On the Scalability of RTCP-Based Network Tomography for IPTV Services

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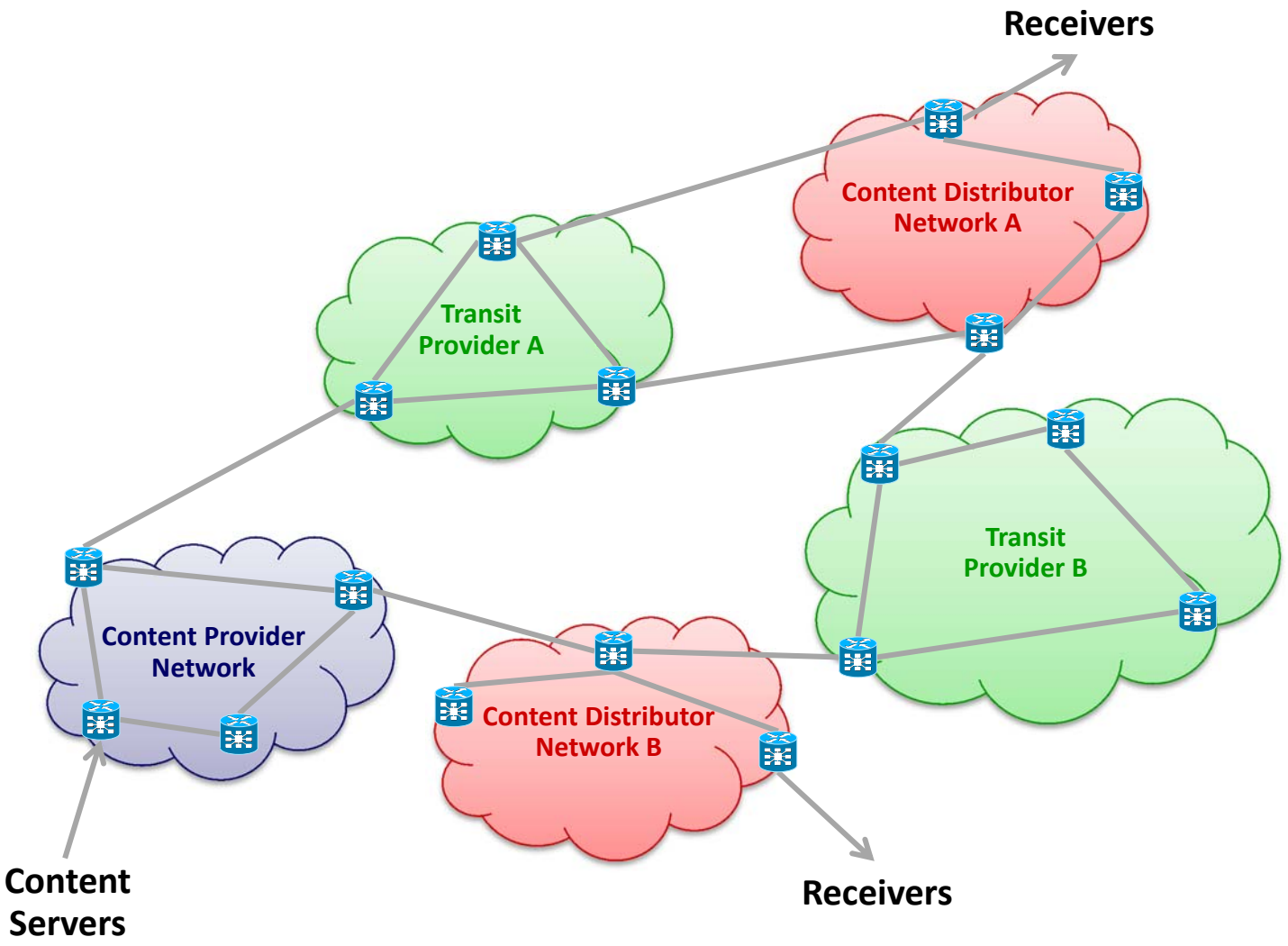
Content Distribution over IP



Broadcast IPTV = IP Multicast

- **Various Transports**

  Native IP multicast, MPLS, L2, optical

- **SSM: Source-Specific Multicast (RFC 4604/4607 – 2006)**

  Receivers subscribe (S,G) channels to receive traffic only from source S sent to G

  Primarily introduced (by IETF) for IPTV-like services

- **Transport Challenges**

  Packet loss

  Out-of-order delivery

  Packet duplication

Despite all the challenges, it is crucial to continuously monitor the quality of experience for all viewers, locate the problems and fix them right away

