STRATEGIC STANDARDS

IP/MPLS network performance and QoS
Part 1: Performance Metrics - Definitions and Practical Usage

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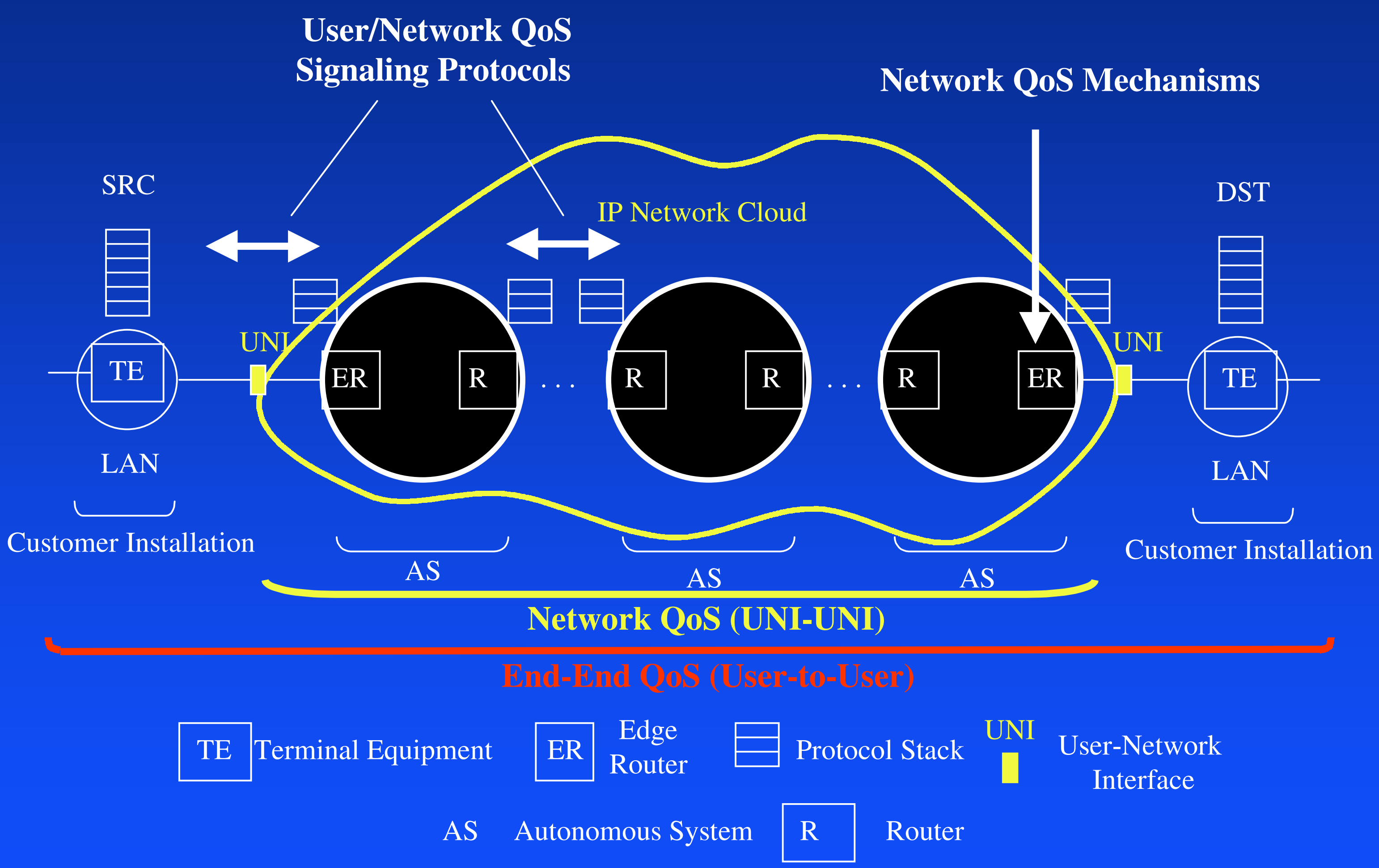
Outline: Focus on Active Measurement

- Reference Path and Terminology
- IP Parameters/Metrics Summary
- Metric Development In-progress
- Performance for MPLS-enabled IP Nets
- Practical Applications
  - Service Providers
  - Customers
  - 3rd Parties

