More Accurate ECN Feedback in TCP (AccECN)

draft-kuehlewind-tcpm-accurate-ecn-03

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Purpose of Talk

- Introduce latest AccECN protocol spec
  - awesome protocol design (IMHO)
  - satisfies numerous conflicting requirements
    - except not as simple as we'd have liked ☹
- seeking adoption, expert review and opinions
  - intent: Experimental
  - full spec (38pp) plus pseudocode examples, design alternatives & outstanding issues (+17pp)
  - consensus prior to implementation

The Problem (Recap)

Congestion Extent, not just Existence

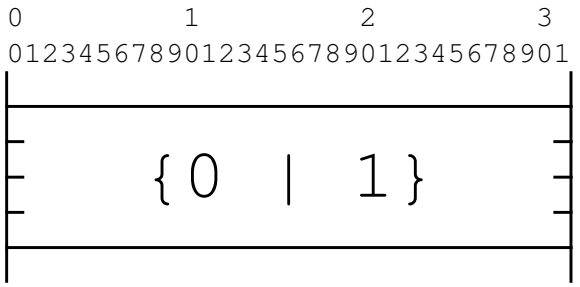
- Current 'classic' ECN feedback in TCP [RFC3168]

```
if (any packet marked in RTT)     {signal 1}
else                              {signal 0}
```

- <ironic> Imagine using a 128b field for 2 addresses

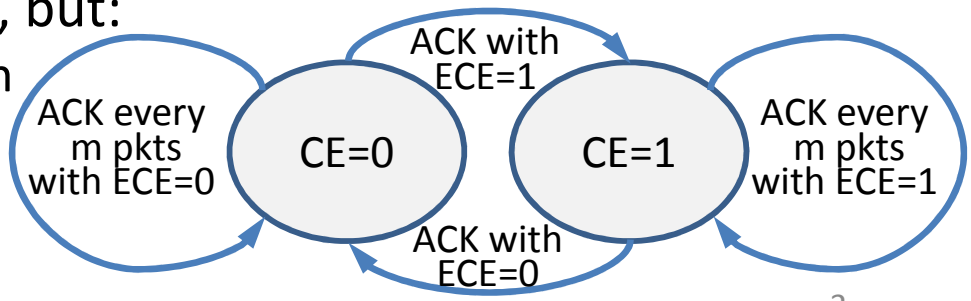
```
if (any bit set)    {address = 1}
else                {address = 0}
```

</ironic>



- Only ECN-for-TCP is so clunky
  - TCP widely uses SACK to identify individual drops
  - modern transports (DCCP, SCTCP, RTP/UDP etc) feed back extent of ECN
  - need to update TCP, in its role as 1 of 2 transport protocols that work

- DCTCP feedback scheme would be nice, but:
  1. new wire protocol but no negotiation
  2. greatly confused by ACK loss
  3. higher congestion → more ACKs



