must specify the entire content of the HTTP request; this gives ultimate flexibility for user to control fields such as authentication

Can also be used to request through a proxy, although there is a specific option for that; see examples later

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## HTTP Operation (GET Example)

Cisco.com

### Simple GET Request to Server nsite-bru.cisco.com:

```
rtr 1
  type http operation get url \
    http://nsite-bru.cisco.com/solutions/TE/
rtr schedule 1 start-time now
```

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## HTTP Operation (Output)

Cisco.com

```
c26f7-1#sh rtr op 1
Entry number: 1
Modification time: *22:01:31.895 MET Sun Apr 11 1993
Number of operations attempted: 1
Number of operations skipped: 0
Current seconds left in Life: 3592
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): 193
Latest operation start time: *22:01:31.902 MET Sun Apr 11 1993
Latest operation return code: OK
Latest DNS RTT: 4
Latest TCP Connection RTT: 8
Latest HTTP Transaction RTT: 181
Latest HTTP Status: 200
Latest HTTP Message Size: 2842
Latest HTTP Entity-Body size: 2677
```

DNS RTT + TCP  
RTT + HTTP RTT

200 = OK

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## HTTP Operation (RAW Example)

Cisco.com

- Use RAW to perform an HTTP get operation on server nutcase through the proxy server nsite-bru:

```
rtr 1
  type http operation raw url \
    http://nsite-bru.cisco.com
http-raw-request
GET http://nutcase.cisco.com HTTP/1.0\r\n
\r\n

exit
rtr schedule 1 start-time now
```

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## HTTP Operation (RAW Authentication)

Cisco.com

- Use RAW to do a HTTP GET operation on server nsite-bru; the requested page is password-protected

```
rtr 1
  type http operation raw url \
    http://nsite-bru.cisco.com
http-raw-request
GET /lab/index.html HTTP/1.0\r\n
Authorization: Basic btNpdGT4biNvoZe=\r\n
\r\n

exit
rtr schedule 1 start-time now
```

“user:password” Encoded in Base64

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## HTTP Operation (Example: Proxy)

Cisco.com

- Use proxy 'nsite-bru' to get to a page on the server 'nutcase':

```
rtr 1
  type http operation get url http://nutcase.cisco.com \
    proxy http://nsite-bru.cisco.com:80
rtr schedule 1 start-time now
```

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## FTP Operation

Cisco.com

- Measures the time to download a file
- Do not abuse: big files gives more realistic results while consumes more bandwidth
- Active or passive mode
- Does not work with SAA responder

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## FTP Operation (Example)

Cisco.com

- Get the file '/home/etychon/test.cap':

```
rtr 1
  type ftp operation get \
    url ftp://etychon:pwd@drop.cisco.com/test.cap rtr
  schedule 1 start-time now
```

- Get the file in '/test.cap':

```
rtr 1
  type ftp operation get \
    url ftp://etychon:pwd@drop.cisco.com//test.cap rtr
  schedule 1 start-time now
```

Absolute vs.  
Relative Path

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## FTP Operation (Output)

Cisco.com

```
c26f7-1#sh rtr op 1
Entry number: 1
Modification time: *04:02:36.295 MET Mon Apr 12 1993
Number of operations attempted: 6
Number of operations skipped: 0
Current seconds left in Life: 1024000 bytes/8.193 s = 124.9 KB/s
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): 8193
Latest operation start time: *04:07:36.299 MET Mon Apr 12
1993
Latest operation return code: OK
Bytes read: 1024000
```

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## Frame Relay Operation\*

Cisco.com

- Measure taken per Virtual Circuit using frame injection
- Round trip time
- Absolute packet loss for all frames sent, not just SAA frames
- Packet corruption, for the SAA-generated frames; the user can specify the number of bytes of data, and the pattern of data to be sent
- Requires SAA responder to be enabled for Frame Relay operations

\*Requires Cisco IOS Version 12.2(2)T or Later

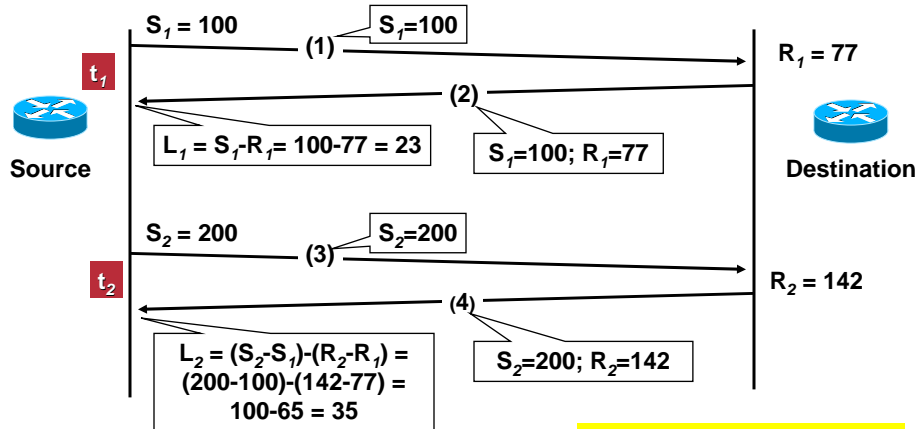
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## Frame Relay (Packet Loss Calculation)

