More Accurate ECN Feedback in TCP

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draft-kuehlewind-tcpm-accurate-ecn-01
draft-kuehlewind-tcpm-accurate-ecn-option-01

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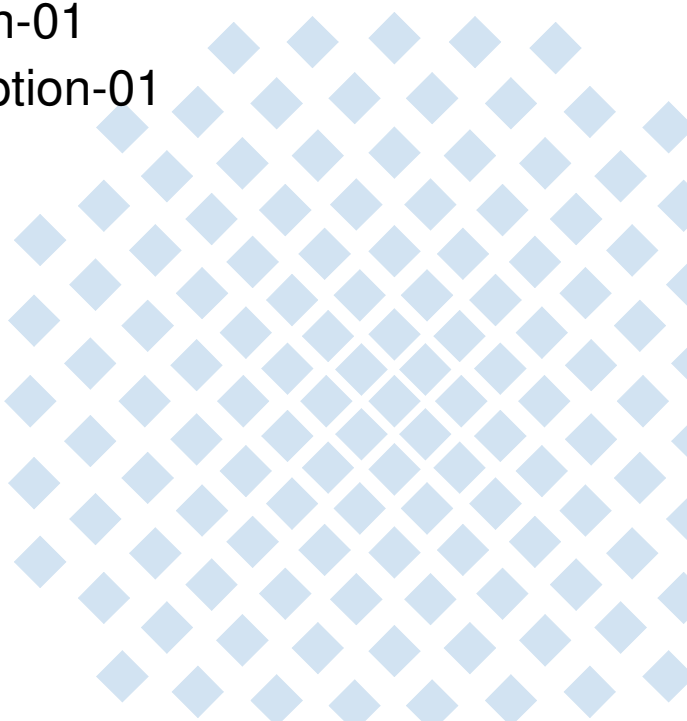

Problem Statement

ECN provides only one congestion feedback signal per RTT ...

> as designed for current congestion control mechanisms
> that will react only once per RTT on congestion

... but new TCP mechanisms need to know how many congestion markings occurred exactly (number of marked packets/bytes).

Scope

- DCTCP: Decrease depended on number of ECN markings
- ConEx: Feedback on expected whole-path congestion
- Congestion control might react differently on ECN in future (ICCRG and LEDBAT ML)

Drafts

1. Accurate ECN Feedback Option in TCP

   (draft-kuehlewind-tcpm-accurate-ecn-option-01)

   – TCP Option for accurate ECN feedback (AccECN) can provide more information
   – Can be used in addition to the classic ECN or the new scheme below
   – Not proposed as default mechanism because of
     • Middlebox issues with new TCP Options
     • Overhead in TCP header

2. More Accurate ECN Feedback in TCP

   (draft-kuehlewind-tcpm-accurate-ecn-01)

   – Mechanism to retrieve more accurate ECN feedback (more than one signal per RTT) by reusing the 3 ECN/ECN-Nonce bits in the TCP header
   – New version now proposes one specific scheme

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Overview ECN in IP

Terminology from [RFC3168]

The ECN field in the IP header

- ECT(0)/ECT(1): either one of the two ECN-Capable Transport codepoints
- CE: the Congestion Experienced codepoint

TCP Accurate ECN Feedback Option Negotiation

```
Kind: TBD
Length: 2 bytes


+------+------+
| Kind |   2  |
+------+------+
   1      1
```

→ Only valid in a <SYN> or <SYN,ACK> during a three way handshake

- MAY send the AccECN negotiation option in an initial SYN

  and MAY send a AccECN option (see next slide) in other segments only if it received this option negotiation in the initial <SYN> or <SYN,ACK>
- MAY send an <SYN,ACK> segment with the AccECN negotiation option in response to a AccECN negotiation option in the <SYN>
- MUST only negotiate for the AccECN option if ECN is negotiated as well

→ Further Option Space could be used to indicate

- if an end point wants get AccECN feedback or not
- how often the AccECN option should be sent (e.g. for at least every 10th data segment)