QoS Reference Model/Terminology



Reference Model from Y.1541, with modifications

Background: Layered Performance Model for IP Networks

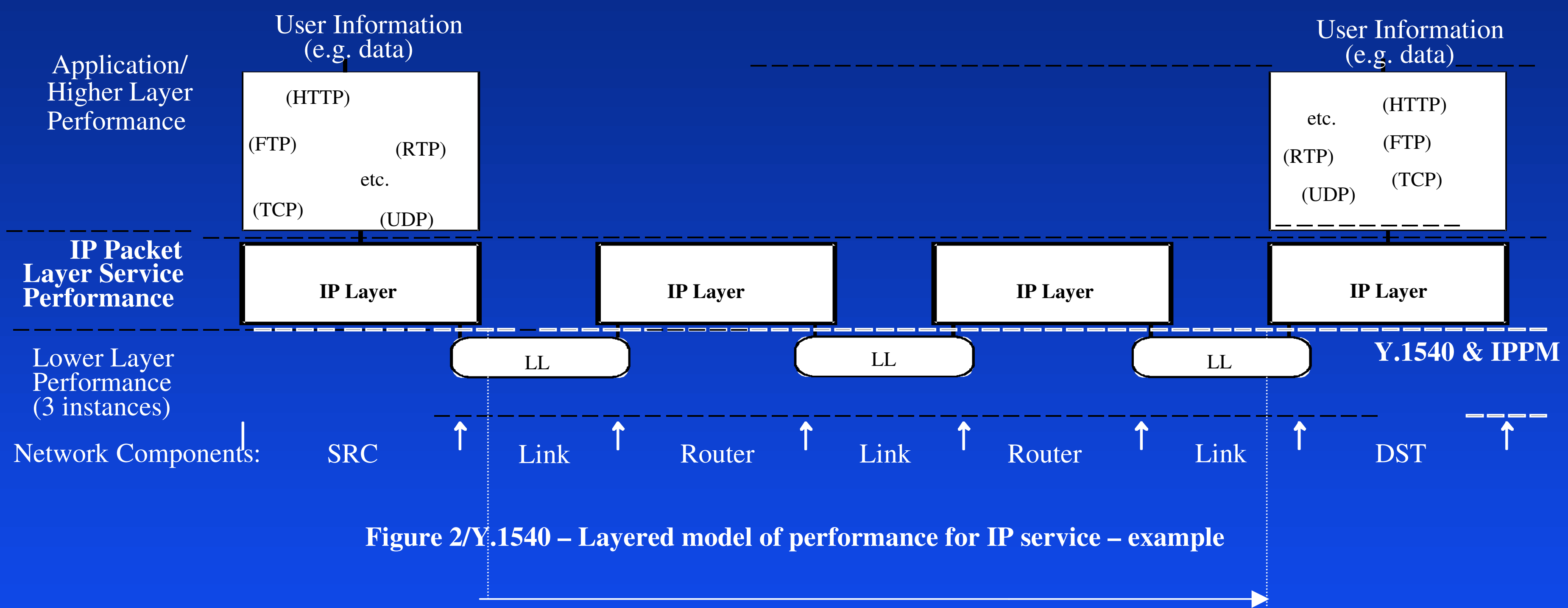


Figure 2/Y.1540 – Layered model of performance for IP service – example

UNI to UNI, or Ingress to Egress IP Measurement

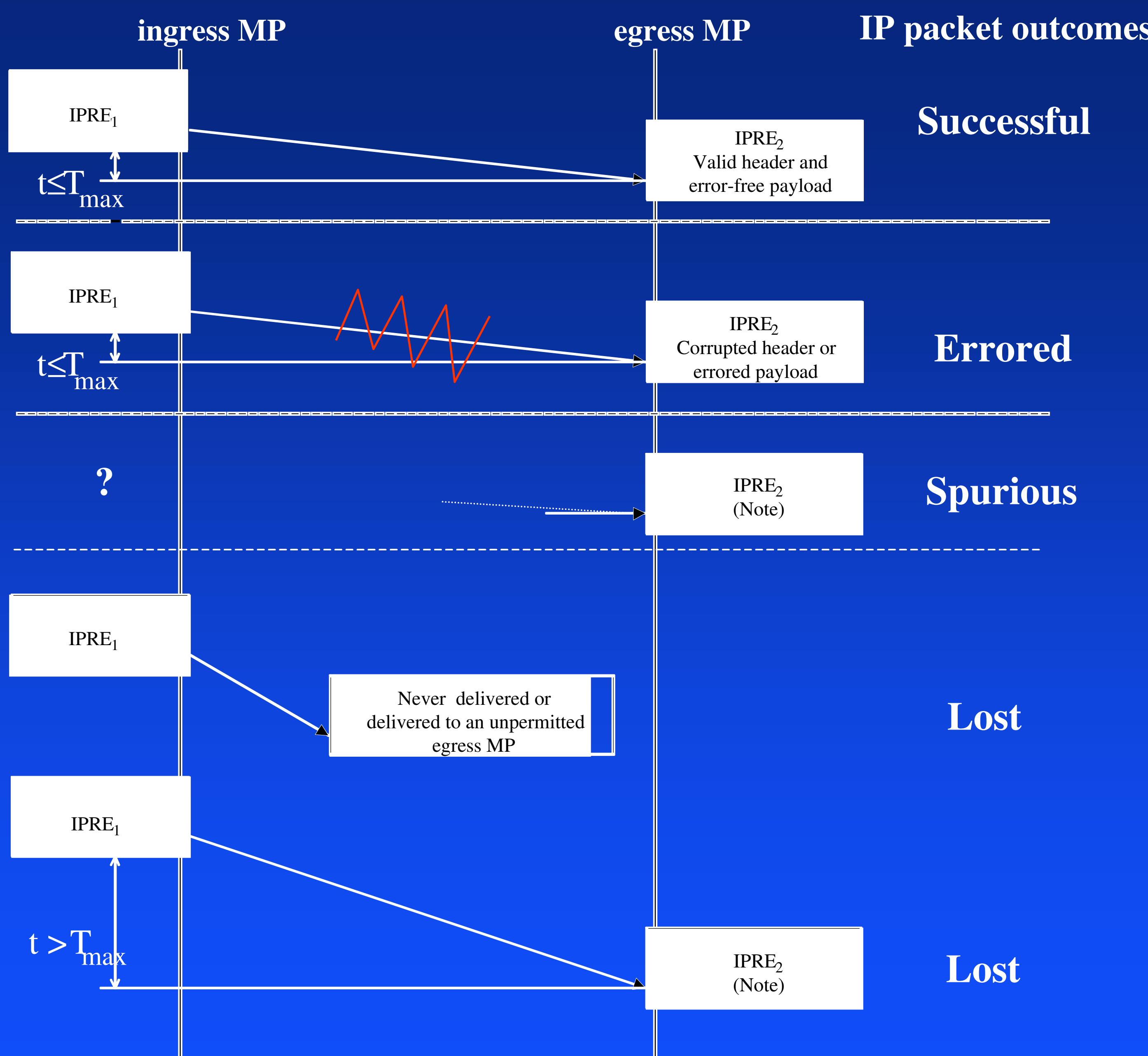
IPTD = IP Packet Transfer Delay: Time for the packet to traverse the UNI-UNI path (1-way).

IPDV = IP Packet Delay Variation: Variation of transfer times over a population of interest.

IPLR = IP Packet Loss Ratio: Ratio of unsuccessful packet transfer outcomes to total attempts.

IPER = IP Packet Error Ratio: Ratio of erred packet transfer outcomes to total attempts.