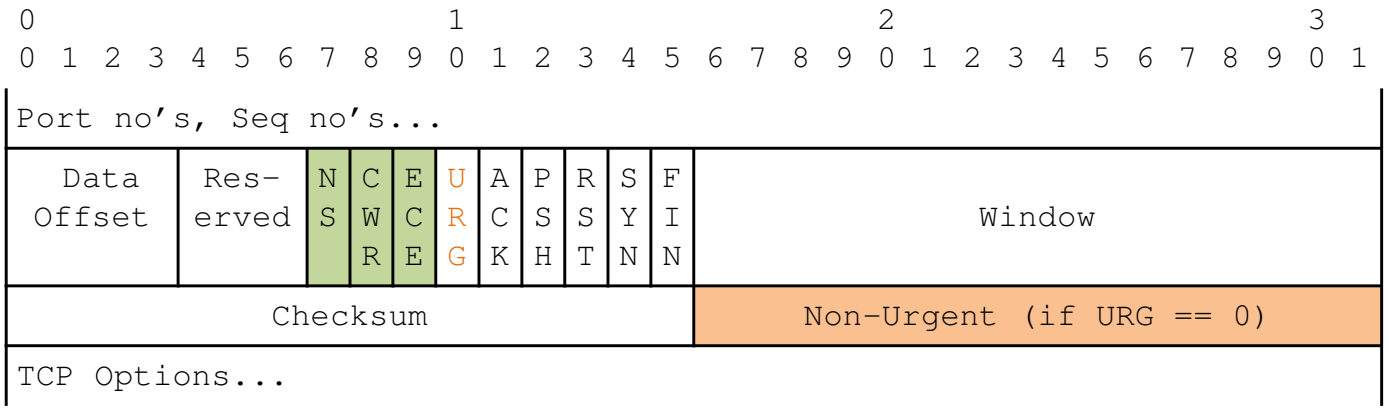
a new problem: feedback of bleached ECN

- erasure of ECN field to Not-ECT (00) in transit
  - RFC3168 notes that this could happen
  - and says it would be very bad
  - but doesn't say what to do about it
- if Not-ECT arrives at a classic ECN receiver
  - it does nothing, and can do nothing

- some tests show that bleaching ECN is common
- AccECN now includes Not-ECT feedback

Where to find spare bits?

- Satisfied requirements with zero extra bits
  - essential part: overloaded 3 existing ECN flags in main TCP header
  - supplementary part: overloaded 15b in Urgent Pointer when redundant



- Non-Zero Urgent Pointer when TCP URG flag = 0?
  - middlebox traversal
    - seems better than for new TCP options in initial tests*
  - opportunistic – not available when URG = 1
    - not useful for most other protocols that need more bits

* Perhaps because earlier Windows versions did not zero the Urgent Pointer when URG=0

Protocol Design II

2 complementary signals

- After successful capability negotiation III

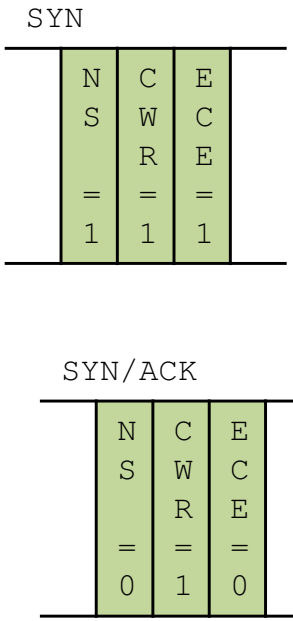
1. cumulative counters of the 3 ECN codepoints IV
2. the sequence of ECN codepoints covered by each delayed ACK V

- note: packet-based not byte-based counters
- note: pure ACKs are not counted

  (there are deep questions behind both these points)

Capability Negotiation

- AccECN is a change to TCP wire protocol
  - only to be used if both ends support it
- client negotiates support on initial SYN
  - using the 3 ECN-related TCP flags
  - server sets the 3 flags accordingly on the SYN/ACK
    - or it replies as the latest variant it recognises
  - if nec. client downgrades to match the server

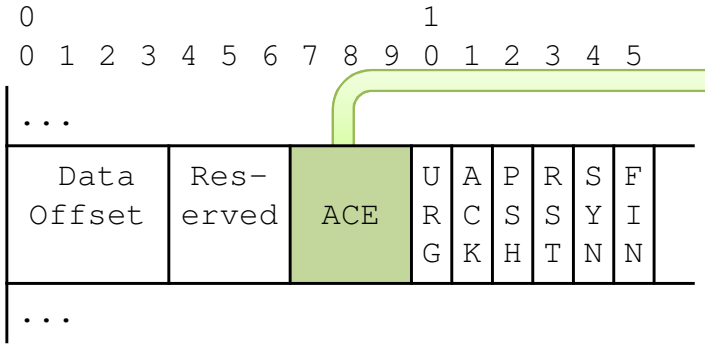


- supp. field not used until 3rd leg of handshake
  - consumes no TCP option space on SYN
  - if at any time supp. field = 0 → middlebox interference

