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Relaxing Restrictions on Explicit Congestion Notification (ECN) Experimentation

Abstract

This memo updates RFC 3168, which specifies Explicit Congestion Notification (ECN) as an alternative to packet drops for indicating network congestion to endpoints. It relaxes restrictions in RFC 3168 that hinder experimentation towards benefits beyond just removal of loss. This memo summarizes the anticipated areas of experimentation and updates RFC 3168 to enable experimentation in these areas. An Experimental RFC in the IETF document stream is required to take advantage of any of these enabling updates. In addition, this memo makes related updates to the ECN specifications for RTP in RFC 6679 and for the Datagram Congestion Control Protocol (DCCP) in RFCs 4341, 4342, and 5622. This memo also records the conclusion of the ECN nonce experiment in RFC 3540 and provides the rationale for reclassification of RFC 3540 from Experimental to Historic; this reclassification enables new experimental use of the ECT(1) codepoint.

Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 7841.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at https://www.rfc-editor.org/info/rfc8311.

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1. Introduction

This memo updates RFC 3168 [RFC3168], which specifies Explicit Congestion Notification (ECN) as an alternative to packet drops for indicating network congestion to endpoints. It relaxes restrictions in RFC 3168 that hinder experimentation towards benefits beyond just removal of loss. This memo summarizes the proposed areas of experimentation and updates RFC 3168 to enable experimentation in these areas. An Experimental RFC in the IETF document stream [RFC4844] is required to take advantage of any of these enabling updates. Putting all of these updates into a single document enables experimentation to proceed without requiring a standards process exception for each Experimental RFC that needs changes to RFC 3168, a Proposed Standard RFC.

There is no need for this memo to update RFC 3168 to simplify standardization of protocols and mechanisms that are documented in Standards Track RFCs, as any Standards Track RFC can update RFC 3168 directly without either relying on updates in this memo or using a standards process exception.

In addition, this memo makes related updates to the ECN specification for RTP [RFC6679] and for three DCCP profiles ([RFC4341], [RFC4342], and [RFC5622]) for the same reason. Each experiment is still required to be documented in one or more separate RFCs, but use of Experimental RFCs for this purpose does not require a process exception to modify any of these Proposed Standard RFCs when the modification falls within the bounds established by this memo (RFC 5622 is an Experimental RFC; it is modified by this memo for consistency with modifications to the other two DCCP RFCs).

Some of the anticipated experimentation includes use of the ECT(1) codepoint that was dedicated to the ECN nonce experiment in RFC 3540 [RFC3540]. This memo records the conclusion of the ECN nonce experiment and provides the explanation for reclassification of RFC 3540 from Experimental to Historic in order to enable new experimental use of the ECT(1) codepoint.

1.1. ECN Terminology

ECT: ECN-Capable Transport. One of the two codepoints, ECT(0) or ECT(1), in the ECN field [RFC3168] of the IP header (v4 or v6). An ECN-capable sender sets one of these to indicate that both transport endpoints support ECN.

Not-ECT: The ECN codepoint set by senders that indicates that the transport is not ECN capable.

CE: Congestion Experienced. The ECN codepoint that an intermediate node sets to indicate congestion. A node sets an increasing proportion of ECT packets to Congestion Experienced (CE) as the level of congestion increases.

1.2. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

2. ECN Experimentation: Overview

Three areas of ECN experimentation are covered by this memo; the cited documents should be consulted for the detailed goals and rationale of each proposed experiment:

Congestion Response Differences: An ECN congestion indication communicates a higher likelihood than a dropped packet that a short queue exists at the network bottleneck node [TCP-ABE]. This difference suggests that for congestion indicated by ECN, a different sender congestion response (e.g., sender backs off by a smaller amount) may be appropriate by comparison to the sender response to congestion indicated by loss. Two examples of proposed sender congestion response changes are described in [TCP-ABE] and [ECN-L4S] -- the proposal in the latter document couples the sender congestion response change to Congestion Marking Differences functionality (see next paragraph). These changes are at variance with the requirement in RFC 3168 that a sender's congestion control response to ECN congestion indications be the same as to drops. IETF approval, e.g., via an Experimental RFC in the IETF document stream, is required for any sender congestion response used in this area of experimentation. See Section 4.1 for further discussion.

Congestion Marking Differences: Congestion marking at network nodes can be configured to maintain very shallow queues in conjunction with a different sender response to congestion indications (CE marks), e.g., as proposed in [ECN-L4S]. The traffic involved needs to be identified by the senders to the network nodes in order to avoid damage to other network traffic whose senders do not expect the more frequent congestion marking used to maintain very shallow queues. Use of different ECN codepoints, specifically ECT(0) and ECT(1), is a promising means of traffic identification for this purpose, but that technique is at variance with the requirement in RFC 3168 that traffic marked as ECT(0) not receive different treatment in the network by comparison to traffic marked as ECT(1). IETF approval, e.g., via an Experimental RFC in the IETF document stream, is required for any differences in congestion marking or sender congestion response used in this area of experimentation. See Section 4.2 for further discussion.