Packet Performance Parameters



NOTE – Outcome occurs independent of IP packet contents

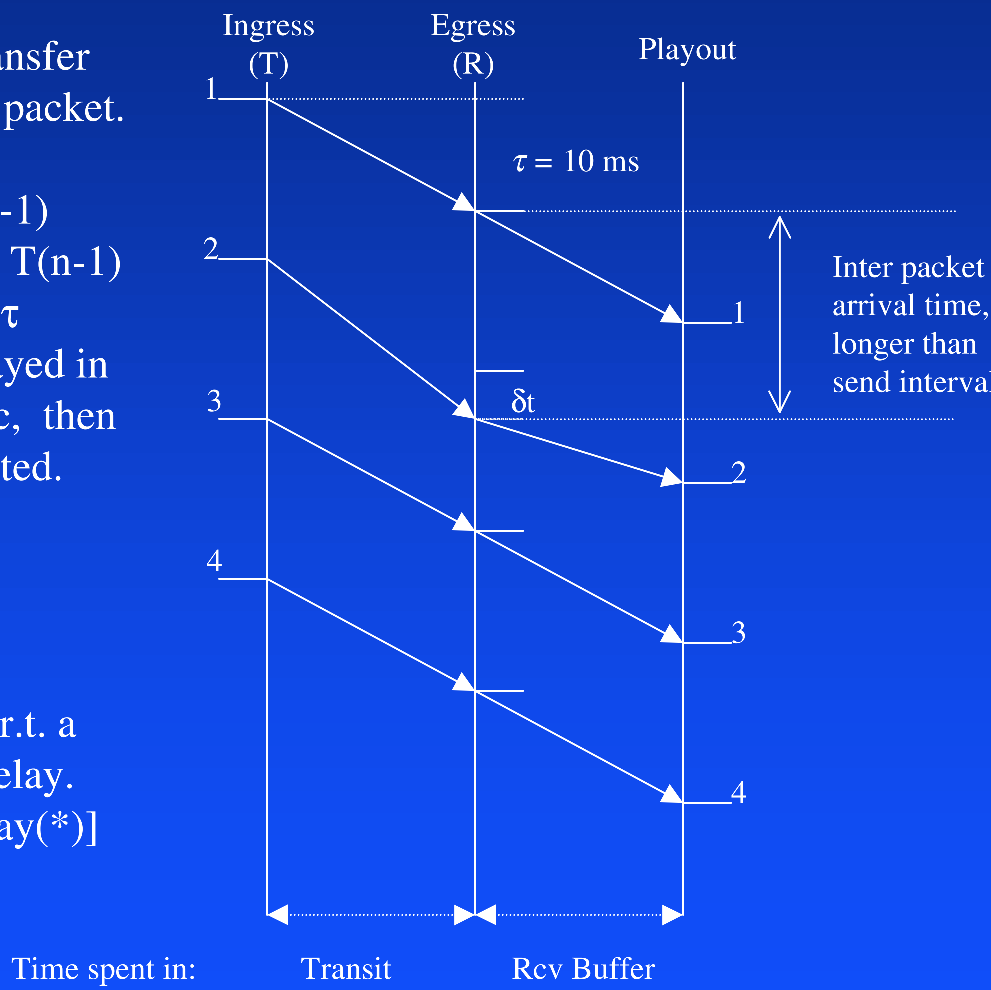
Metric/Parameter Definitions

	IETF IPPM RFCs	ITU-T Recs.
Framework	2330	Y.1540 cl 1 thru 5
Sampling	2330 Poisson 3432 Periodic	(future work in SG4 ?)
Loss	2680	Y.1540 cl 5.5.6
Delay	2679 (1-way) 2681 (Round Trip)	Y.1540 cl 6.2
Delay Variation	3393	Y.1540 cl 6.2.2 G.1020 (short term)
Availability	2678	Y.1540 cl 7
Bulk Transfer Cap	3148	
Loss Patterns	3357	Some in G.1020

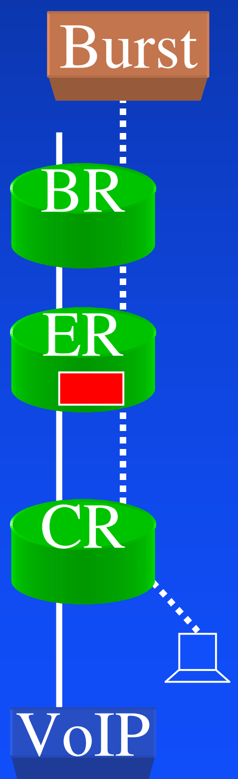
Comparison of IETF and ITU-T Delay Variation Metrics

