ECN for RTP over UDP/IP

draft-westerlund-avt-ecn-for-rtp-00.txt
draft-carlberg-avt-rtp-ecn-02.txt
draft-carlberg-avt-rtcp-xr-ecn-01.txt

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Motivation

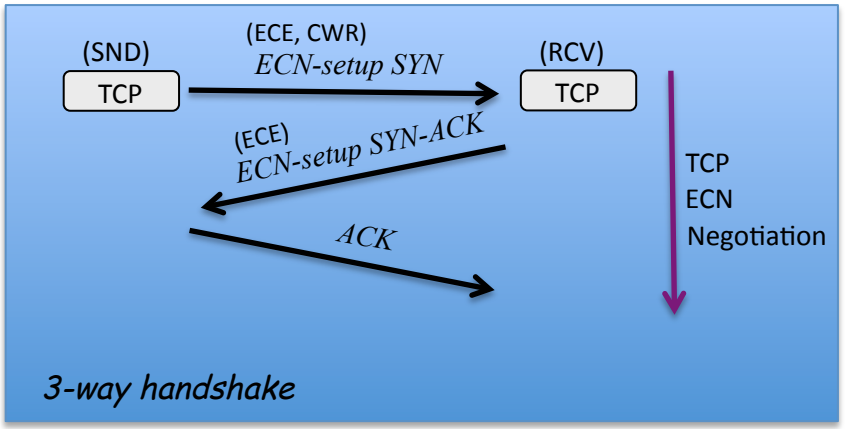
- ECN provides for advanced warning of persistent congestion
  - RFC3168(§5.1): “the CE codepoint should not be set by a router based on the instantaneous queue size”
- ECN-CE warning is more useful to real-time flows (TCP can always ARQ)
  - Provides opportunity for adaption *before* loss occurs
- RTP/SDP provides a way forward

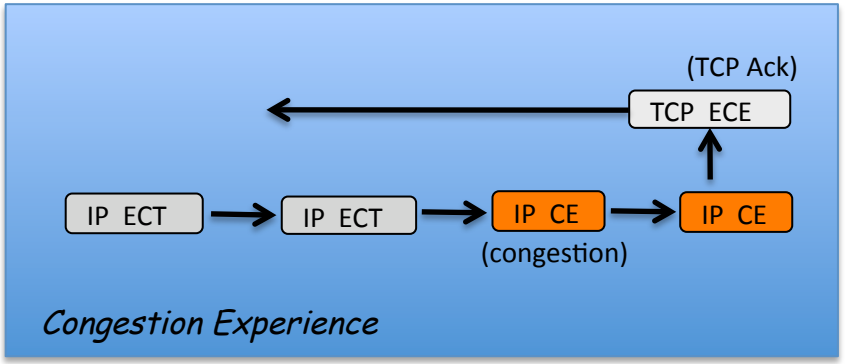
Dynamic adaptation RTP

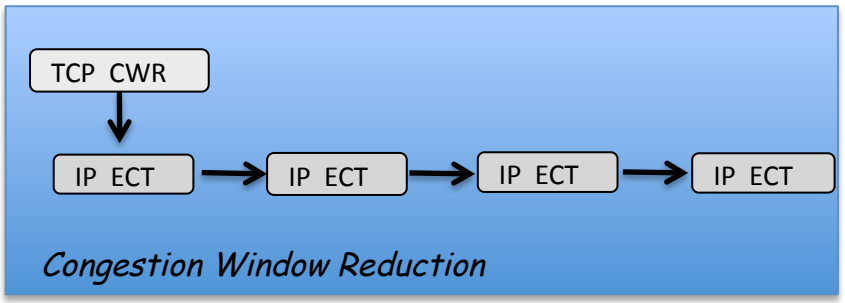
- Many RTP flows do not do adaptation to loss
  - Using loss as a signal is a bit late
- There are now a number of variable bit rate codecs
- ECN allows
  - Early congestion response
    - Mechanisms are out of scope for this draft
  - Improved user experience

Background

- Explicit Congestion Notification (ECN)
  - Two Layer design (RFC-3168):
    - Network: hop-by-hop marking
    - Transport: negotiation and feedback
  - Active Queue Management (AQM)
    - E.g., Random Early Detection (RED), *marks* packets instead of dropping
- In-Band signaling
  - IP: two bits in diff-serv field
    - ECN Capable Transport (ECT) (01, 10)
    - Congestion Experience (CE) (11)
    - ECN not supported (00)
  - TCP: two bits
    - ECN Echo, Congestion Window Reduced
  - TCP ECN Nonce (RFC 3540)