Cisco.com



**Legend:**  
 $S_x$  = Packets Sent at tx  
 $R_x$  = Packets Received at tx  
 $L_x$  = Packets Lost at tx

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## Frame Relay Operation (Example)

Cisco.com

- **Defining the Frame Relay operation:**

```
router(config)# rtr 5
router(config-rtr)# type frame-relay \
    interface serial0 dlci 130
router(config)# rtr schedule 5 start-time now
```

- **Enabling the Frame Relay responder:**

```
router(config)# rtr responder type frame-relay all
```

- **Or for one specific VC:**

```
router(config)# rtr responder type frame-relay \
    interface serial1 130
```

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## PathJitter Operation\*

Cisco.com

- **Runs in two phases: route discovery, and hops evaluation; (see next slide)**
- **Per hop round trip time**
- **Per hop packet loss**
- **Per hop cumulated jitter with noise reduction (RFC1889)**
- **No SAA responder required on the destination, nor on the hops**

\*Requires Cisco IOS Version 12.2(2)T or Later

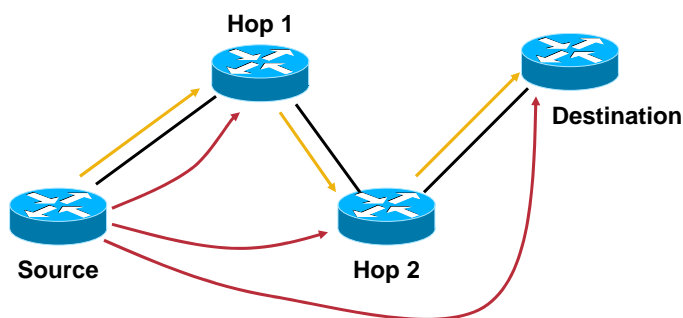
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## PathJitter Operation (Two Phases)

Cisco.com



**1. Discover the path with traceroute**

**2. Evaluate each hop one-by-one for RTT, packet lost, and round-trip total jitter**

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## PathJitter Operation (Example)

Cisco.com

- Trace the hops to '10.52.128.1':

```
rtr 1
type pathJitter dest-ipaddr 10.52.128.1
rtr schedule 1 start-time now
```

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## PathJitter Operation (Output)

Cisco.com

### ---- Path Jitter Statistics ----

```
Source IP      - 10.52.132.5
Destination IP - 10.52.128.1
Number of Echos - 10
Interval between Echos - 20 ms
Target Only    - Disabled (default)
```

```
Hop IP 10.52.132.2:
  RTT:1          PacketLoss:0      Jitter:0
  MinRTT:1       MaxRTT:2          SumRTT:19      Sum2RTT:37
  MinPosJitter:1 MaxPosJitter:1     SumPos:1       Sum2Pos:1
  MinNegJitter:0 MaxNegJitter:0     SumNeg:0       Sum2Neg:0
  OutOfSequence:0 DiscardedSamples:0
Hop IP 10.52.128.1:
  RTT:1          PacketLoss:0      Jitter:0
  MinRTT:1       MaxRTT:3          SumRTT:14      Sum2RTT:24
  MinPosJitter:2 MaxPosJitter:2     SumPos:2       Sum2Pos:4
  MinNegJitter:1 MaxNegJitter:1     SumNeg:2       Sum2Neg:2
  OutOfSequence:0 DiscardedSamples:0
```

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## Agenda

Cisco.com

- SLA Concept
- Network Disturbance
- Active Measurement Overview
- Architecture
- Configuration
- **Options**
- Monitoring and Debugging

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## SA AGENT OPTIONS



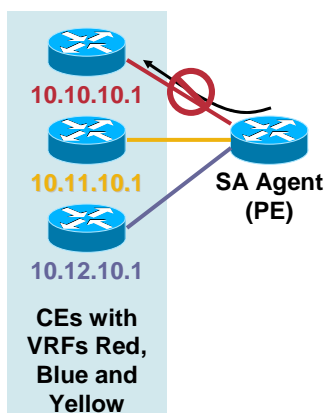
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## VRF-Awareness Issue (For MPLS/VPN)