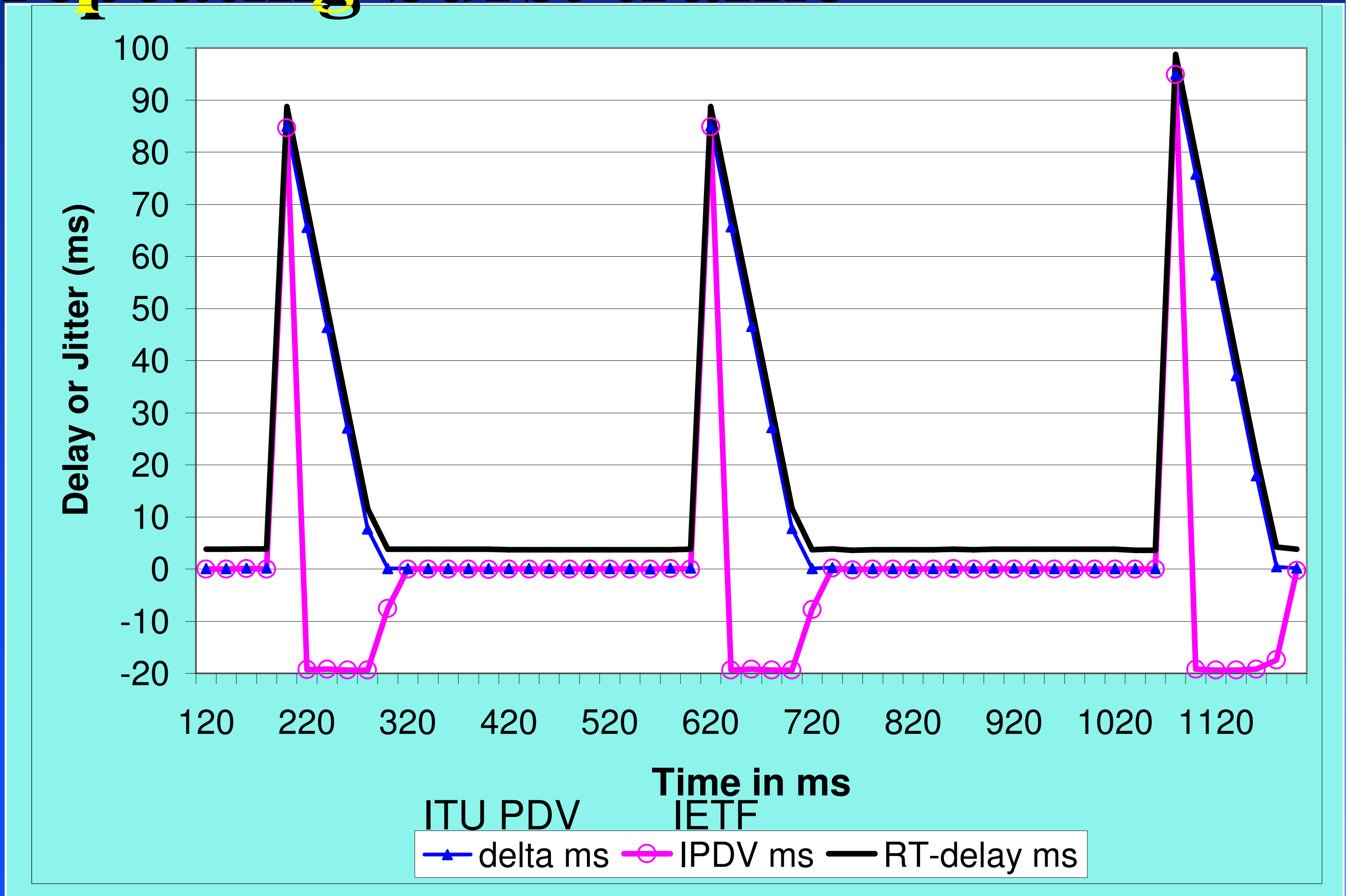
IETF IPDV is a measure of transfer delay variation w.r.t. previous packet.
For Packet n,
IPDV(n) = Delay(n) - Delay(n-1)
or = R(n) - R(n-1) - T(n) - T(n-1)
If the nominal transfer time is τ =10msec, and packet 2 is delayed in transit for an additional 5 msec, then **two** IPDV values will be affected.
IPDV(2) = 15 - 10 = 5 msec
IPDV(3) = 10 - 15 = -5 msec
IPDV(4) = 10 - 10 = 0 msec

ITU-T SG 13 PDV is delay w.r.t. a reference, usually minimum delay.
PDV(n) = Delay(n) - Min[Delay(*)]
PDV(1,3,4)=0 PDV(2)=5



Transient Delay Variation caused by repeating burst traffic





What is Packet Reordering?

Packets arrive at Dst, but not in send order.

1, 2, 3, 7, 8, 9, 10, 11,... Loss,no reordering

1, 2, 3, 7, 8, 9, 4, 5, 6, 10, 11,...reordering

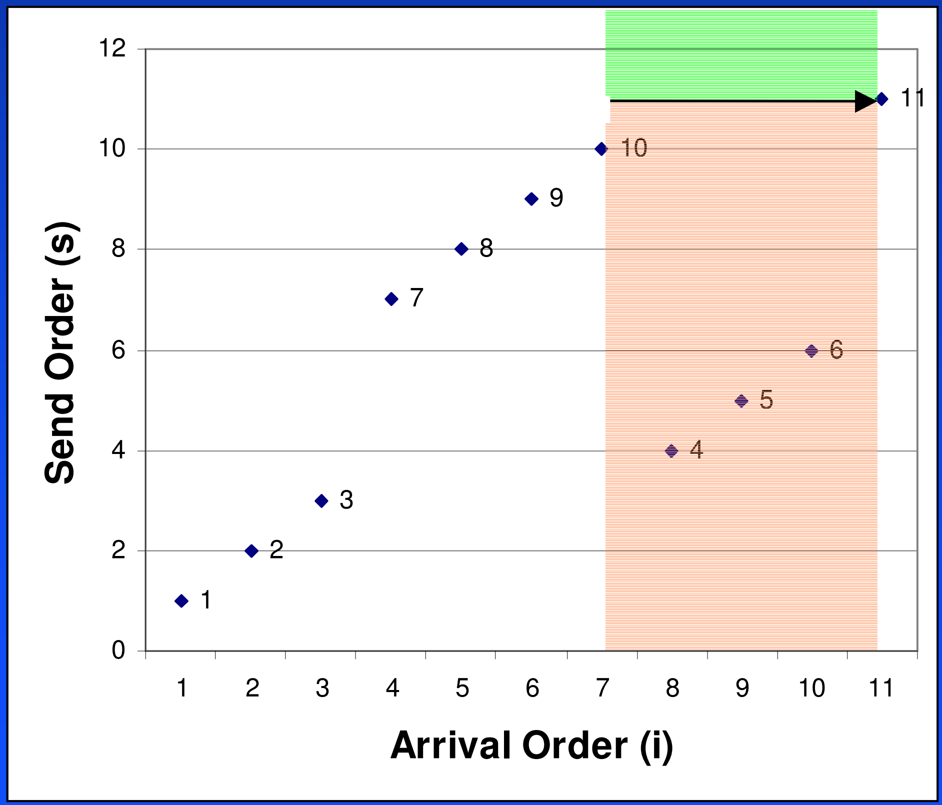
In the "world of order" all these packets are of interest.

```
1, 2, 3, 7, 8, 9, 4, 5, 6, 10, 11,...
         | Early |  Late   |
```

No reordering until Late Packets Arrive
# of Early Packets => Reordering Extent

Definition of Reordered Packet

- Packet **s** is reordered when its sequence number is less than the Next Expected threshold (set to **n**+1 by the arrival of a previous packet, s=n).