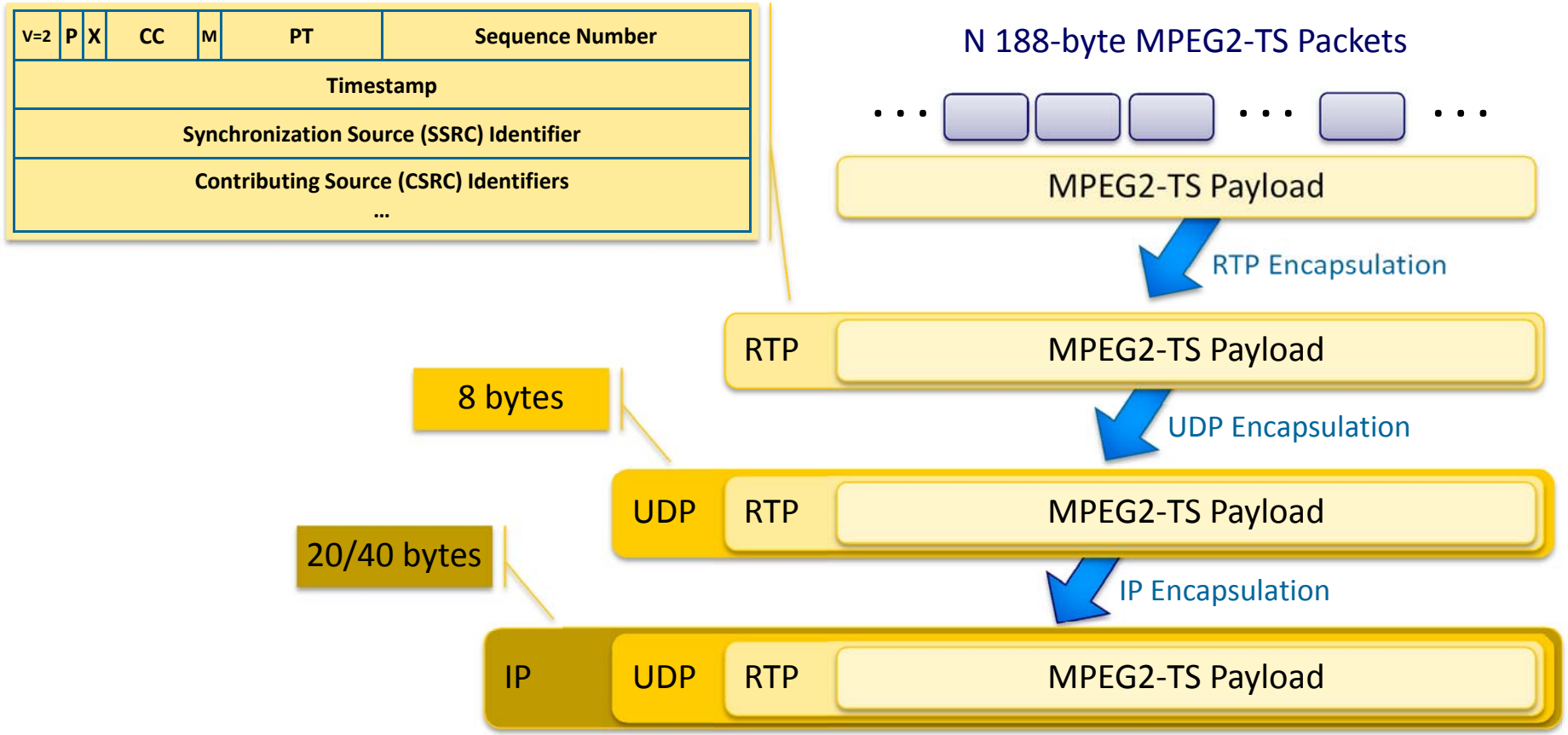
Real-Time Transport Protocol (RTP)

http://tools.ietf.org/html/rfc3550

- **Basics**
  - First specified by IETF in 1996, later updated in 2003 (RFC 3550)
  - Runs over any transport-layer protocol (Typically over UDP)
  - Runs over both unicast and multicast
  - No built-in reliability
- **Main Services**
  - Payload type identification
  - Sequence numbering
  - Timestamping
- **Extensions**
  - Basic RTP functionality uses a 12-byte header
  - RFC 5285 defines an RTP header extension mechanism
- **Control Plane – RTCP**
  - Provides minimal control and identification functionality
  - Enables a scalable monitoring functionality (Sender, receiver, extended reports)