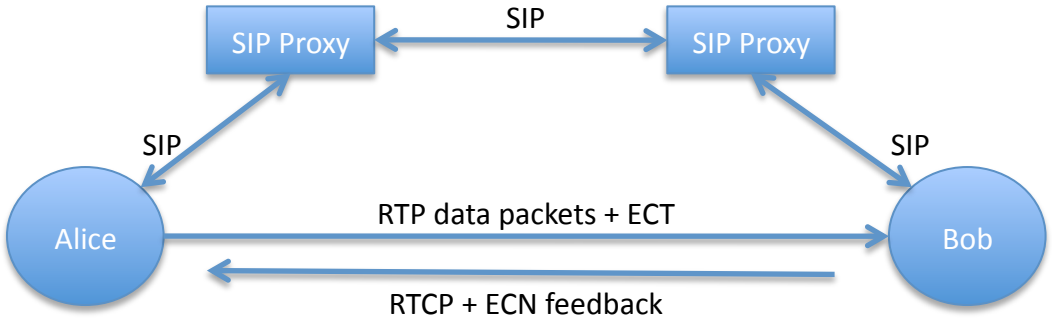






ECN for RTP over UDP/IP

- Initially seems straight-forward:
  - Signal ECN support in SIP using SDP offer/answer
  - Set ECT on RTP data packets sent in UDP/IP
  - Send feedback piggybacked on RTCP reception reports
    - (No portable way to monitor received ECN marks on UDP)
  - Respond to ECN-CE by varying media encoding rate



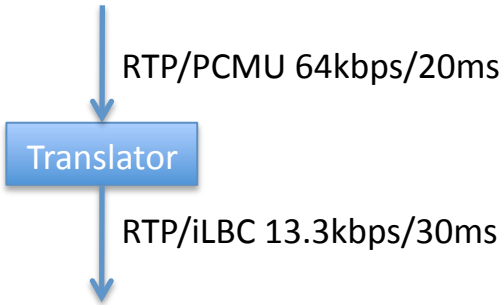
- Yes, but…

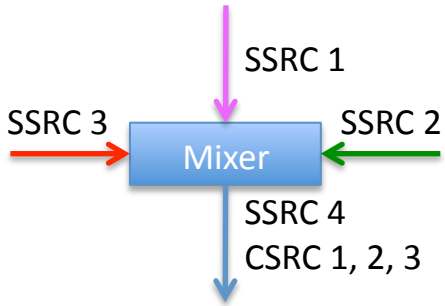
Why is ECN for RTP Difficult? (1/3)

- Signalling
  - Signalling can negotiate end-point *capability*; says nothing about ability of media path ability to support ECN
- Feedback
  - RTCP feedback on congestion events is slow – seconds rather than RTT
    - AVPF helps, but may still limit amount of feedback that can be sent
- Congestion Response
  - Codecs adaptive, within some constraints; frequent variation destroys user experience; not TCP-friendly

Why is ECN for RTP Difficult? (2/3)

- Middle-boxes
  - RTP *translators* and *mixers* within the network
    - Translator is a middle-box; must interpose itself in the ECN negotiation, split the connection, respond to congestion
    - Mixer acts as end-point; terminates transport connections





  - Only *part* of an RTP session may support ECN

Why is ECN for RTP Difficult? (3/3)

- Multicast
  - RTP is inherently a *group* communication protocol
    - ASM with many-to-many groups and multicast feedback
    - SSM with unicast feedback, potentially very large groups
      - IPTV channels, potentially millions of receivers
  - ECN per sender tree? For the entire group? All receivers? Again, only *parts* of the session may support ECN
  - May require receiver driven congestion response (layered coding?)

ECN for RTP over UDP/IP: Proposal

- Four pieces to the proposed solution:
  - Negotiation of ECN capability
    - SIP with SDP offer/answer; ICE option
  - Initiation and verification of ECT
    - Using RTP and RTCP
    - Using STUN and ICE
  - Ongoing use of ECN with RTP session
  - Failure detection, verification, and fallback

Negotiation of ECN Capability

- SIP with SDP offer/answer
  - SDP offer include new attribute to indicate ECN capability of the offering entity
    - `a=ecn-capable-rtp`
    - `a=rtp-ecn: <sendonly|sendrecv>`
  - Answering entity replies; negotiates ECN *capability*
  - Portable APIs exist to set ECN bits on UDP packets, but not to read them from received packets
    - Should we support devices that can send ECN, but not receive it?