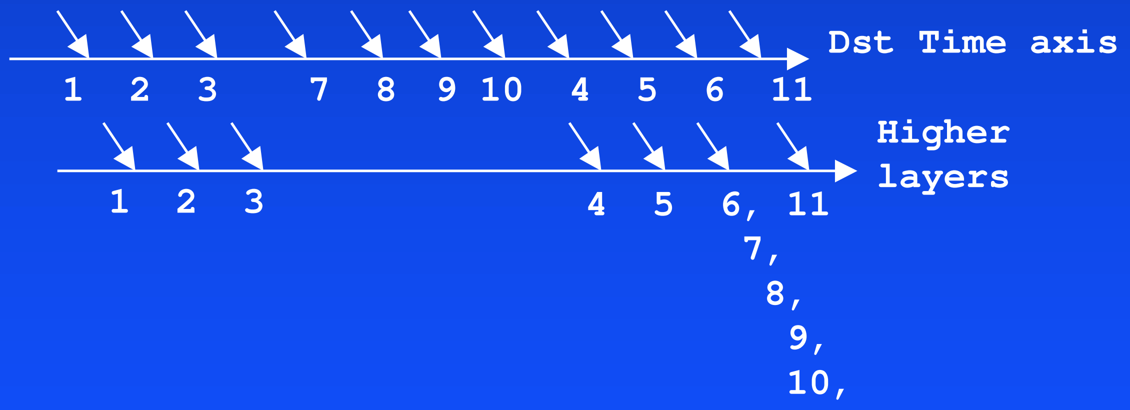


Affect of Reordered Packets on most applications

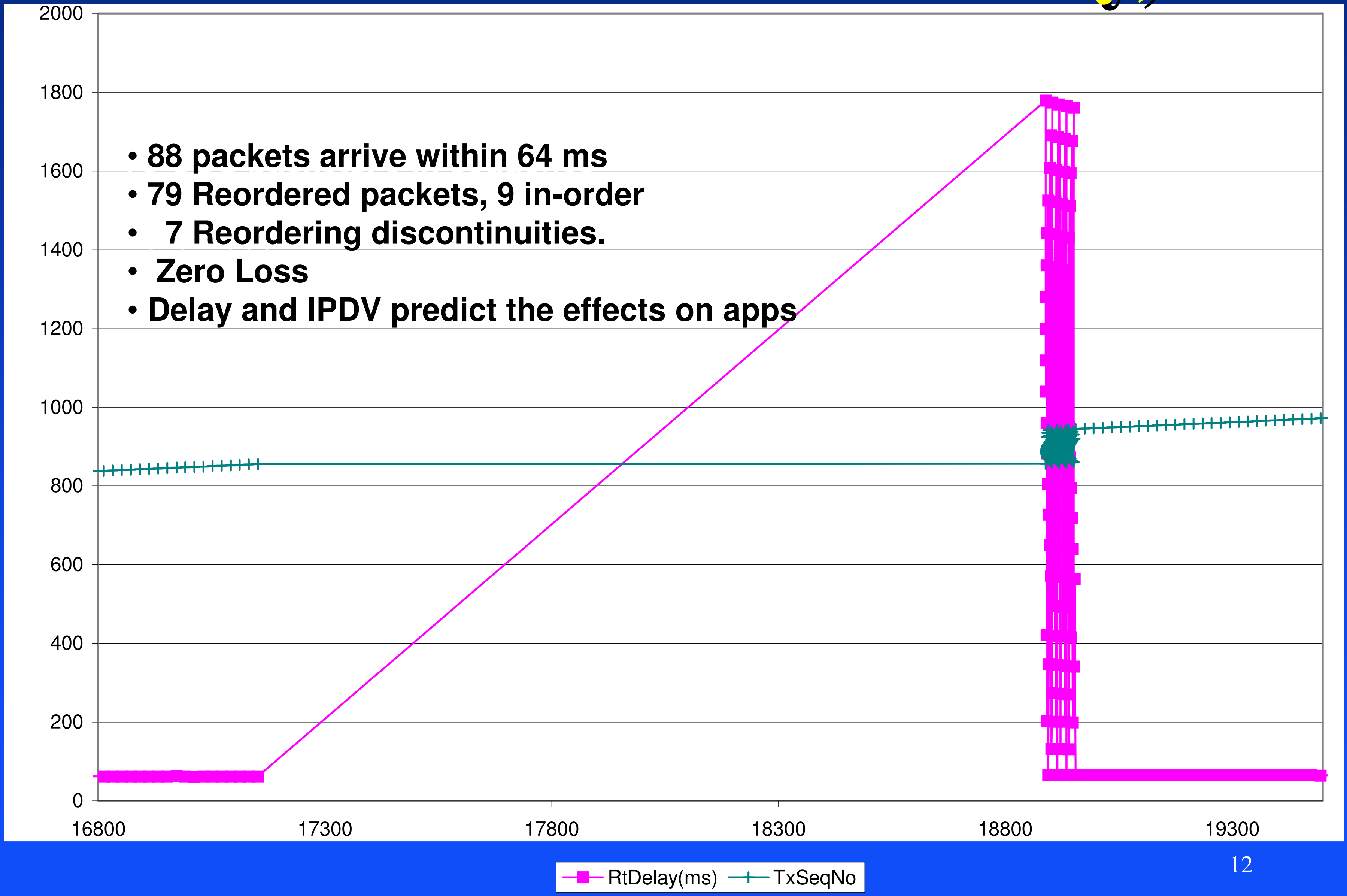
- Receivers must perform work to restore order