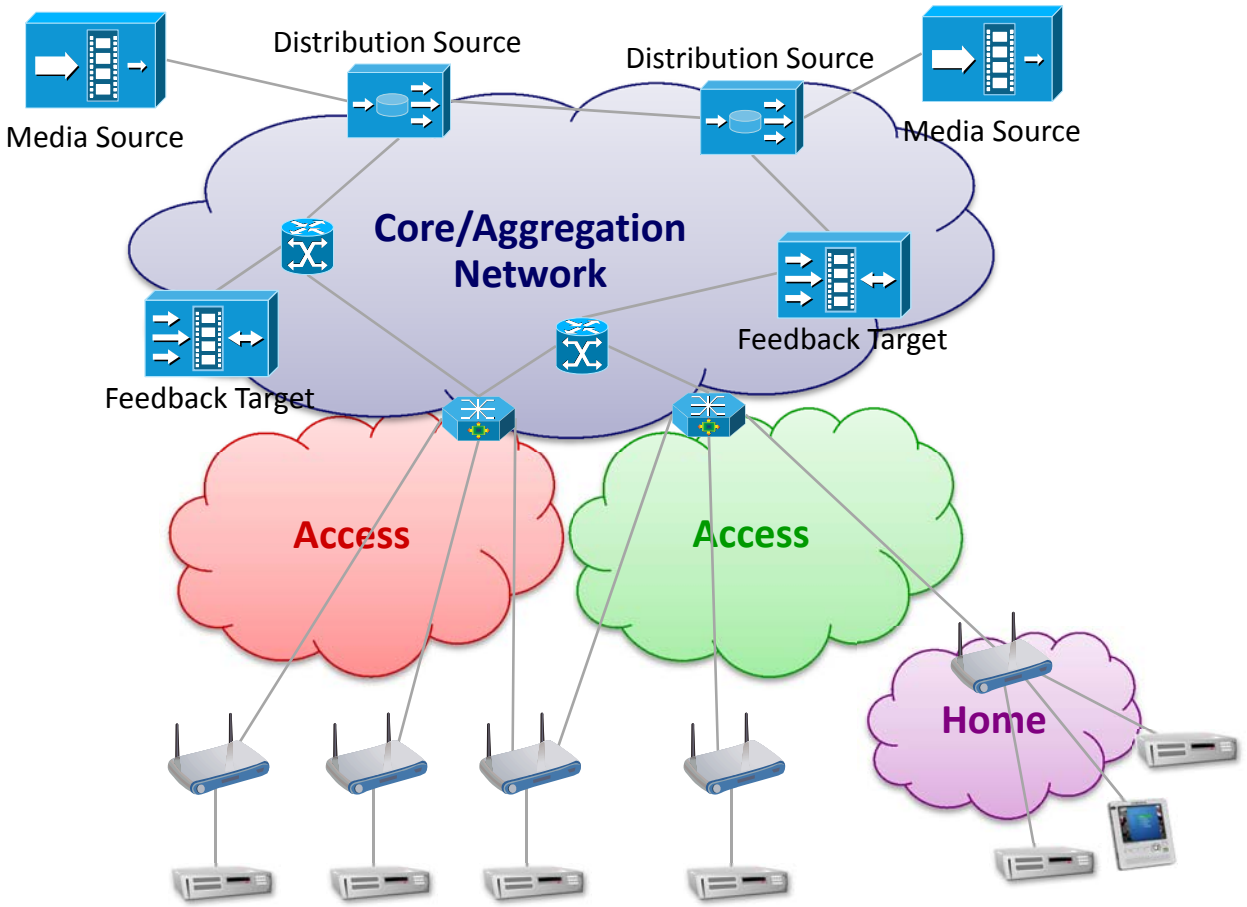
RTP Transport of MPEG2 Transport Streams