TCP Control Packets and Retransmissions: RFC 3168 limits the use of ECN with TCP to data packets, excluding retransmissions. With the successful deployment of ECN in large portions of the Internet, there is interest in extending the benefits of ECN to TCP control packets (e.g., SYNs) and retransmitted packets, e.g., as proposed in [ECN-TCP]. This is at variance with RFC 3168's prohibition of ECN for TCP control packets and retransmitted packets. See Section 4.3 for further discussion.

The scope of this memo is limited to these three areas of experimentation. This memo expresses no view on the likely outcomes of the proposed experiments and does not specify the experiments in detail. Additional experiments in these areas are possible, e.g., on use of ECN to support deployment of a protocol similar to Data Center TCP (DCTCP) [RFC8257] beyond DCTCP's current applicability that is limited to data center environments. The purpose of this memo is to remove constraints in Standards Track RFCs that stand in the way of these areas of experimentation.

2.1. Effective Congestion Control is Required

Congestion control remains an important aspect of the Internet architecture [RFC2914]. Any Experimental RFC in the IETF document stream that takes advantage of this memo's updates to any RFC is required to discuss the congestion control implications of the experiment(s) in order to provide assurance that deployment of the experiment(s) does not pose a congestion-based threat to the operation of the Internet.

2.2. Network Considerations for ECN Experimentation

ECN functionality [RFC3168] is becoming widely deployed in the Internet and is being designed into additional protocols such as Transparent Interconnection of Lots of Links (TRILL) [ECN-TRILL]. ECN experiments are expected to coexist with deployed ECN functionality, with the responsibility for that coexistence falling primarily upon designers of experimental changes to ECN. In addition, protocol designers and implementers, as well as network operators, may desire to anticipate and/or support ECN experiments. The following guidelines will help avoid conflicts with the areas of ECN experimentation enabled by this memo:

1. Forwarding behavior as described in RFC 3168 remains the preferred approach for routers that are not involved in ECN experiments, in particular continuing to treat the ECT(0) and ECT(1) codepoints as equivalent, as specified in Section 4.2 below.

2. Network nodes that forward packets SHOULD NOT assume that the ECN CE codepoint indicates that the packet would have been dropped if ECN were not in use. This is because Congestion Response Differences experiments employ different congestion responses to dropped packets by comparison to receipt of CE-marked packets (see Section 4.1 below), so CE-marked packets SHOULD NOT be arbitrarily dropped. A corresponding difference in congestion responses already occurs when the ECN field is used for Pre-Congestion Notification (PCN) [RFC6660].

3. A network node MUST NOT originate traffic marked with ECT(1) unless the network node is participating in a Congestion Marking Differences experiment that uses ECT(1), as specified in Section 4.2 below.

Some ECN experiments use ECN with packets where ECN has not been used previously, specifically TCP control packets and retransmissions; see Section 4.3 below. The new middlebox behavior requirements in that section are of particular importance. In general, any system or protocol that inspects or monitors network traffic SHOULD be prepared to encounter ECN usage on packets and traffic that currently do not use ECN.

ECN field handling requirements for tunnel encapsulation and decapsulation are specified in [RFC6040], which is in the process of being updated by [ECN-SHIM]. Related guidance for encapsulations whose outer headers are not IP headers can be found in [ECN-ENCAP]. These requirements and guidance apply to all traffic, including traffic that is part of any ECN experiment.

2.3. Operational and Management Considerations

Changes in network traffic behavior that result from ECN experimentation are likely to impact network operations and management. Designers of ECN experiments are expected to anticipate possible impacts and consider how they may be dealt with. Specific topics to consider include possible network management changes or extensions, monitoring of the experimental deployment, collection of data for evaluation of the experiment, and possible interactions with other protocols, particularly protocols that encapsulate network traffic.

For further discussion, see [RFC5706]; the questions in Appendix A of RFC 5706 provide a concise survey of some important aspects to consider.

3. ECN Nonce and RFC 3540

As specified in RFC 3168, ECN uses two ECN-Capable Transport (ECT) codepoints, ECT(0) and ECT(1), to indicate that a packet supports ECN. RFC 3168 assigned the second codepoint, ECT(1), to support ECN nonce functionality that discourages receivers from exploiting ECN to improve their throughput at the expense of other network users. That ECN nonce functionality is fully specified in RFC 3540 [RFC3540]. This section explains why RFC 3540 has been reclassified from Experimental to Historic and makes associated updates to RFC 3168.

While the ECN nonce works as specified, and has been deployed in limited environments, widespread usage in the Internet has not materialized. A study of the ECN behavior of the top one million web servers using 2014 data [Trammell15] found that after ECN was negotiated, none of the 581,711 IPv4 servers tested were using both ECT codepoints, which would have been a possible sign of ECN nonce usage. Of the 17,028 IPv6 servers tested, four set both ECT(0) and ECT(1) on data packets. This might have been evidence of use of the ECN nonce by these four servers, but it might equally have been due to erroneous re-marking of the ECN field by a middlebox or router.