1, 2, 3, 7, 8, 9, 10, 4, 5, 6, 11, 12, ...

| Buffered || Reordered |

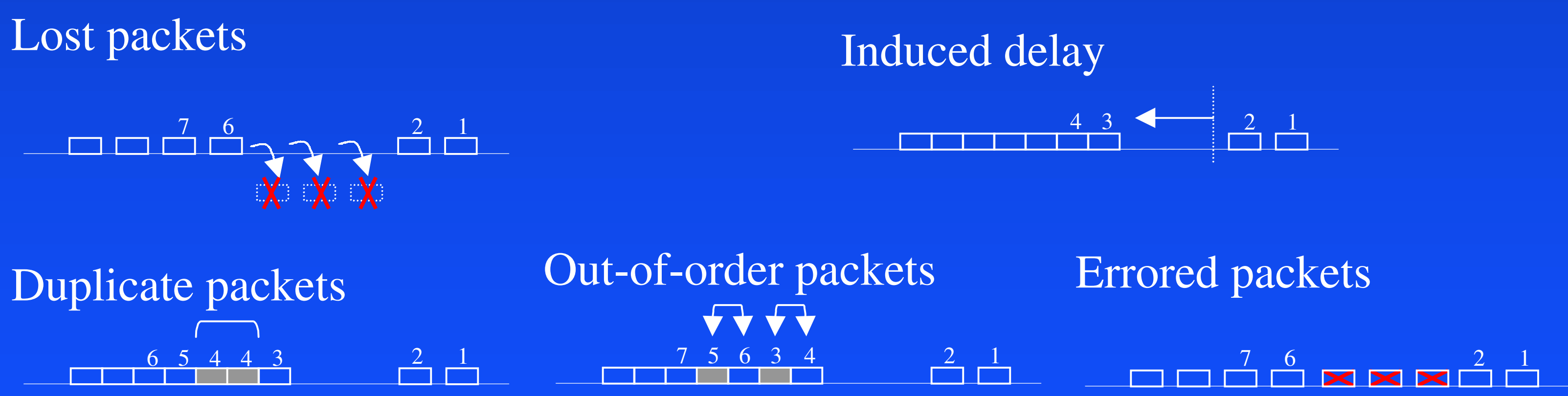


Blender: Dst Time vs RT Delay,ms



Failure Recovery Time

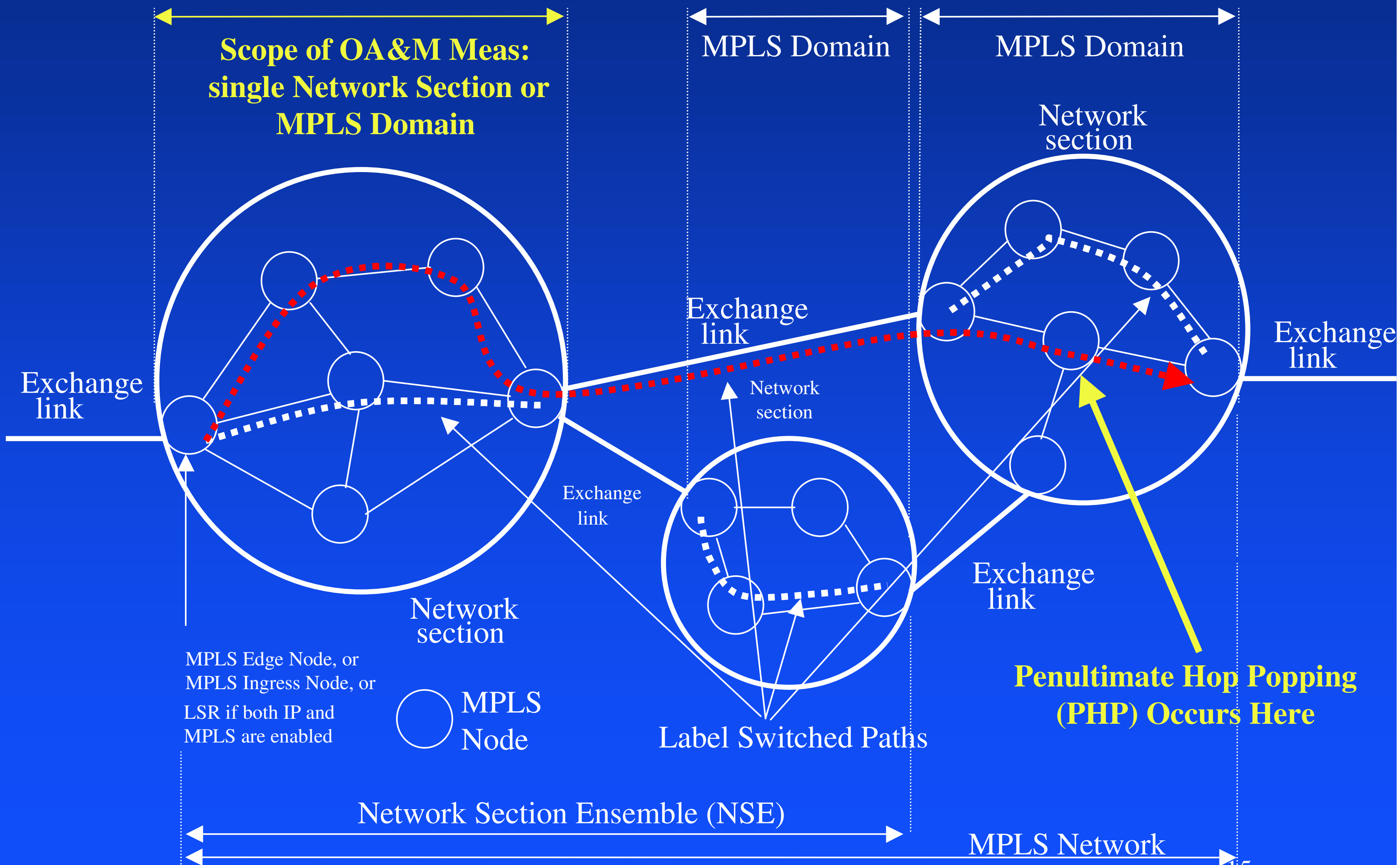
- When recovery was a simple outage, characterization was simple, too.
- IETF Benchmarking Methodology WG has identified 5 possible recovery scenarios:



New Measurement Challenges for MPLS-enabled IP Networks

- Most (all?) IP/Packet Network challenges
- Two main categories of MPLS Domains:
  - LDP-based, connection-less
  - Traffic Engineering, connection oriented
- Label Switched Paths are Unidirectional
- point to point and multi-point to point
- Many options for Failure Recovery
- LSP identity optionally removed (PHP)
- Work in progress in SG 13 = Y.MPLSperf

New Measurement Challenges for MPLS-enabled IP Networks



New Measurement Challenges for MPLS-enabled IP Networks

- New Network Protocols
  - New Opportunities to Blackhole Traffic
- Detect this new class of failures with
  - MPLS/LSP-Ping, Like ICMP Echo Request, plus
    - One-way Delay measurement possible
    - LSP Traceroute possible
  - Y.1711 MPLS OA&M Connectivity Verification
    - First version approved, adding fast failure detection

Implementations: Customers, Service Providers & 3rd Parties

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$ ping R2 (or R3)
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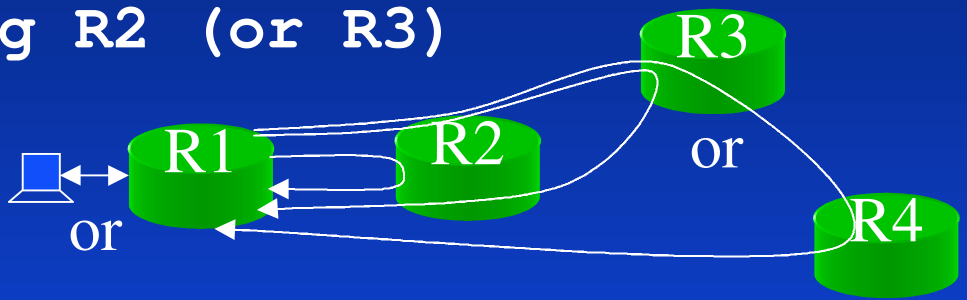
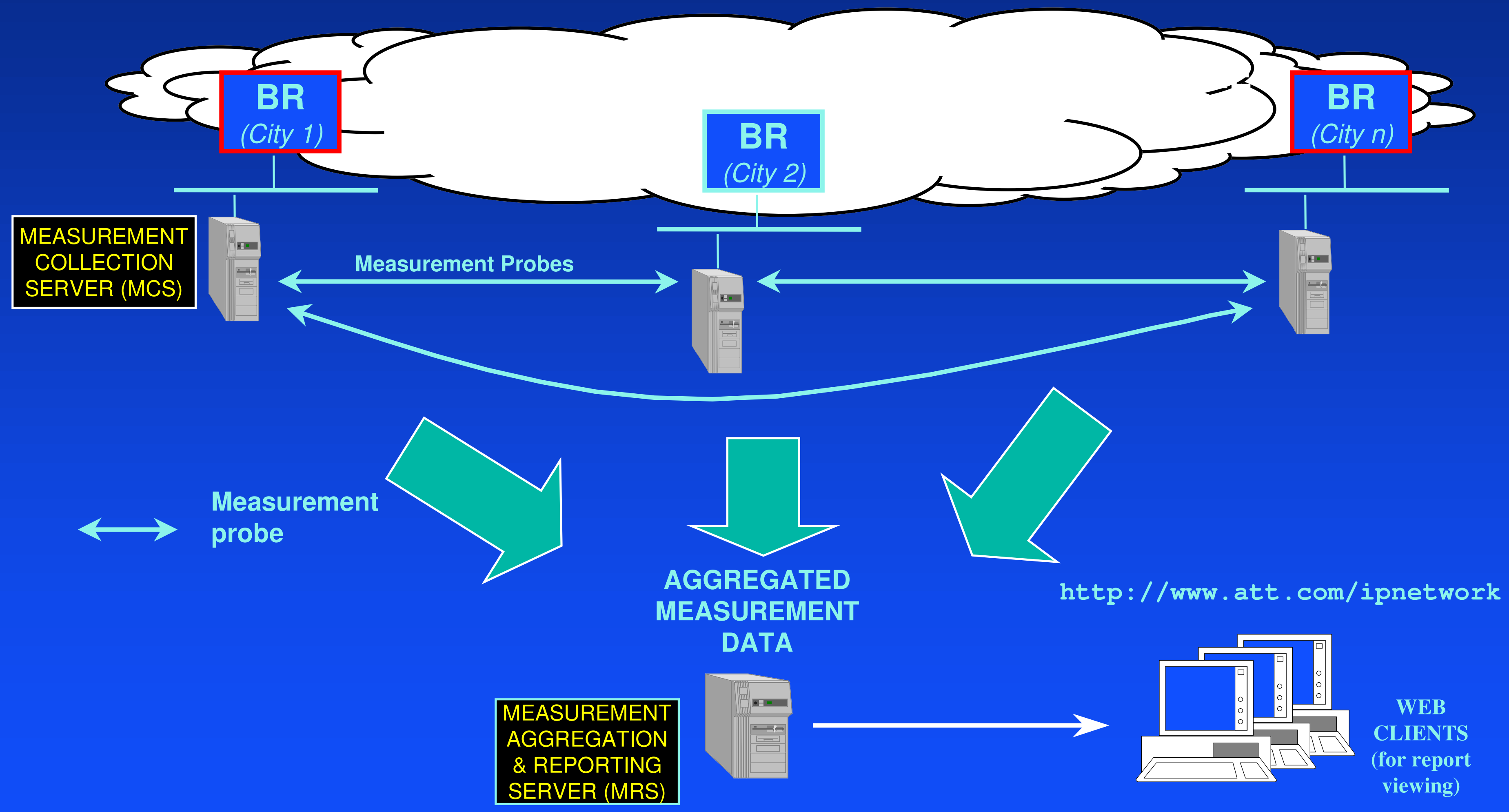