http://tools.ietf.org/html/rfc2250



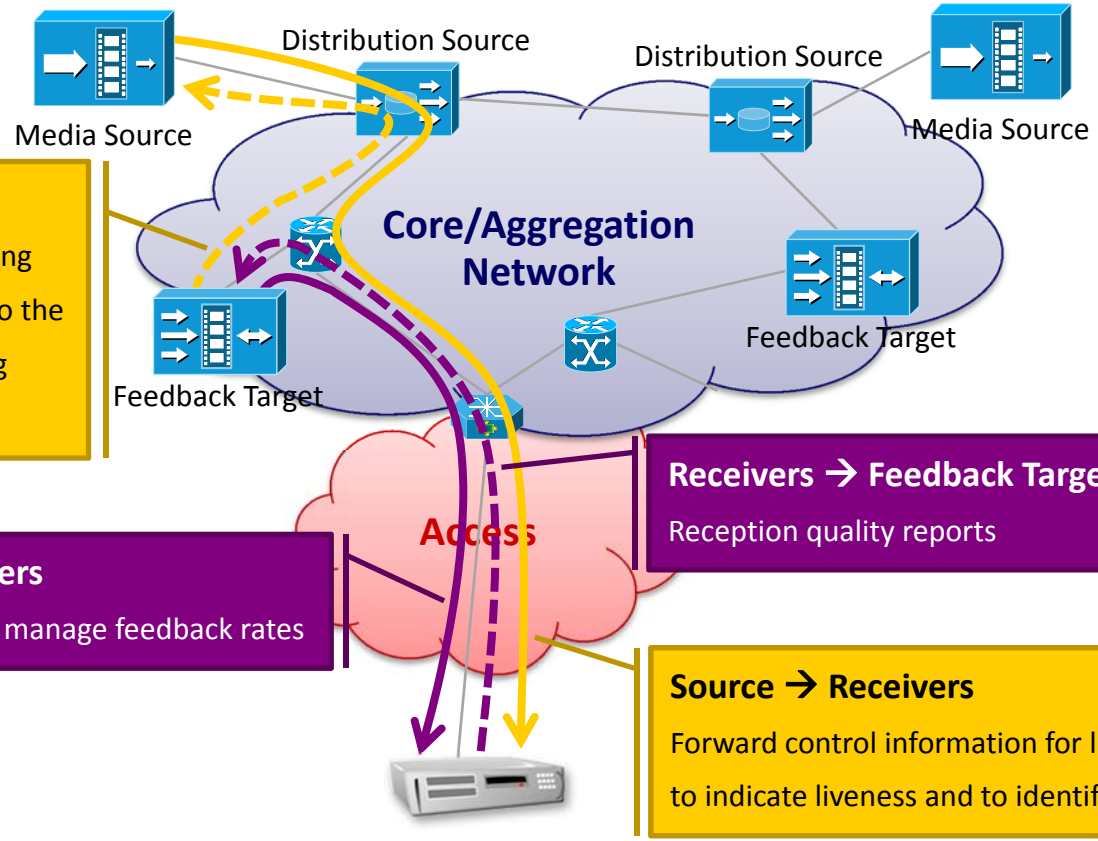
Default IP header size is 20 and 40 bytes for IPv4 and IPv6, respectively

IPTV Distribution and a Scalable Monitoring Architecture



IP STBs join the respective multicast session(s) for the desired TV channel
Unicast feedback from IP STBs are collected by the feedback targets

Four RTCP Flows, Two RTCP Loops



Feedback Targets → Source

Reception quality reports reporting quality of the path from source to the feedback target and summarizing reception quality for receivers

Receivers → Feedback Target

Reception quality reports

Feedback Target → Receivers

Forward control information to manage feedback rates

Source → Receivers

Forward control information for lip-synchronization, to indicate liveness and to identify the source

The RTCP Reception Quality Reports

- **RTCP Receiver Reports summarize the reception quality**
  - Timestamp of (and delay from) the last received sender report
  - Highest sequence number seen so far
  - Number and fraction of the lost RTP packets
  - Estimate of the interarrival jitter
- **RTCP Extended Reports (XR) provide**
  - Detailed transport-level stats and application-specific information about the RTP transport
  - Several advantages over traditional and proprietary monitoring solutions
- **RTCP XR framework is easily extensible to report on**
  - Packet-level loss events, loss patterns, mean time between losses, loss durations, etc.
    - → Correlation engines identify, characterize and isolate the problems
  - Audiovisual reception quality
  - Effectiveness of the loss-repair methods
    - → Loss-repair methods can be adapted and improved depending on the network conditions
  - Effectiveness of channel change acceleration

