Re-ECN: Adding Accountability for Causing Congestion to TCP/IP

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initial draft

- IETF-63 Paris July 05
  - new research results (SIGCOMM'05) using ECN nonce codepoints
  - TSVWG chair asked for our proposal by IETF-64
  - hold ECN nonce ([RFC3540](http://example.com/rfc3540)) at experimental status

- re-ECN: adding accountability for causing congestion to TCP/IP
  - initial draft: [draft-briscoe-tsvwg-re-ecn-tcp-00.txt](http://example.com/draft-briscoe-tsvwg-re-ecn-tcp-00.txt)
  - other formats: [www.cs.ucl.ac.uk/staff/B.Briscoe/pubs.html#retcp](http://example.com/www.cs.ucl.ac.uk/staff/B.Briscoe/pubs.html#retcp)
  - ultimate intent: standards track (hope for working group draft soon)
  - intent today: get you excited enough to read it, and break it
  - status: haven’t simulated this 2-bit IPv4/v6 proposal yet
  - our simulations based on a multibit ECN IPv6 extension header

* changed 2 field names since draft-00 – new terminology in this presentation
the problem: accountability for causing congestion

• main concern
  • non-compliance with e2e congestion control (e.g. TCP-friendly)?
  • how can ingress netwk detect whole path congestion? police cc?

• not just per-flow congestion response
  • smaller: per-packet
    – single datagram ‘flows’
  • bigger: per-user
    – a congestion metric so users can be held accountable
    – 24x7 heavy sources of congestion, DDoS from zombie hosts
  • even bigger: per-network
    – a metric for holding upstream networks accountable if they allow their users to congest downstream networks
previous work

• detect high *absolute* rate [commercial boxes]
  • but nothing wrong with high rate at low congestion

• sampled rate response to *local* congestion [RED + sin bin]
  • but congestion typical at both ends (access networks)

• transport control *embedded in* networks [ATM]
  • but limits behaviours to those standardised by network operators

• *honest* senders police feedback from rcvrs [ECN nonce]
  • but not all senders are community spirited (VoIP, video, p2p?, DoS)

• per-packet, per-user & per-network congestion policing
  • minimal previous work
basic idea (IP layer)

- sender re-inserts congestion feedback into forward data: “re-feedback”
  on every **Echo-CE** from transport (e.g. TCP)
  sender sets **ECT(0)**
  else sets **ECT(1)**

- and new Feedback-Established (FE) flag
ECN (recap)

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<tr>
<th>code-point</th>
<th>standard designation</th>
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<tr>
<td>00</td>
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<td>10</td>
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<td>11</td>
<td>CE</td>
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ECE in TCP

ECN rate

ECT (0)

CE

n
resource index

0% 100% code-point rate

3% ECE

3% CE

0% 3% ECN rate

0% ...i... n

resource index

S
N_A
N_B
N_D
R_1
re-ECN (sketch)

- on every Echo-CE from TCP, sender sets ECT(0), else sets ECT(1)
- at any point on path, diff betw rates of ECT(0) & CE is downstream congestion
- routers unchanged

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\[
 v_i \approx \text{ECT}(0) - \text{CE}
\]
incentive framework (user-network)

- packets carry view of downstream path congestion to each router
- so ingress can police rate response
  - using path congestion declared by sender
- won’t snd or rcv just understate congestion? 
- no – egress drops negative balance
egress dropper (sketch)

- drop enough traffic to make rate of $CE = ECT(0)$
- goodput best if rcv & snd honest about feedback & re-feedback

cheating sender or receiver understates $ECT(0)$

code-point rate

- simple per pkt algorithm
  - max 5 cmp's, 5 adds, 1 shift
- dropper treats traffic in bulk
- can spawn focused droppers
  - misbehaving aggregates/flows prevalent in drop history
ingress policer (sketch)