- Select Ping Target - make Round-trip connectivity and RTT measurement
- Accuracy Issues include path through router, path through net (asymmetries), response time at target, sampling rates
- Compare to current perf. to “normal”

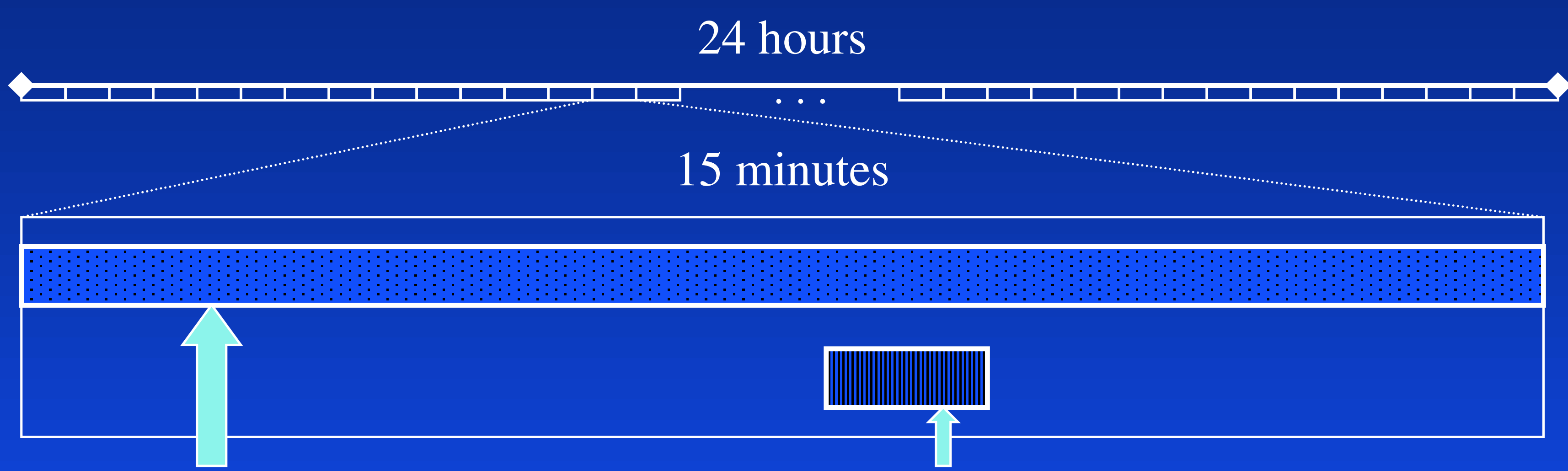
AT&T Global IP Measurements



Technical Collaborators at AT&T

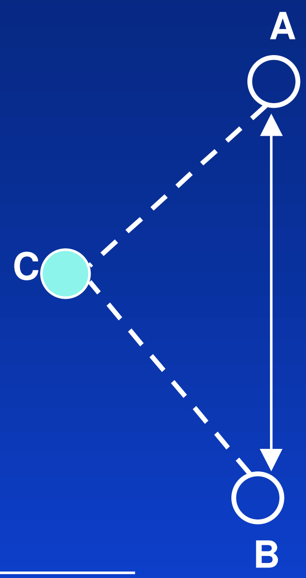
- Len Ciavattone
- Kevin D'Souza
- George Holubec
- Madhukar Kshirsagar
- Ron Kulper
- Arvind Ramarajan
- Gomathi Ramachandran

AT&T's IP Measurement Design



- Poisson Sequence (RFC2330)
  - 15 minute duration
  - λ = 0.3 pkts/sec
  - Type UDP, IPv4
  - 278 bytes total
  - ~300 packets sent
  - unbiased sample
- Periodic Sequence (RFC3432)
  - 1 minute duration
  - Random Start Time
  - 20 ms packet spacing
  - Type UDP, IPv4
  - 60 bytes total
  - ~3000 packets sent

Results: A-B Route Changes



Time, h:m	Type	Lost Packets	Burst Duration	ACB route duration m:s
0:49	Poisson	5 consec	23 sec	4:32
1:07	Poisson	5 consec	15 sec	<2:00
1:09	Periodic	54 consec	1.04 sec	(return)
1:18	Poisson	4 consec	26 sec	2:10
1:30	Poisson	5 consec	28 sec	2:03

Summary

- Performance Management through Active Measurement
- Summary & Comparison of Parameters/Metrics
- In-progress Metric Development
- Parameter Framework for MPLS has new challenges
- Active Measurement Implementations
  - Ping for connectivity and ...
  - Dedicated Measurement Systems
- AT&T continuously measures its IP Network as part of QoS assurance

Resources and References

- L. Ciavattone, A. Morton and G. Ramachandran, "Standardized Active Measurements on a Tier 1 IP Backbone," IEEE Communications Magazine, June 2003.
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- X.Xiao, et al., "A Practical Approach for Providing QoS in the Internet Backbone," IEEE Communications Magazine, December 2002.
- D. Meyer, et al., "Trends in Measurement and Monitoring of Internet Backbones," Panel at NANOG 26, slides etc. at http://www.nanog.org/mtg-0210/measurement.html
- ITU-T Rec. Y.1540, "Internet Protocol Data Communication Service – IP Packet Transfer and Availability Performance Parameters," 2003.
- IETF IP Performance Metrics Working Group, links to RFC 2330, other IPPM RFCs and Internet Draft on Reordering: http://www.ietf.cnri.reston.va.us/html.charters/ippm-charter.html
- Draft New Recommendation Y.MPLSperf, "Performance and Availability Parameters for MPLS Networks"
- New Recommendation G.1020, "Performance Parameter Definitions for Quality of Speech and other Voiceband Applications Utilising IP Networks"
- RFC 792, "Internet Control Message Protocol," J. Postel, September 1981.