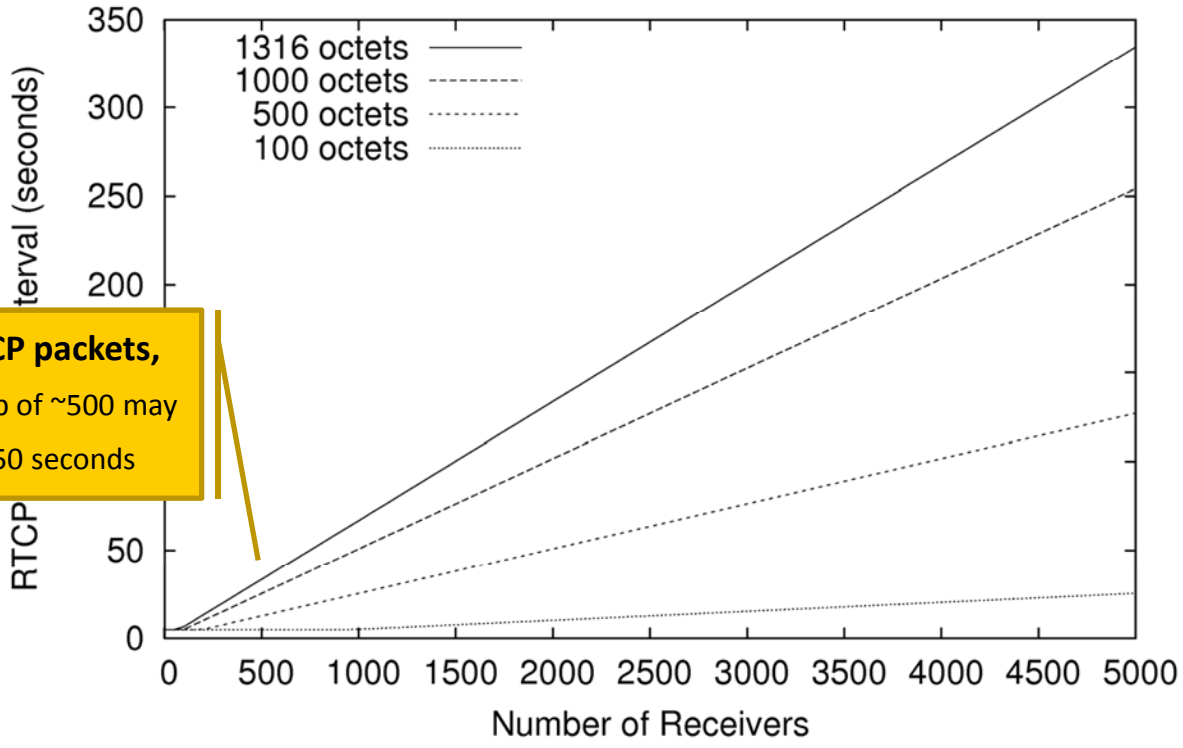
RTCP Extended Reports (XR)

http://tools.ietf.org/html/rfc3611

V=2	P	RC	PT=RR=201	Length
SSRC of Packet Sender				
SSRC of Distribution Source				
Fraction Lost			Cumulative Number of Packets Lost	
Extended Highest Sequence Number Received				
Interarrival Jitter				
Last SR (LSR)				
Delay since Last SR (DLSR)				
V=2	P	SC	PT=SDES=202	Length
SSRC/CSRC_1				
CNAME=1			Length	Canonical Name (MAC Address)
...				
V=2	P	Rsvd.	PT=XR=207	Length
SSRC				
BT			Type Specific	Block Length
Type-specific Block Contents ...				

The Feedback Target ↔ Receivers RTCP Feedback Loop

Impact of Group Size on the Reporting Interval



With 1316-byte RTCP packets,
each receiver in a group of ~500 may send a report at every 50 seconds

Media bandwidth is 4.2 Mbps (400 pps) and RTCP packet size is from 100 to 1316 bytes