- packets arrive carrying view of downstream path congestion
- can police to any desired rate equation, e.g., TCP
- token bucket implementation: drop whenever empties
  - bounded flow-state using sampling

\[
\text{compliant rate} \quad x_{TCP} \approx \frac{ks}{T \sqrt{p}}
\]

\[
\text{actual rate} \quad x = \frac{s}{\Delta t}
\]

- above equations are conceptual, in practice can re-arrange
  - you get \( 1/p \) by counting bytes between \( \text{ECT}(0) \) marks
  - high perf. root extraction per \( \text{ECT}(0) \) mark challenging (like pulling teeth)
- for RTT need sister proposal for ‘re-TTL’ (tba)
accountability for congestion

other applications

• congestion-history-based policer (congestion cap)
  • throttles causes of past heavy congestion (zombies, 24x7 p2p)

• DDoS mitigation

• QoS & DCCP profile flexibility
  • ingress can unilaterally allow different rate responses to congestion

• load sharing, traffic engineering
  • multipath routers can compare downstream con

• bulk metric for inter-domain SLAs or charges
  • bulk volume of ECT (0) less bulk volume of CE
  • upstream networks that do nothing about policing, DoS, zombies etc will break SLA or
flow start

- re-ECN TCP capability handshake in draft
- feedback established (FE) flag in IPv4 header or IPv6 extension
  - future-proofing if short flows or single datagrams dominate traffic mix
  - FE flag only set by sender, only read by re-ECN security apps
  - leave FE=0 at flow start
  - if packet has FE=0, don’t include its ECN marking in bulk averages
  - sender incentive to be truthful about FE flag
  - bit 48 (Currently Unused) flag in IPv4 header?
- TCP flow start specifics in draft
- guidelines for adding re-ECN to other transports in draft
re-ECN incremental deployment

- only REQUIRED change is TCP sender behaviour
- precision only if receiver is re-ECN capable too
- optional compatibility mode for ‘legacy’ ECN rcvrs
  - inclined to leave it out (so few Legacy-ECN hosts out there)
- no change from ECN behaviour for
  - routers
  - tunnels
  - IPsec
  - middleboxes etc
- add egress droppers and ingress policers over time
  - policers not necessary in front of trusted senders
re-ECN deployment transition

- if legacy firewalls block FE=1, sender falls back to FE=0
  - FE=0 on first packets anyway, so see connectivity before setting FE=1
  - if sender has to wrongly clear FE=0, makes dropper over-strict for all
- sender (and receiver): re-ECN transport (from legacy ECN)
  - ingress policer (deliberately) thinks legacy ECN is highly congested
    - 50% for nonce senders, 100% for legacy ECN
  - policers should initially be configured permissively
  - over time, making them stricter encourages upgrade from ECN to re-ECN
re-ECN deployment incentives

- **access network operators**
  - revenue defence for their QoS products
  - can require competing streaming services over best efforts to buy the right to be unresponsive to congestion

- **egress access operators: dropper**
  - can hold upstream neighbour networks accountable for congestion they cause in egress access
  - without egress dropper, border congestion could be understated

- **ingress access operators: policer**
  - if downstream networks hold upstream accountable (above)
  - ingress will want to police its heavy & malicious users
  - ingress can choose to rate-limit Not-ECT

- **backbone networks**
  - unless hold upstream accountable will be held accountable by downstream

- **vendors of policing equipment**
  - network operators invite to tender

- **sender (and receiver): re-ECN transport (from Not-ECT)**
  - network operator pressure encourages OS vendor upgrades (sweetener below)
  - Not-ECT rate-limits (above) encourage user upgrades

- **end device OS vendors**
  - network operators hold levers (policers) to encourage customer product upgrades

**everyone gains from adding accountability to TCP/IP except the selfish and malicious**
re-ECN limitations

• snd or rcv can turn off ECN altogether to avoid policing
  • example: suffer drops (say 5%) instead of marking
  • but just add 5% FEC to compensate
  • not policed, so can add say 50% FEC to get 145% goodput
  • effectively how VoIP over BE works today
  • (ECN nonce no better in this respect)
  • solution: rate limit Not-ECT traffic in the future???