ECN Probing

- End-point ECN capability != path ECN capability
- Broken middle-boxes exist which can disrupt ECN
  - Drop packets with ECT marks
  - Zero out ECT marks in transit
- Need to probe path to determine if ECN supported
  - Using STUN as part of an ICE exchange
  - Using RTP and RTCP

ECN Probing using STUN/ICE (1/2)

- Additional signalling: capability to probe the path for ECN support using STUN as part of an ICE exchange
  - `a=ice-options: rtp+ecn`
  - Details to be resolved: `a=ice-options` poorly defined

- Possible for unicast flows where ICE is supported
  - Subset of possible use-cases

ECN Probing using STUN/ICE (2/2)

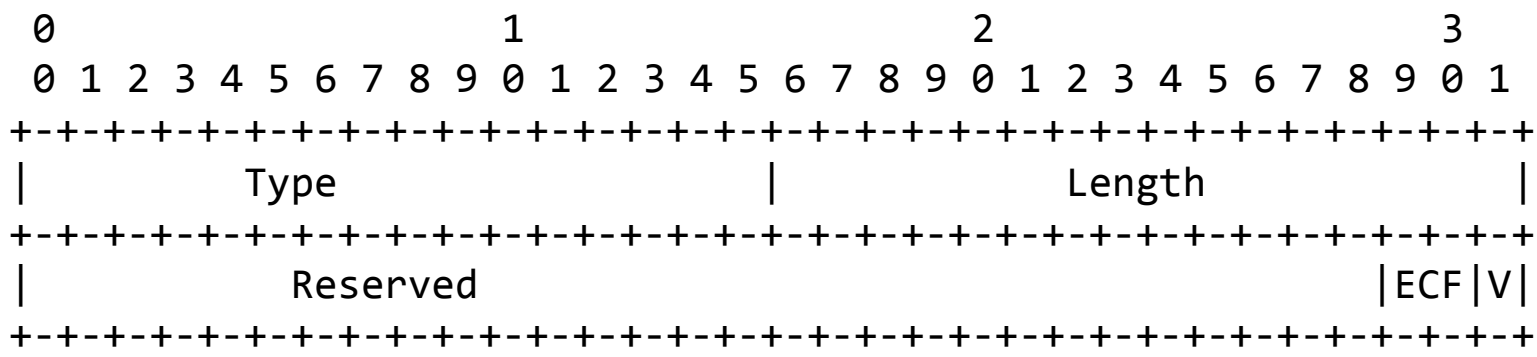


Figure 1: ECN Check Stun Attribute

V: Valid (1 bit) ECN Echo value field is valid when set to 1, and invalid when set 0.

ECF: ECN Echo value field (2 bits) contains the ECN filed value of the STUN packet it echoes back when field is valid. If invalid the content is arbitrary.

Reserved: Reserved bits (29 bits) SHALL be set to 0 and SHALL be ignored on reception.

ECN Probing using RTP/RTCP

- Basic RTP/RTCP probing mechanism:
  - Sender starts by ECT marking small fraction of RTP packets
    - Comfort noise, no-op, or similar
  - Receivers report reception of ECT marked packets
    - New RTCP report blocks sent using AVPF, described later
  - Sender waits for receiver population to stabilise
  - If all receivers reported reception of ECT marked packets, sender may switch to ECT marking all packets
- Per-sender; gracefully supports groups; conservative