Cumulative ECN Codepoint Counters

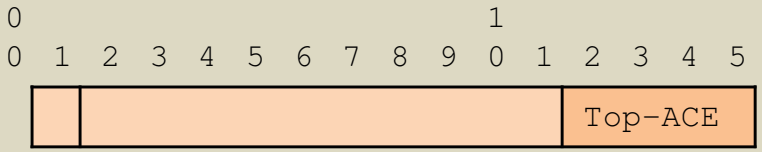
after SYN/ACK

- Data receiver counts arriving CE, ECT(1) & Not-ECT (11, 01 & 00)*
- Selects one counter to feed back in each ACK
  - encodes in the ACE field, overloading the 3 ECN flags
  - encoding fits a base 4, base 3 and base 1 counter in 3 bits!



ACE	CE (base 4)	ECT(1) (base 3)	Not-ECT (base 1)
000	0		
001	1		
010	2		
011	3		
100		0	
101		1	
110		2	
111			0

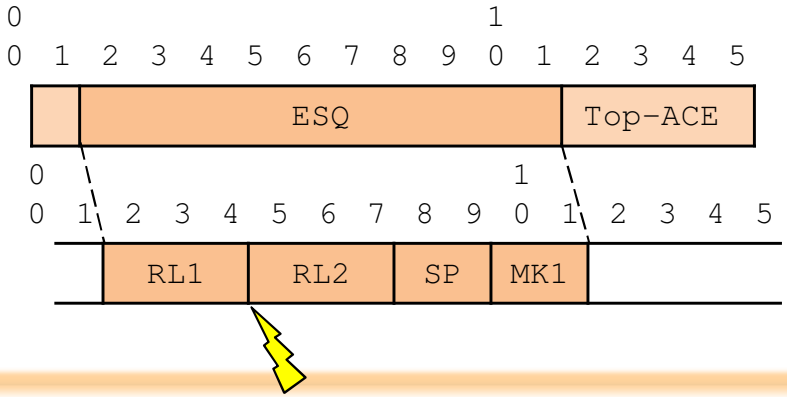
- includes 4 most significant bits of the selected counter in the supp. field



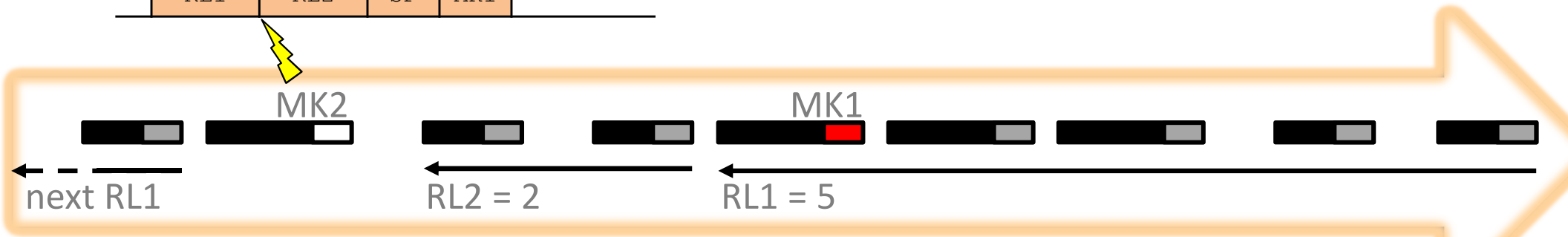
* ECT(0) found from remainder and from sequence field if available

Protocol Design V

ECN Sequence covered by each Delayed ACK



- ECN Sequence (ESQ) field
  - encodes 2 **R**un-**L**engths of **SP**aces, each ending in one possibly different **MarK**



- Value of ACE selects MK2 (no need to encode in ESQ)
- Receiver sends a Delayed ACK on any of these events:
  a) Max delayed ACK coverage is reached (e.g. 2 full-sized segments)
  b) Delayed ACK timer expires (e.g. 500ms)
  c) Pattern becomes too complex to encode
- in one ACK, it is possible to encode a sequence of:
  - up to 15 segments for typical marking patterns
  - 3 segments for any possible marking pattern

