

Transport Working Group  
Internet-Draft  
Updates: [3168](#), [8311](#) (if approved)  
Intended status: Standards Track  
Expires: September 11, 2019

J. Morton  
Bufferbloat.net  
D. Taeht  
TekLibre  
March 10, 2019

**The Some Congestion Experienced ECN Codepoint  
draft-morton-taht-sce-00**

Abstract

This memo reclassifies ECT(1) to be an early notification of congestion on ECT(0) marked packets, which can be used by AQM algorithms and transports as an earlier signal of congestion than CE. It is a simple, transparent, and backward compatible upgrade to existing IETF-approved AQMs, [RFC3168](#), and nearly all congestion control algorithms.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of [BCP 78](#) and [BCP 79](#).

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at <https://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on September 11, 2019.

Copyright Notice

Copyright (c) 2019 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to [BCP 78](#) and the IETF Trust's Legal Provisions Relating to IETF Documents (<https://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in [Section 4.e](#) of

the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

## Table of Contents

<a href="#">1.</a>	<a href="#">Terminology</a>	<a href="#">2</a>
<a href="#">2.</a>	<a href="#">Introduction</a>	<a href="#">2</a>
<a href="#">3.</a>	<a href="#">Background</a>	<a href="#">2</a>
<a href="#">4.</a>	<a href="#">Some Congestion Experienced</a>	<a href="#">3</a>
<a href="#">5.</a>	<a href="#">Examples of use</a>	<a href="#">5</a>
<a href="#">5.1.</a>	<a href="#">Cubic</a>	<a href="#">5</a>
<a href="#">5.2.</a>	<a href="#">TCP receiver side handling</a>	<a href="#">5</a>
<a href="#">5.3.</a>	<a href="#">Other</a>	<a href="#">5</a>
<a href="#">6.</a>	<a href="#">Related Work</a>	<a href="#">5</a>
<a href="#">7.</a>	<a href="#">IANA Considerations</a>	<a href="#">5</a>
<a href="#">8.</a>	<a href="#">Security Considerations</a>	<a href="#">6</a>
<a href="#">9.</a>	<a href="#">Acknowledgements</a>	<a href="#">6</a>
<a href="#">10.</a>	<a href="#">References</a>	<a href="#">6</a>
<a href="#">10.1.</a>	<a href="#">Normative References</a>	<a href="#">6</a>
<a href="#">10.2.</a>	<a href="#">Informative References</a>	<a href="#">6</a>
	<a href="#">Authors' Addresses</a>	<a href="#">7</a>

## [1.](#) Terminology

The keywords MUST, MUST NOT, REQUIRED, SHALL, SHALL NOT, SHOULD, SHOULD NOT, RECOMMENDED, MAY, and OPTIONAL, when they appear in this document, are to be interpreted as described in [\[RFC2119\]](#).

## [2.](#) Introduction

This memo reclassifies ECT(1) to be an early notification of congestion on ECT(0) marked packets, which can be used by AQM algorithms and transports as an earlier signal of congestion than CE ("Congestion Experienced").

This memo limits its scope to the redefinition of the ECT(1) codepoint as SCE, "Some Congestion Experienced", with a few brief illustrations of how it may be used.

## [3.](#) Background

[\[RFC3168\]](#) defines the lower two bits of the (former) TOS byte in the IPv4/6 header as the ECN field. This may take four values: Not-ECT, ECT(0), ECT(1) or CE.

Binary Keyword References

-----



00	Not-ECT (Not ECN-Capable Transport)	[RFC 3168]
01	ECT(1) (ECN-Capable Transport(1))	[RFC 3168]
10	ECT(0) (ECN-Capable Transport(0))	[RFC 3168]
11	CE (Congestion Experienced)	[RFC 3168]

Research has shown that the ECT(1) codepoint goes essentially unused, with the "Nonce Sum" extension to ECN having not been implemented in practice and thus subsequently obsoleted by [RFC8311] (section 3). Additionally, known [RFC3168] compliant senders do not emit ECT(1), and compliant middleboxes do not alter the field to ECT(1), while compliant receivers all interpret ECT(1) identically to ECT(0). These are useful properties which represent an opportunity for improvement.