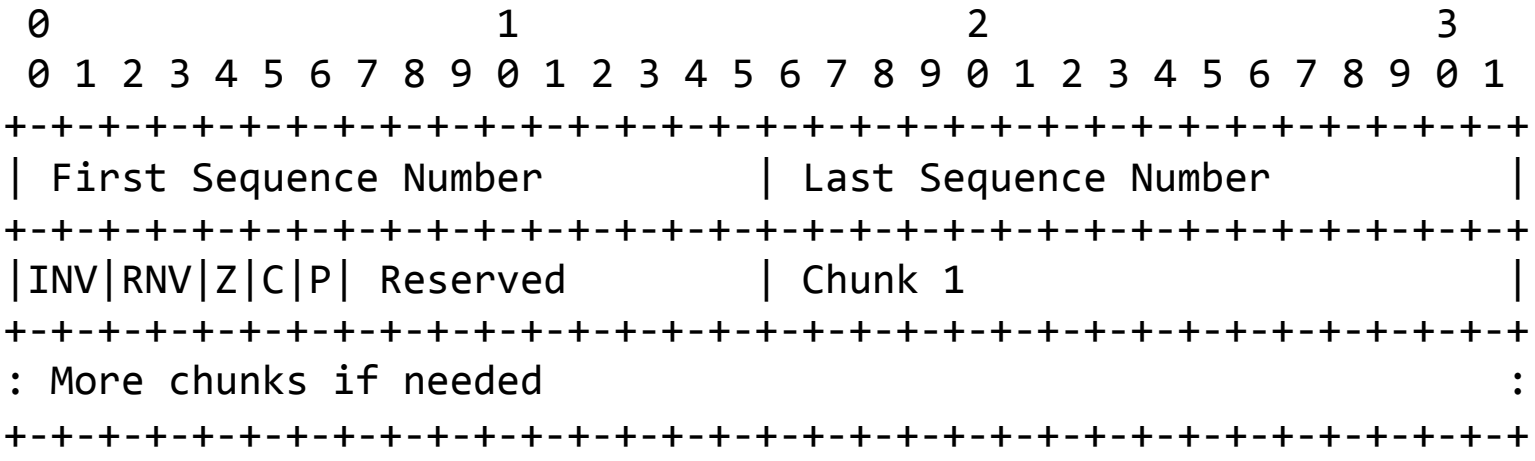
ECN Usage with RTP

- Sender ECT-marks all packets
- Receivers send ECN feedback
  - Regular RTCP: indicate continued receipt of ECT-marks
  - AVPF feedback: receipt of ECN-CE packets
- Respond to ECN-CE as-if packet loss occurred; reduce path data rate

- Need to continually monitor, since path may fail
  - Discussion later

RTCP Feedback: Regular

- Use new RTCP XR report
- Initial straw man for the data it should report:
  - Start + end sequence numbers, bitmaps of lost and marked packets, ECN nonce value
  - Considering alternative that avoid ECN nonce



RTCP Feedback: Congestion/Probe

- Need rapid feedback during probing period, or if ECN-CE marked packet received
- Use new AVPF feedback packet
  - Should be small enough to use immediate mode
  - Aim for similar format to regular reports

Congestion Response

- Receipt of ECN-CE indicates congestion
  - Path data rate must be reduced, or packet loss will occur
  - Two options:
    - Sender-based rate reduction: change media encoding options
    - Receiver-driven rate reduction: layered media coding
  - Lots of options for *how* to adapt; probably not TCP-friendly

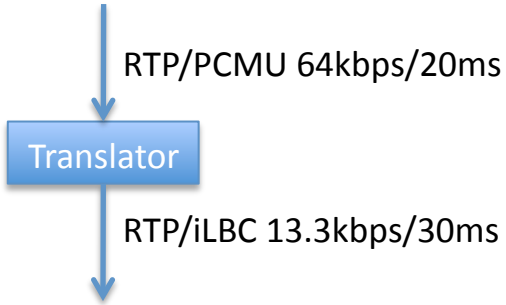
- Incentive to react to ECN-CE:
  - If you react, you control how media quality is reduced
  - If you don't react, network will drop packets – worse quality

Ongoing Verification of ECN

- Why might ECN support change?
  - New receivers join a multicast group
  - Mobility changes the path, putting a new broken middle box on path
- How to detect and fallback?
  - Regular RTCP feedback will show (some) receivers not getting ECT-marked packets
  - Fall-back to occasional ECT-probes for safety
    - This is deliberately conservative for multicast groups

ECN Usage with RTP: Translators

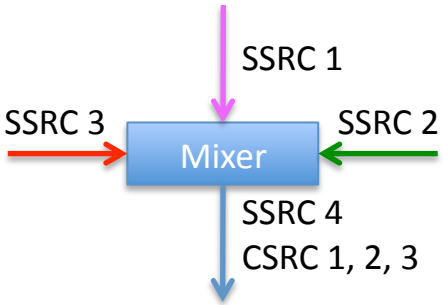
- Translator that doesn't modify media
  - Multicast ↔ unicast; IPv4 ↔ IPv6
  - Pass ECN and RTCP unchanged



- Translator that combines or splits packets
  - Split → copy ECN marks; combine → pick worst ECN mark
  - Rewrite RTCP ECN feedback to match
- Translator that is a media transcoder
  - Must interpose translator into ECN negotiation
  - Must generate and respond to ECN feedback on each segment → non-trivial

ECN Usage with RTP: Mixers

- Mixer acts as an RTP endpoint for ECN purposes
  - Treats all paths independently
  - For each path:
    - Negotiate capability and check path support
    - Generate RTCP ECN feedback
    - Respond to ECN feedback
  - Possible that some paths support ECN, others don't



Implementation Experiences

- Host capability to get/set ECN (TOS) bits
  - Set ECN/TOS on most platforms (setsockopt())
  - Get ECN per packet is only possible on Linux
    - setsockopt(,IP_RECVTOS,,), recvmsg() cmsghdr
  - Design to cope with differing hosts
- Network paths (tunnels, middleboxes, routers etc)
  - Currently most paths reset DSCP bits
  - Currently some paths reset ECN bits
  - Design to cope with differing paths
- Current implementation using UCL PhD's (Soo Hyun) TFWC congestion control

Input and Future Directions

- Any questions or comments?
- Authors working on a combined Internet-Draft
- Desire that this becomes a working group draft
  - Suggest AVT as the formal home for the work, with regular review by TSVWG
  - Target: standards track