Examples VI

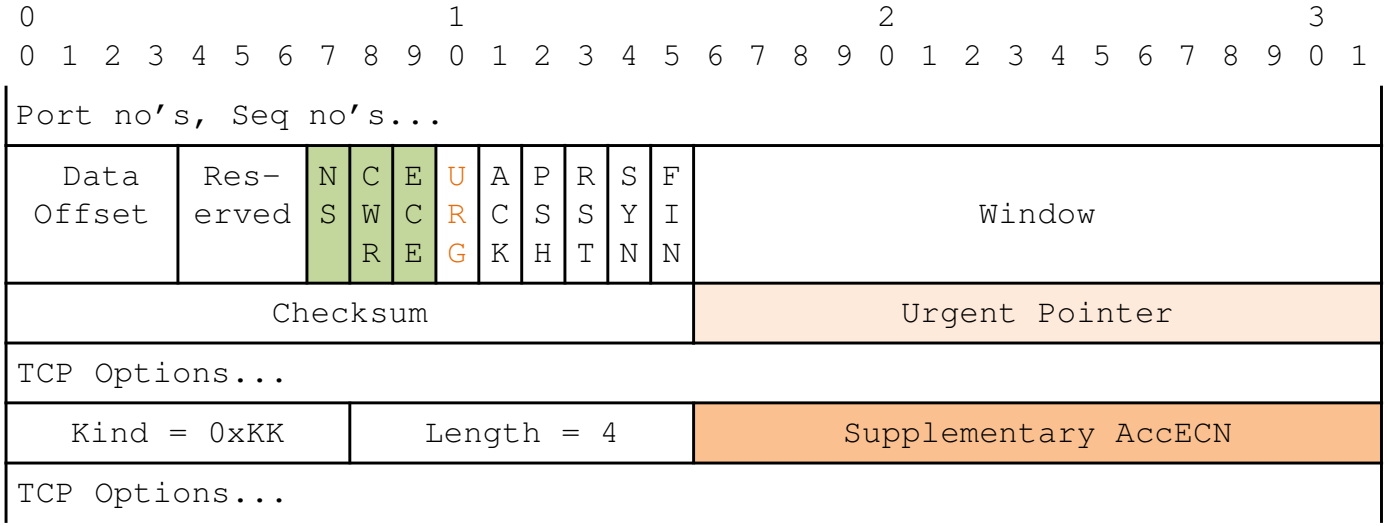
AccECN Protocol Features Summary

Requirement	Classic ECN	ECN Nonce	DCTCP	AccECN Urg-Ptr	AccECN TCP opt	AccECN essential
Resilience	+	+	-	+	+	o
Timeliness	o	o	-	+	+	+
Integrity	-	o	+*	+*	+*	+*
Accuracy	-	-	-	+	+	+
Ordering	-	-	+	+	+	-
Complexity	++	+	o	-	-	o
Overhead	++	o	o	+	o	++
Compatibility	o	o	-	o	-	o

* = compatible with an independent zero-overhead integrity solution

Opportunistic but not Presumptuous?

- Presumptuous to reassign Urgent Pointer experimentally?
- While experimental:
  - use a TCP option for the supplementary part
  - Reserved 15b in Urgent Pointer
    - to use if this progresses to standards track
  - Experimental implementations required to recognise either location
- AccECN still ‘works’ if TCP option is cleared or discarded

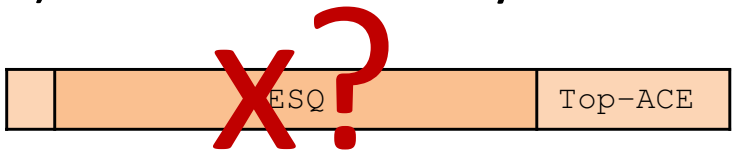


Interaction with other TCP variants

- Server can use AccECN with SYN Cookies
    - capability negotiation can be inferred
- AccECN compatible with main TCP options:
    - Max Segment Size (MSS)
    - Timestamp
    - Window Scaling
    - Selective ACKs (SACK)
    - Authentication Option (TCP-AO)
    - TCP Fast Open (TFO)
    - Multipath TCP (MPTCP)
- AccECN consumes no option space on the SYN
  – even when deployed experimentally as a TCP option

Open Design Issues

1. Could simplify by removing sequence (ESQ) feedback entirely?



   - Instead require the receiver to disable delayed ACKs?
     - during slow-start (Linux receiver does this heuristically)?
     - requested by the sender?
   - But, is ACKing every segment acceptable?