• dependency on getting re-TTL standardised
• takes a while for dropper & policer to detect malice
  • binary marking inherently slow to signal changes
• flow state at ingress policer & egress dropper
  • initial designs of policer and dropper with bounded state using sampling
  • don’t need port numbers – can just use IP address(es)
summary

• accountability for congestion
  • long-standing weakness of the Internet architecture
  • re-ECN appears to be a simple architectural fix in 1.5 bits

• main weakness with binary marking is attack detection speed

• request that ECN nonce is held as experimental
  • nonce only useful if sender polices receiver on behalf of network
  • re-ECN allows networks to police both sender and receiver and each other
  • re-ECN offers other accountability uses
  • but community needs time to assess

• makes ECN deployment more likely
  • change tied to new capabilities/products
  • not just performance enhancement
plans in IETF

- finish re-ECN draft
  - currently the text runs out after the TCP/IPv4 protocol spec
- re-TTL draft
- informational draft
  - on security applications, incl performance

- we strongly encourage review on the tsvwg list

- we are well aware this will be a long haul
Re-ECN: Adding Accountability for Causing Congestion to TCP/IP

draft-briscoe-tsvwg-re-ecn-tcp-00.txt

Q&A
path congestion typically at both edges

- congestion risk highest in access nets
  - cost economics of fan-out
- but small risk in cores/backbones
  - failures, anomalous demand
allowance for losing some ECT(0)

- aim for equal rates of ECT(0) and CE at egress
  - sender inflates ECT(0) to 3/97 = 3.09%
  - allows for 3% of 3.09% = 0.09% ECT(0) getting marked CE
  - simple packet counting algorithm for sender in draft (self-clocked)
- ‘legacy’ ECN receiver repeats ECE for a round trip until CWR
  - hides second and subsequent CE per RTT
  - new CE counter technique in draft
    - uses three flags in TCP options as a 3-bit CountCE counter, modulo 8
    - still safe against pure ACK losses
      - if ack’d seqno gap ≥ 8, assume all missed ACKs marked
flow start

• re-ECN capability handshake in draft
• feedback established (FE) flag in IPv4 header or IPv6 extension
  • future-proofing if short flows or single datagrams dominate traffic mix
  • set by sender, used by re-ECN applications
  • leave FE=0 at flow start
  • if packet has FE=0 don’t include its ECN marking in bulk averages
  • bit 48 (Currently Unused) flag in IPv4 header?

• getting feedback established, general idea for TCP
  • start with ECT(0) (be conservative until feedback established)
  • only set FE=1 on packets released by feedback
    – packets 2 and 6, 8, 10 etc during slow-start (assuming init window =4)
    – once in congestion avoidance, set FE=1 on all packets

• guidelines for adding re-ECN to other transports in draft
inter-domain accountability for congestion

- metric for inter-domain SLAs or charges
  - bulk volume of ECT(0)less bulk volume of CE
  - measure of downstream congestion allowed by upstream nets
  - volume charging tries to do this, but badly
  - aggregates and deaggregates precisely to responsible networks
  - upstream networks that do nothing about policing, DoS, zombies break SLA or get charged more
congestion competition – inter-domain routing

- if congestion → profit for a network, why not fake it?
  - upstream networks will route round more highly congested paths
  - \( N_A \) can see relative costs of paths to \( R_1 \) thru \( N_B \) & \( N_C \)

- the issue of monopoly paths
  - incentivise new provision
  - collusion issues require market regulation
BT IPR related to draft-briscoe-tsvwg-re-ecn-tcp-00.txt

- See IPR declaration at https://datatracker.ietf.org/public/ipr_detail_show.cgi?ipr_id=651 which overrides this slide if there is any conflict

1) WO 2005/096566 30 Mar 2004 published
2) WO 2005/096567 30 Mar 2004 published
3) PCT/GB 2005/001737 07 May 2004
4) GB 0501945.0 (EP 05355137.1) 31 Jan 2005
5) GB 0502483.1 (EP 05255164.5) 07 Feb 2005

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