TCP Accurate ECN (AccECN) Feedback Option

```
 Kind: TBD (same as above)
 Length: 12 bytes

+------+------+---------+---------+-------+-------+-------+-----------+
| Kind |  12  | ECT(0)  | ECT(1)  |  CE   |non-ECT| loss  |CE in bytes|
+------+------+---------+---------+-------+-------+-------+-----------+
   1      1        2         2        1       1       1         3
```

- SHOULD be included in every ACK
  - To reduce network load the AccECN option MAY not be send in every ACK
- Counter wrap-arounds
  - MUST send at least three ACKs/segments with the AccECN option between counter wrap around
  - Whenever an AccECN option is received with smaller counter value than in the previous one and the respective ACK acknowledges new data, a wrap around MUST be assumed

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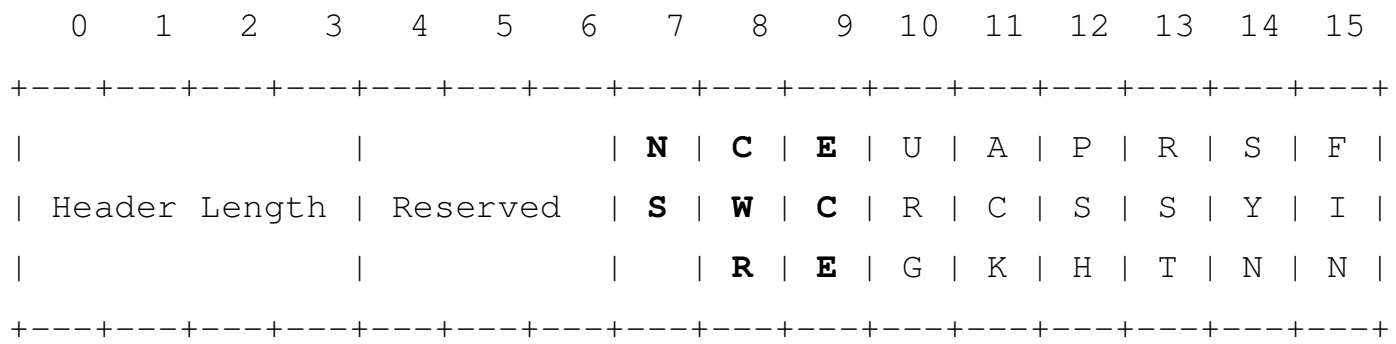
Overview ECN and ECN Nonce in TCP

Terminology from [RFC3168] and [RFC3540]

The ECN field in the IP header

- ECT(0)/ECT(1): either one of the two ECN-Capable Transport codepoints
- CE: the Congestion Experienced codepoint

The ECN flags in bytes 13 and 14 of the TCP Header



- CWR: the Congestion Window Reduced flag
- ECE: the ECN-Echo flag
- NS: ECN Nonce Sum

Codepoint Coding for More Accurate ECN Feedback

- Use of these 3 header flags as one 3-bit more Accurate ECN (AcE) field

```
  0   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|               |           |           | U | A | P | R | S | F |
| Header Length | Reserved  |    AcE    | R | C | S | S | Y | I |
|               |           |           | G | K | H | T | N | N |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
```

→ 8 possible codepoints: 5 for "congestion indication" (CI) counter; 3 undefined

AcE	NS	CWR	ECE	CI (base5)
0	0	0	0	0
1	0	0	1	1
2	0	1	0	2
3	0	1	1	3
4	1	0	0	4
5	1	0	1	-
6	1	1	0	-
7	1	1	1	-

More Accurate ECN Feedback in TCP

More Accurate ECN TCP Receiver

- congestion indication (CI) counter: # of CE markings during a connection
  → For each incoming segment with a CE marking increase CI by 1
- With each ACK calculate CI modulo 5 and set the respective codepoint in the AcE field
  - SHOULD switch from a delayed ACK behavior to send ACKs immediately in a high congestion situation (to avoid counter wrap-arounds)
  - MUST send value of CI counter by default; send other (undefined) codepoints if needed
  - MUST echo the CI in the next ACK whenever a CE is received
  - MUST repeat each CI codepoint directly on the subsequent ACK