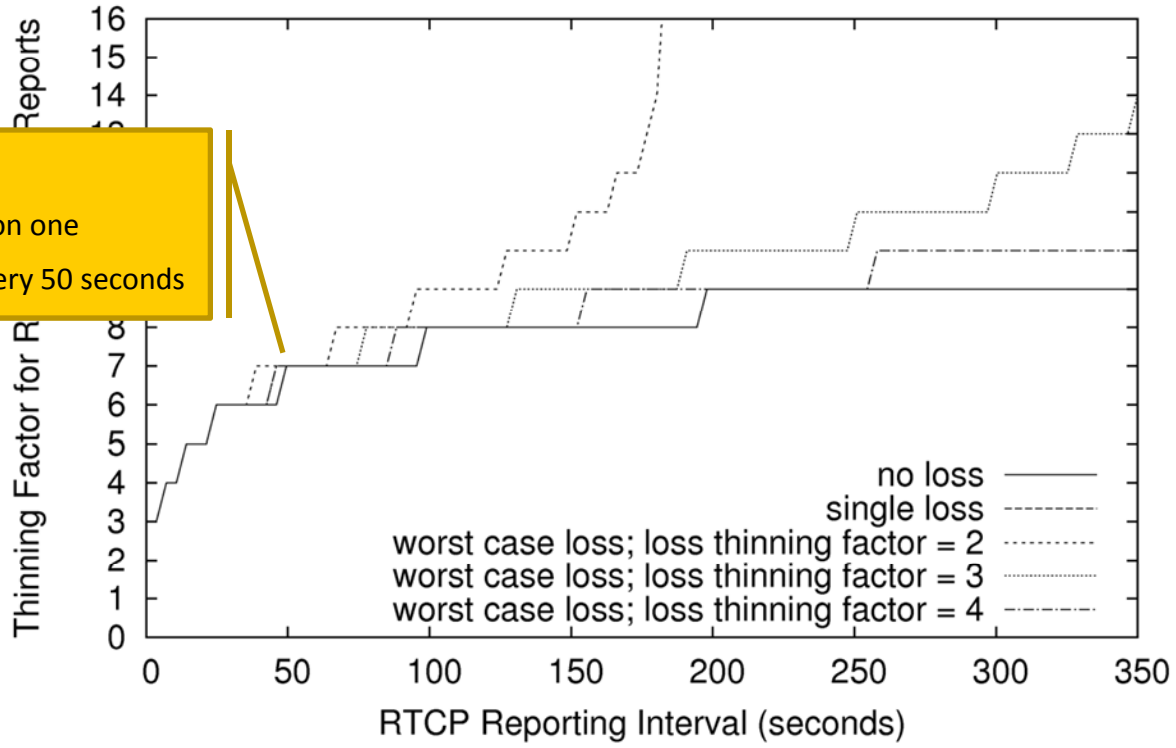
The Feedback Target ↔ Receivers RTCP Feedback Loop