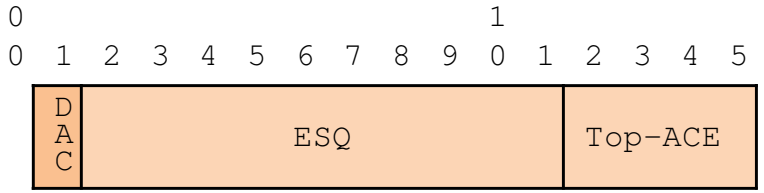
2. Could simplify by using Urgent Pointer for experimental protocol?

- See Appendix C of draft, for these and 7 other more detailed issues

Alternative Design Choices

Roughly highest importance first

- Earlier ECN feedback (on SYN/ACK)
- Remote Delayed ACK Control



where to draw the line?

- Earlier ECN fall-back (on SYN/ACK)
- Shave 1 bit off ECN sequence field

See Appendix B of draft

summary & next steps

Requirement	AccECN Urg-Ptr
Resilience	+
Timeliness	+
Integrity	+
Accuracy	+
Ordering	+
Complexity	-
Overhead	+
Compatibility	o

- awesome protocol design (IMHO)
  - capability negotiation and 3 counters in 7b
    - even works in 3b, if middlebox clears other 4b
  - sequence of up to 15 x 4 codepoints in 10b
    - most likely of 2^{30} combinations in a 2^{10} space
  - zero (extra) header bits
- still room for improvement
  - draft written to support consensus process
  - fully specified protocol, but also...
  - a container for design alternatives & issues
- adoption call please

More Accurate ECN Feedback in TCP (AccECN)

Requirements
draft-ietf-tcpm-accecn-reqs-06
Proposed Protocol Spec
draft-kuehlewind-tcpm-accurate-ecn-03

Q&A

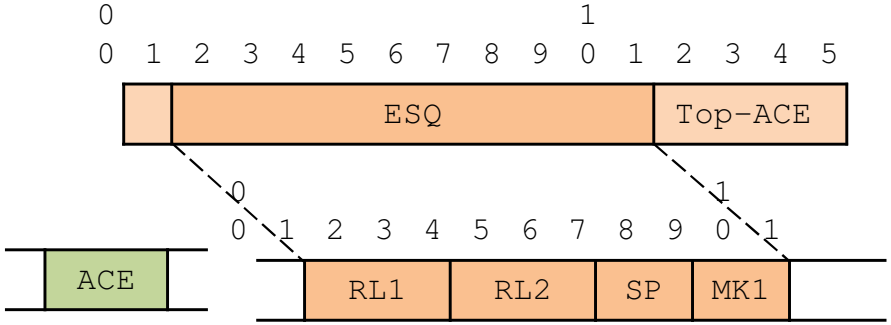
spare slides

Protocol Design VI

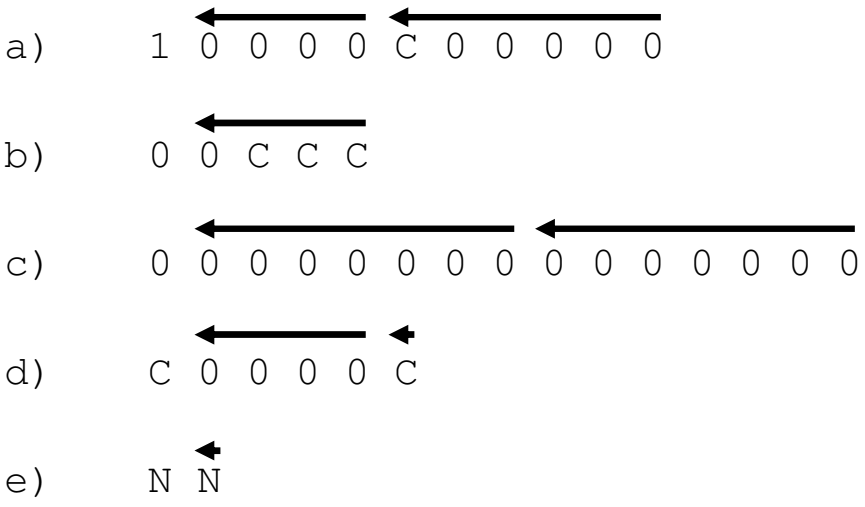
ECN Sequence covered by each Delayed ACK