Cisco.com



- How to send probe packets from SA agent to a specific VPN?
- By default, local processes are not executed in a VRF context
- Route lookup is done in the global routing table, and the wrong route is selected

**We Need a Way to Execute an Operation in a VRF Context—e.g. Red, Blue or Yellow**

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## Solution: SAA for MPLS/VPN

Cisco.com

- SAA operations are vrf-aware since 12.2(2)T, 12.2(6)S, 12.0(26)S
- Supported on ICMP Echo, ICMP Path Echo, UDP Echo and UDP Jitter operations
- Allows measurement from PE to anything
- Use `vrf vrf-name option`

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## SAA for MPLS/VPN (Example)

Cisco.com

- Sends probes to a remote SAA in the context of the blue VPN:

```
rtr 1
  type jitter dest-ipaddr 10.52.130.68 \
    dest-port 3456
  vrf blue
rtr schedule 1 start-time now
```

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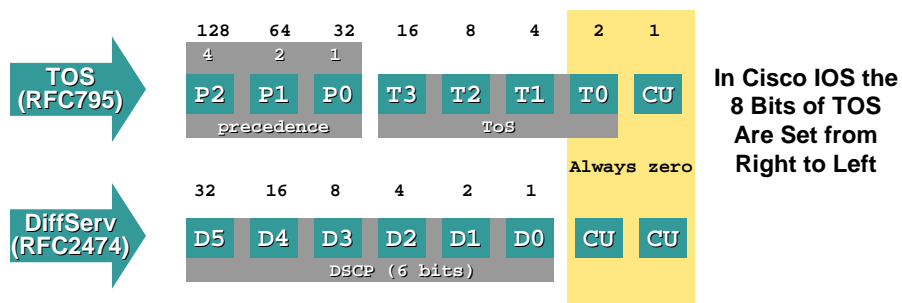
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# TOS Marking

- Probes can be TOS marked
- Only TOS setting is supported, no diffserv;  
(see next slide to perform translation)

# Converting Between TOS and DiffServ



Binary	TOS	DSCP	Precedence
101 000	160 (0xA0)	40	5
101 100	176 (0xB0)	44	5
001 110	56 (0x38)	14	1

# Agenda

Cisco.com

- SLA Concept
- Network Disturbance
- Active Measurement Overview
- Architecture
- Configuration
- Options
- **Monitoring and Debugging**

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## MONITORING AND DEBUGGING SA AGENT



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## SAA Application Version

Cisco.com

```
c26f7-12#sh rtr app
Response Time Reporter
Version: 2.2.0 Round Trip Time MIB
Max Packet Data Size (ARR and Data): 16384
Time of Last Change in Whole RTR: 11:27:28.000 CET Tue Aug 27 2002
System Max Number of Entries: 500

Number of Entries configured: 1
  Number of active Entries: 0
  Number of pending Entries: 0
  Number of inactive Entries: 1

Supported Operation Types
Type of Operation to Perform: echo
Type of Operation to Perform: pathEcho
<...>

Supported Protocols
Protocol Type: ipIcmpEcho
Protocol Type: ipUdpEchoAppl
<...>

Number of configurable probe is 499
RTR low memory water mark: 3647960
```

Maximum Number of Probes  
One Can Configure

Supported Operations  
for the Current Engine

Supported Protocols  
for the Operations;  
(Will Disappear in  
Engine 2)

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## Operational State

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- Show the actual state of an operation:

```
show rtr operational-state operation-number
```

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## Operational State (Output)

Cisco.com

```
c26f7-12#sh rtr op 1
      Current Operational State
Entry Number: 1
Modification Time: 17:46:26.000 CET Fri Aug 23 2002
Diagnostics Text:
Last Time this Entry was Reset: Never
Number of Octets in use by this Entry: 1490
Connection Loss Occurred: FALSE
Timeout Occurred: FALSE
Over Thresholds Occurred: FALSE
Number of Operations Attempted: 60
Current Seconds Left in Life: 0
Operational State of Entry: inactive
Latest Completion Time (milliseconds): 3347
Latest Operation Start Time: 18:45:26.000 CET Fri Aug 23 2002
Latest Operation Return Code: ok
Latest ftp://user:password@drop.cisco.com/test.cap
```

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## Schedule and Stop

Cisco.com

- To schedule operation **<n>** to start:

```
rtr schedule <n> [life seconds] [start-time {pending |
now | hh:mm [month day | day month]}] [ageout seconds]
```

- To stop a running operation **<n>**:

```
rtr schedule <n>
```

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## Scheduling Caveat

Cisco.com

- If you configure multiple operations to start *'now'*, they'll all start at the same time after a router reload
- Consider using the option *'after'* instead of *'now'*
- Example, new operations are started every second:

```
rtr schedule <n> start-time after 00:01:00
rtr schedule <n+1> start-time after 00:01:01
rtr schedule <n+2> start-time after 00:01:02
```