Required Thinning Factor for Receipt Time Reports

In a group of ~500,

each receiver may report on one

in every 128 packets at every 50 seconds

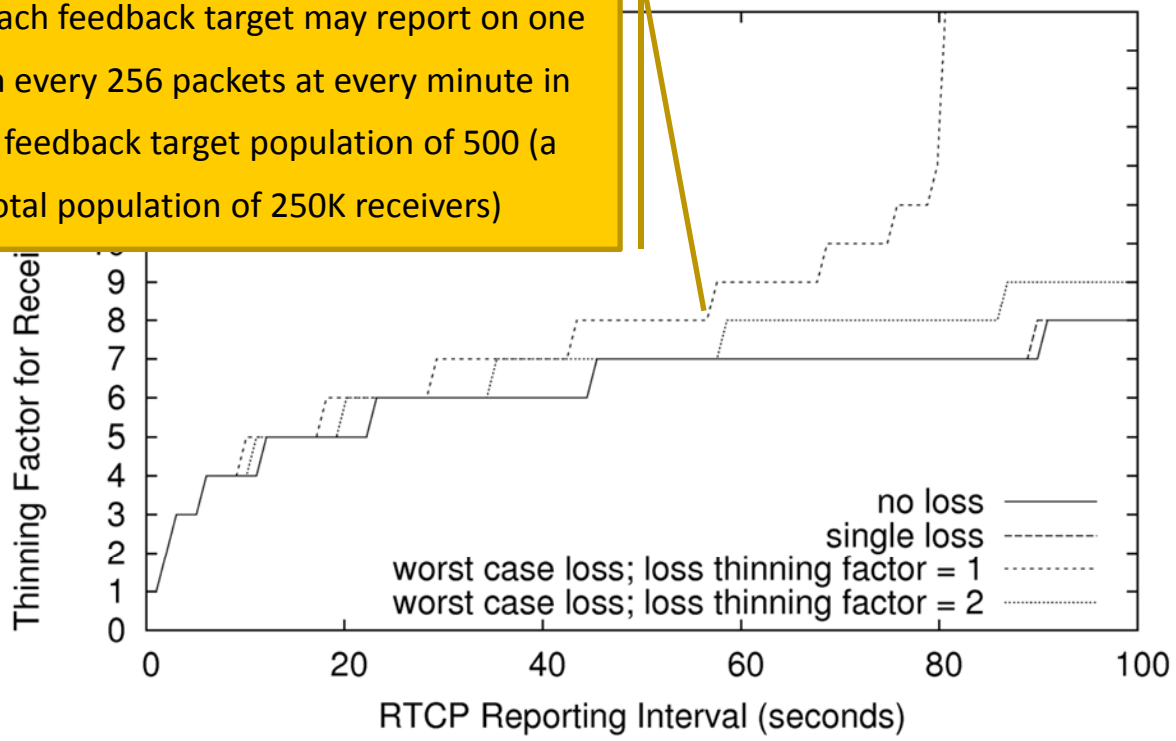


Media bandwidth is 4.2 Mbps (400 pps) and RTCP packet size is 1316 bytes

The Source ↔ Feedback Targets RTCP Feedback Loop

Required Thinning Factor for Receipt Time Reports

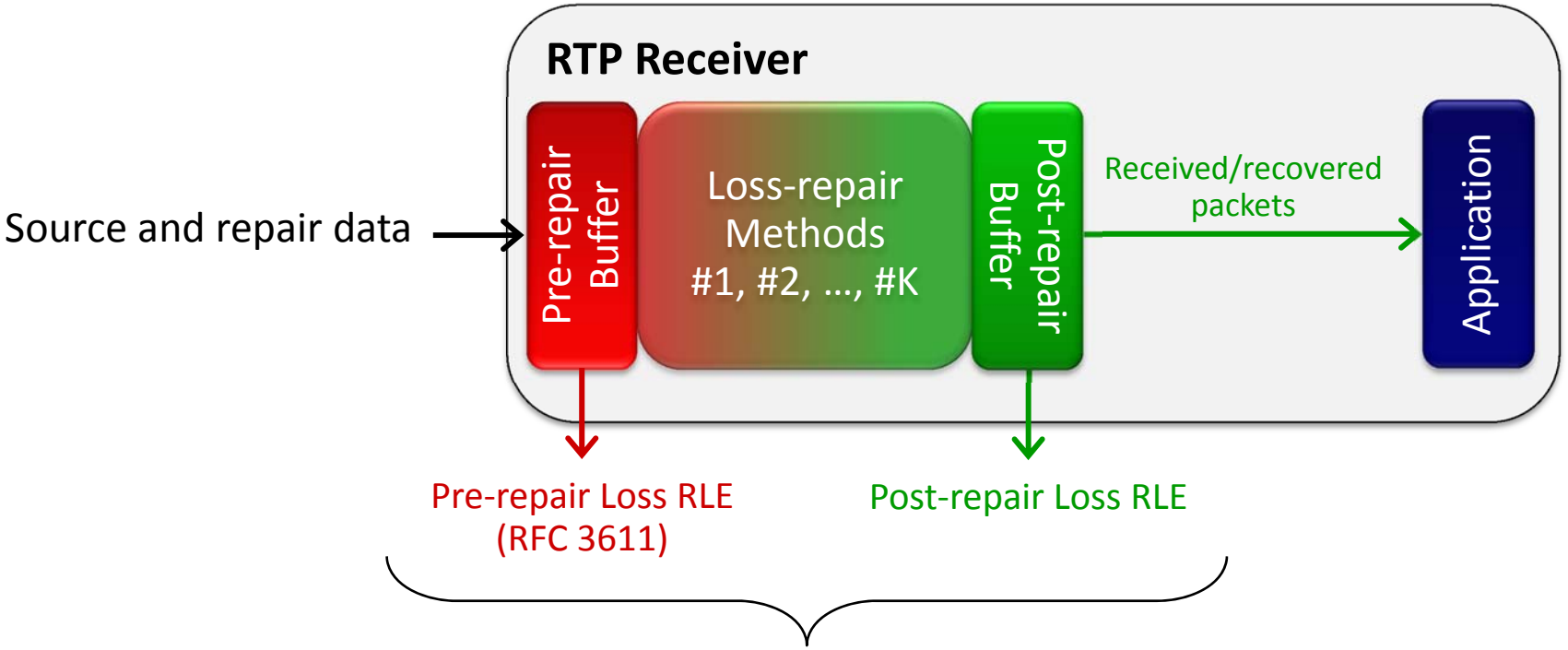
With 1316-byte RTCP packets,
each feedback target may report on one in every 256 packets at every minute in a feedback target population of 500 (a total population of 250K receivers)