  → Cope with a certain amount of ACK loss and avoid counter wrap-arounds

More Accurate ECN TCP Sender

- Congestion indication received (CI.r) counter: # of CE markings as signaled by the receiver, and reconstructed by the sender
  → For each ACK increase CI.r by D (= difference between local CI.r value modulo 5 and the signaled CI value of the codepoint in the ACK)

Use with ECN Nonce (Appendix)

Codepoints with Dual Counter Feedback

One field in TCP ACK but encoding 2 counters in 8 codepoints

1. Congestion Indication (CI) counter: number of CE marks
2. ECT(1) (E1) counter: number of ECT(1) signals (ECN Nonce Sum)

ECI	NS	CWR	ECE	CI (base5)	E1 (base3)
0	0	0	0	0	-
1	0	0	1	1	-
2	0	1	0	2	-
3	0	1	1	3	-
4	1	0	0	4	-
5	1	0	1	-	0
6	1	1	0	-	1
7	1	1	1	-	2

- By default an accurate ECN receiver MUST echo the CI counter (modulo 5)
- The receiver MUST repeat the codepoint directly on the subsequent ACK
- Whenever ECT(1) occurs, E1 will be echoed; expect CI has increase before next ACK

Review Comments

1. Needs to be clearer what an implementer must do
   → We will address this
2. Relation to RFC3168?
   – Does not obsolete RFC3168 but does it update RFC3168?
3. Single repeat of each codepoint unnecessary?
   – Proposal to calculate whether wrap could have happened, and to calculate the worst-case count of CE marks
   → We will add this heuristic
   → A repeat can still improve robustness (e.g. if less than every second segment get ack'ed)
4. ECT in the IP header of the SYN and SYN-ACK
   – In SYN optional! We will address this
   – In SYN-ACK optional or mandatory? I'd say optional
5. ECN Nonce support needs to be mandatory (only for receiver feedback)
   – Working group feedback?
6. Advanced Compatibility Mode
   – Should we remove this?
7. Alternative proposal

Adoption as working group document?

1. Accurate ECN Feedback Option in TCP

   (draft-kuehlewind-tcpm-accurate-ecn-option-01)

   → Is the working group interested in adopting this document to specify a new TCP Option for accurate ECN feedback (AccECN)?

      Fields and size of the option are open to changes....

2. More Accurate ECN Feedback in TCP

   (draft-kuehlewind-tcpm-accurate-ecn-01)

   → Is the working group interested in adopting this document to specify for a more accurate ECN feedback mechanism which is reusing bits in the TCP header and as such can (only) be used as an alternative to the classic ECN?

      → Does the working group see the codepoint coding scheme as a good starting point for a more accurate ECN feedback mechanism?

Question?

Backup

Negotiation in the TCP Handshake

1. Host A indicates a request to get more accurate ECN feedback by setting **NS=1, CWR=1** and **ECE=1** in the **initial SYN**

   Classic ECN will still be negotiated (with CWR=1 and ECE=1)

2. Host B returns a **SYN ACK** with flags **CWR=1** and **ECE=0**

   Broken receiver that just reflect SYN bits get detected

Ac	N	E	I	[SYN] A->B	[SYN,ACK] B->A	Mode
				NS CWR ECE	NS CWR ECE	
AB				1 1 1	X 1 0	accurate ECN
A	B			1 1 1	1 0 1	ECN Nonce
A		B		1 1 1	0 0 1	classic ECN
A			B	1 1 1	0 0 0	Not ECN
A			B	1 1 1	1 1 1	Not ECN (broken)

Ac: *Ac*curate ECN Feedback, N: ECN-*N*once (RFC3540), E: *E*CN (RFC3168),
I: Not-ECN (*I*mplicit congestion notification)