Experience gained with 7 years of [RFC8290] deployment in the field suggests that it remains difficult to maintain the desired 100% link utilisation, whilst simultaneously strictly minimising induced delay due to excess queue depth - irrespective of whether ECN is in use. This leads to a reluctance amongst hardware vendors to implement the most effective AQM schemes because their headline benchmarks are throughput-based.

The underlying cause is the very sharp "multiplicative decrease" reaction required of transport protocols to congestion signalling (whether that be packet loss or CE marks), which tends to leave the congestion window significantly smaller than the ideal BDP when triggered at only slightly above the ideal value. The availability of this sharp response is required to assure network stability (AIMD principle), but there is presently no standardised and backwards-compatible means of providing a less drastic signal.

#### 4. Some Congestion Experienced

As consensus has arisen that some form of ECN signaling should be an earlier signal than drop, this Internet Draft changes the meaning of ECT(1) to be SCE, meaning "Some Congestion Experienced". The above ECN-field codepoint table then becomes:

Binary Keyword References

-----

00	Not-ECT (Not ECN-Capable Transport)	[@RFC3168]
01	SCE (Some Congestion Experienced)	[This Internet-draft]
10	ECT (ECN-Capable Transport)	[@RFC3168]
11	CE (Congestion Experienced)	[@RFC3168]



This permits middleboxes implementing AQM to signal incipient congestion, below the threshold required to justify setting CE, by converting some proportion of ECT codepoints to SCE ("SCE marking"). Existing [\[RFC3168\]](#) compliant receivers MUST transparently ignore this new signal, and both existing and SCE-aware middleboxes MAY convert SCE to CE in the same circumstances as for ECT, thus ensuring backwards compatibility with [\[RFC3168\]](#) ECN endpoints.

Permitted ECN codepoint packet transitions by middleboxes are:

Not-ECT	->	Not-ECT or DROP
ECT	->	ECT or SCE or CE or DROP
SCE	->	SCE or CE or DROP
CE	->	CE or DROP

In other words, for ECN-aware flows, the ECN marking of an individual packet MAY be increased by a middlebox to signal congestion, but MUST NOT be decreased, and packets SHALL NOT be altered to appear to be ECN-aware if they were not originally, nor vice versa. Note however that SCE is numerically less than ECT, but semantically greater, and the latter definition applies for this rule.

New SCE-aware receivers and transport protocols SHALL continue to apply the [\[RFC3168\]](#) interpretation of the CE codepoint, that is, to signal the sender to back off send rate to the same extent as if a packet loss were detected. This maintains compatibility with existing middleboxes, senders and receivers.

New SCE-aware receivers and transport protocols SHOULD interpret the SCE codepoint as an indication of mild congestion, and respond accordingly by applying send rates intermediate between those resulting from a continuous sequence of ECT codepoints, and those resulting from a CE codepoint. The ratio of ECT and SCE codepoints received indicates the relative severity of such congestion, such that 100% SCE is very close to the threshold of CE marking, 100% ECT indicates that the bottleneck link may not be fully utilised, and a 1:1 balance of ECT and SCE codepoints indicates that the present send rate is a good match to the bottleneck link.

Details of how to implement SCE awareness at the transport layer will be left to additional Internet Drafts yet to be submitted.

To maximise the benefit of SCE, middleboxes SHOULD produce SCE markings sooner than they produce CE markings, when the level of congestion increases.



## **5. Examples of use**

### **5.1. Cubic**

Consider a TCP transport implementing CUBIC congestion control. This presently exhibits exponential cwnd growth during slow-start, polynomial cwnd growth in steady-state, and multiplicative decrease upon detecting a single CE marking or packet loss in one RTT cycle.

With SCE awareness, it might exit slow-start upon detecting a single SCE marking, switch from polynomial to Reno-linear cwnd growth when the SCE:ECT ratio exceeds 1:2, halt cwnd growth entirely when it exceeds 1:1, and implement a Reno-linear decline when it exceeds 2:1, in addition to retaining the sharp 40% decrease on detecting CE.

In ideal circumstances, the above behaviour would result in the send rate stabilising at a level which produces between 50% and 66% SCE marking at some bottleneck on the path. The middlebox performing this marking can thus control the send rate smoothly to an ideal value, maximising throughput with minimum average queue length.

### **5.2. TCP receiver side handling**

SCE can potentially be handled entirely by the receiver and be entirely independent of any of the dozens of [[RFC3168](#)] compliant congestion control algorithms, for example by manipulating the TCP receive window in a similar manner to the sender's congestion window.