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## Probe Configuration [1/2]

Cisco.com

- *'sh rtr config <n>'*: probe's config details:

```
c26f7-12#sh rtr config 1
Complete Configuration Table (includes defaults)
Entry Number: 1
Owner:
Tag:
Type of Operation to Perform: jitter
Reaction and History Threshold (milliseconds): 5000
Operation Frequency (seconds): 60
Operation Timeout (milliseconds): 5000
Verify Data: FALSE
Status of Entry (SNMP RowStatus): active
Protocol Type: jitterAppl
Target Address: 10.52.132.68
Source Address: 0.0.0.0
Target Port: 9999
Source Port: 0
Request Size (ARR data portion): 32
Response Size (ARR data portion): 32
Num of Packets per probe: 10
Interval between packets(milliseconds): 20
Control Packets: enabled
Loose Source Routing: disabled
< . . .>
```

Source Address Is  
Automatic (from  
Outgoing Interface)

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## Probe Configuration [2/2]

Cisco.com

```
<. . .>
LSR Path:
Type of Service Parameters: 0x0
Life (seconds): 3600
Next Scheduled Start Time: Start Time already passed
Entry Ageout (seconds): never
Connection Loss Reaction Enabled: FALSE
Timeout Reaction Enabled: FALSE
Threshold Reaction Type: never
Threshold Falling (milliseconds): 3000
Threshold Count: 5
Threshold Count2: 5
Reaction Type: none
Verify Error Reaction Enabled: FALSE
Number of Statistic Hours kept: 2
Number of Statistic Paths kept: 1
Number of Statistic Hops kept: 1
Number of Statistic Distribution Buckets kept: 1
Statistic Distribution Interval (milliseconds): 20
Number of History Lives kept: 0
Number of History Buckets kept: 15
Number of History Samples kept: 1
History Filter Type: none
`
```

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## Deleting

Cisco.com

- To delete an operation **<n>**:

```
router(config)# no rtr <n>
```

- To delete all operations:

```
router(config)# rtr reset
```

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## Start Debugging an Operation

Cisco.com

- To debug operation **<n>** activity:

```
router# debug rtr trace <n>
```

- To debug activity of the responder:

```
router# debug rtr trace 0
```

The Responder Is the Equivalent  
of Operation Zero

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## Start Debugging an Operation

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- To debug errors for operation **<n>** :

```
router# debug rtr error <n>
```

- To debug errors the responder:

```
router# debug rtr error 0
```

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## Debug Sample Output

Cisco.com

```
16:27:45.402: RTR 1: Starting An Echo Operation - IP RTR Probe 1
16:27:45.406:      source=10.52.132.69(49175)  dest-ip=10.52.132.68(9999)
16:27:45.406: sending control msg:
16:27:45.406:  Ver: 1 ID: 144 Len: 52
16:27:45.406: cmd: command: RTT_CMD_JITTER_PORT_ENABLE, ip: 10.52.132.68,
      port: 9999, duration: 5200
16:27:45.414: receiving reply
16:27:45.414:  Ver: 1 ID: 144 Len: 8
16:27:45.422: sdTime: 2104279296 dsTime: -2017879294
16:27:45.422: responseTime (1): 2
16:27:45.442: sdTime: 2104279296 dsTime: -2017879295
16:27:45.442: jitterOut: 0
16:27:45.442: jitterIn: -1
16:27:45.442: responseTime (2): 1
< . . . >
```

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## REFERENCES (IF YOU WANT TO GO DEEPER)



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## References

Cisco.com

- **Cisco IOS documentation on CCO:**  
<http://www.cisco.com/univercd/cc/td/doc/product/software/ios120/120newft/120t/120t5/saaoper.htm>
- **SAA User Guide:**  
[http://www.cisco.com/warp/public/cc/pd/iosw/prodli/saaug\\_ai.htm](http://www.cisco.com/warp/public/cc/pd/iosw/prodli/saaug_ai.htm)
- **Measuring Delay, Jitter, and Packet Loss with Cisco IOS SAA and RTTMON:**  
<http://www.cisco.com/warp/public/126/saa.html>

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Cisco.com

- **SA Agent Support for Frame Relay, VoIP, and MPLS VPN Monitoring:**  
<http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122newft/122t/122t2/ft1csaa.htm>

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## Feedback

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- **Any question, feedback or suggestion regarding SAA, please use the e-mail alias:**

**cs-saa@cisco.com**

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**QUESTIONS?  
(AND HOPEFULLY, ANSWERS...)**



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## Complete Your Online Session Evaluation!

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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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# CISCO SYSTEMS



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