RTCP packet size is 1316 bytes

RTCP XR Example: Loss RLE Reports

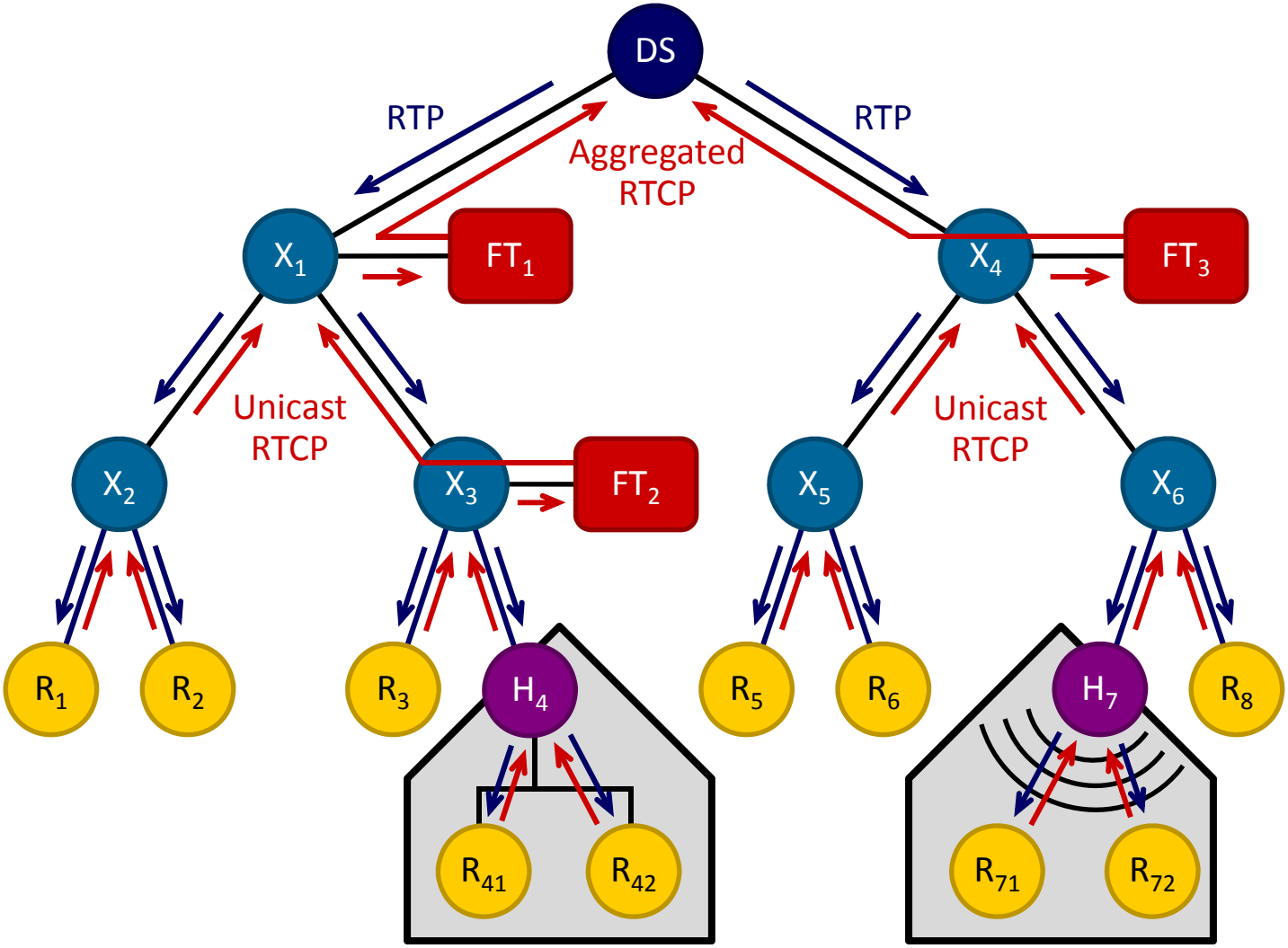
http://tools.ietf.org/html/draft-ietf-avt-post-repair-rtcp-xr



The difference tells us the aggregated performance of the loss-repair methods

Fault Isolation through Network Tomography

To Appear in IEEE Network in H1 of 2010



Summary

- **An IPTV system needs to continuously monitor the viewer quality of experience with little or no human assistance**
  - RTCP provides a scalable monitoring architecture with little network overhead
- **The IPTV system needs to process the incoming reports to diagnose and isolate the problem(s) and inefficiencies**
  - Instrumenting RTCP at endpoints and strategic middle boxes
    - Enables efficient data collection
    - Allows fault isolation through network tomography

Questions