Alternatively, some mechanism may be defined to feed back SCE signals to the sender explicitly. Details of this are left to future I-Ds.

### **5.3. Other**

New transports under development such as QUIC SHOULD implement a multi-bit and finer grained signal back to the sender based on SCE.

## **6. Related Work**

[RFC8087] [[RFC7567](#)] [[RFC7928](#)] [[RFC8290](#)] [[RFC8289](#)] [[RFC8033](#)] [[RFC8034](#)]

## **7. IANA Considerations**

There are no IANA considerations.





## **8. Security Considerations**

There are no security considerations.

## **9. Acknowledgements**

Many thanks to John Gilmore, the members of the ecn-sane project, the "cake" bufferbloat.net mailing list, the IETF AQM mailing list, and the IETF TSVWG.

## **10. References**

### **10.1. Normative References**

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), DOI 10.17487/RFC2119, March 1997, <<https://www.rfc-editor.org/info/rfc2119>>.
- [RFC8311] Black, D., "Relaxing Restrictions on Explicit Congestion Notification (ECN) Experimentation", [RFC 8311](#), DOI 10.17487/RFC8311, January 2018, <<https://www.rfc-editor.org/info/rfc8311>>.

### **10.2. Informative References**

- [RFC3168] Ramakrishnan, K., Floyd, S., and D. Black, "The Addition of Explicit Congestion Notification (ECN) to IP", [RFC 3168](#), DOI 10.17487/RFC3168, September 2001, <<https://www.rfc-editor.org/info/rfc3168>>.
- [RFC7567] Baker, F., Ed. and G. Fairhurst, Ed., "IETF Recommendations Regarding Active Queue Management", [BCP 197](#), [RFC 7567](#), DOI 10.17487/RFC7567, July 2015, <<https://www.rfc-editor.org/info/rfc7567>>.
- [RFC7928] Kuhn, N., Ed., Natarajan, P., Ed., Khademi, N., Ed., and D. Ros, "Characterization Guidelines for Active Queue Management (AQM)", [RFC 7928](#), DOI 10.17487/RFC7928, July 2016, <<https://www.rfc-editor.org/info/rfc7928>>.
- [RFC8033] Pan, R., Natarajan, P., Baker, F., and G. White, "Proportional Integral Controller Enhanced (PIE): A Lightweight Control Scheme to Address the Bufferbloat Problem", [RFC 8033](#), DOI 10.17487/RFC8033, February 2017, <<https://www.rfc-editor.org/info/rfc8033>>.



- [RFC8034] White, G. and R. Pan, "Active Queue Management (AQM) Based on Proportional Integral Controller Enhanced PIE) for Data-Over-Cable Service Interface Specifications (DOCSIS) Cable Modems", [RFC 8034](#), DOI 10.17487/RFC8034, February 2017, <<https://www.rfc-editor.org/info/rfc8034>>.
- [RFC8087] Fairhurst, G. and M. Welzl, "The Benefits of Using Explicit Congestion Notification (ECN)", [RFC 8087](#), DOI 10.17487/RFC8087, March 2017, <<https://www.rfc-editor.org/info/rfc8087>>.
- [RFC8289] Nichols, K., Jacobson, V., McGregor, A., Ed., and J. Iyengar, Ed., "Controlled Delay Active Queue Management", [RFC 8289](#), DOI 10.17487/RFC8289, January 2018, <<https://www.rfc-editor.org/info/rfc8289>>.
- [RFC8290] Hoeiland-Joergensen, T., McKenney, P., Taht, D., Gettys, J., and E. Dumazet, "The Flow Queue CoDel Packet Scheduler and Active Queue Management Algorithm", [RFC 8290](#), DOI 10.17487/RFC8290, January 2018, <<https://www.rfc-editor.org/info/rfc8290>>.

#### Authors' Addresses

Jonathan Morton  
Bufferbloat.net  
Koekkoenranta 21  
PITKAeJAeRVI 31520  
FINLAND

Phone: +358 44 927 2377  
Email: [chromatix99@gmail.com](mailto:chromatix99@gmail.com)

David M. Taeht  
TekLibre  
20600 Aldercroft Heights Rd  
Los Gatos, Ca 95033  
USA

Phone: +18312059740  
Email: [dave@taht.net](mailto:dave@taht.net)