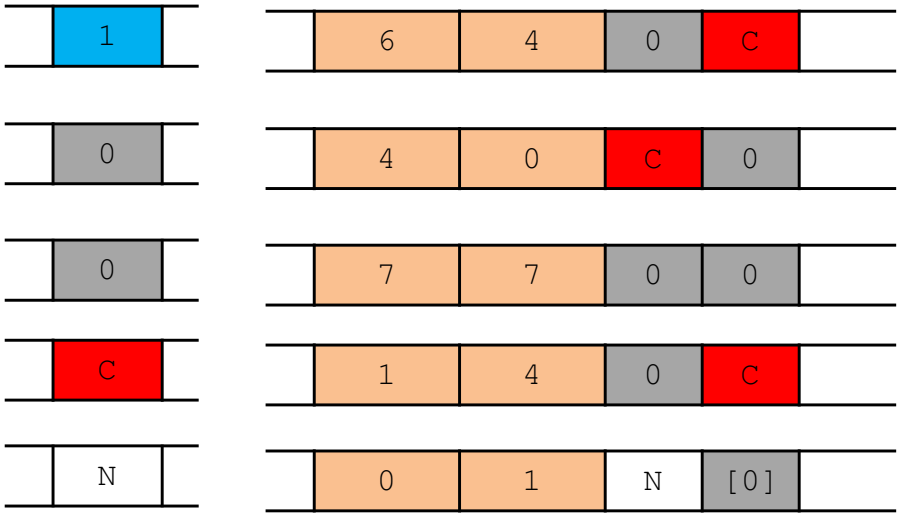
- SPace or MarK1 can be any of:

N: Not-ECT (00)
0: ECT(0) (10)
1: ECT(1) (01)
C: CE (11)



- Examples





Protocol Features detailed explanations

Requirement	Classic ECN	ECN Nonce	DC TCP	AccECN Urg-Ptr	AccECN TCP opt	AccECN essential
Resilience	+	+	-	+	+	o
Timeliness	o	o	-	+	+	+
Integrity	-	o	+*	+*	+*	+*
Accuracy	-	-	-	+	+	+
Ordering	-	-	+	+	+	-
Complexity	++	+	o	-	-	o
Overhead	++	o	o	+	o	++
Compatibility	o	o	-	o	-	o

- Resilience
  - DCTCP confused by ACK loss
- Timeliness
  - Classic ECN: only timely once per RTT
  - DCTCP is always 1 transition behind
- Integrity
  - ECN nonce: relies on receiver incriminating itself
  - DCTCP & AccECN compatible with approach in draft-moncaster-tcpm-rcv-cheat
- Accuracy
  - DCTCP lack of resilience impacts accuracy
- Ordering
  - 'AccECN essential' is the fall-back when a middlebox clears the sequence field
- Complexity
  - Hard to quantify
- Overhead
  - ECN Nonce marked down because it consumes the last ECN-IP codepoint
  - AccECN Urg-Ptr marked down because it prevents others using the Urgent Pointer
- Compatibility
  - Class ECN has had continuing problems with middlebox traversal
  - DCTCP is unsafe to interoperate with other TCP variants
  - 'AccECN Urg-Ptr' seems good at traversal, but more experiments needed
  - 'AccECN TCP opt' unlikely to traverse middleboxes that wipe TCP options