With the emergence of new experimental functionality that depends on use of the ECT(1) codepoint for other purposes, continuing to reserve that codepoint for the ECN nonce experiment is no longer justified. In addition, other approaches to discouraging receivers from exploiting ECN have emerged; see Appendix B.1 of [ECN-L4S]. Therefore, in support of ECN experimentation with the ECT(1) codepoint, this memo:

- Declares that the ECN nonce experiment [RFC3540] has concluded and notes the absence of widespread deployment.

- Updates RFC 3168 [RFC3168] to remove discussion of the ECN nonce and use of ECT(1) for that nonce.

The four primary updates to RFC 3168 that remove discussion of the ECN nonce and use of ECT(1) for that nonce are as follows:

1. The removal of the paragraph in Section 5 that immediately follows Figure 1; this paragraph discusses the ECN nonce as the motivation for two ECT codepoints.

2. The removal of Section 11.2, "A Discussion of the ECN nonce", in its entirety.

3. The removal of the last paragraph of Section 12, which states that ECT(1) may be used as part of the implementation of the ECN nonce.

4. The removal of the first two paragraphs of Section 20.2, which discuss the ECN nonce and alternatives. No changes are made to the rest of Section 20.2, which discusses alternative uses for the fourth ECN codepoint.

In addition, other less-substantive changes to RFC 3168 are required to remove all other mentions of the ECN nonce and to remove implications that ECT(1) is intended for use by the ECN nonce; these specific text updates are omitted for brevity.

4. Updates to RFC 3168

The following subsections specify updates to RFC 3168 to enable the three areas of experimentation summarized in Section 2.

4.1. Congestion Response Differences

RFC 3168 specifies that senders respond identically to packet drops and ECN congestion indications. ECN congestion indications are predominately originated by Active Queue Management (AQM) mechanisms in intermediate buffers. AQM mechanisms are usually configured to maintain shorter queue lengths than non-AQM-based mechanisms, particularly non-AQM drop-based mechanisms such as tail-drop, as AQM mechanisms indicate congestion before the queue overflows. While the occurrence of loss does not easily enable the receiver to determine if AQM is used, the receipt of an ECN CE mark conveys a strong likelihood that AQM was used to manage the bottleneck queue. Hence, an ECN congestion indication communicates a higher likelihood than a dropped packet that a short queue exists at the network bottleneck node [TCP-ABE]. This difference suggests that for congestion indicated by ECN, a different sender congestion response (e.g., sender backs off by a smaller amount) may be appropriate by comparison to the sender response to congestion indicated by loss. However, Section 5 of RFC 3168 specifies that:

> Upon the receipt by an ECN-Capable transport of a single CE packet, the congestion control algorithms followed at the end-systems MUST be essentially the same as the congestion control response to a *single* dropped packet.

This memo updates this text from RFC 3168 to allow the congestion control response (including the TCP Sender’s congestion control response) to a CE-marked packet to differ from the response to a dropped packet, provided that the changes from RFC 3168 are

documented in an Experimental RFC in the IETF document stream. The specific change to RFC 3168 is to insert the words "unless otherwise specified by an Experimental RFC in the IETF document stream" at the end of the sentence quoted above.

RFC 4774 [RFC4774] quotes the above text from RFC 3168 as background, but it does not impose requirements based on that text. Therefore, no update to RFC 4774 is required to enable this area of experimentation.

Section 6.1.2 of RFC 3168 specifies that:

> If the sender receives an ECN-Echo (ECE) ACK packet (that is, an ACK packet with the ECN-Echo flag set in the TCP header), then the sender knows that congestion was encountered in the network on the path from the sender to the receiver. The indication of congestion should be treated just as a congestion loss in non-ECN-Capable TCP. That is, the TCP source halves the congestion window "cwnd" and reduces the slow start threshold "ssthresh".

This memo also updates this text from RFC 3168 to allow the congestion control response (including the TCP Sender's congestion control response) to a CE-marked packet to differ from the response to a dropped packet, provided that the changes from RFC 3168 are documented in an Experimental RFC in the IETF document stream. The specific change to RFC 3168 is to insert the words "Unless otherwise specified by an Experimental RFC in the IETF document stream" at the beginning of the second sentence quoted above.

4.2. Congestion Marking Differences

Taken to its limit, an AQM algorithm that uses ECN congestion indications can be configured to maintain very shallow queues, thereby reducing network latency by comparison to maintaining a larger queue. Significantly more aggressive sender responses to ECN are needed to make effective use of such very shallow queues; "Datacenter TCP (DCTCP)" [RFC8257] provides an example. In this case, separate network node treatments are essential, both to prevent the aggressive low-latency traffic from starving conventional traffic (if present) and to prevent any conventional traffic disruption to any lower-latency service that uses the very shallow queues. Use of different ECN codepoints is a promising means of identifying these two classes of traffic to network nodes; hence, this area of experimentation is based on the use of the ECT(1) codepoint to request ECN congestion marking behavior in the network that differs from ECT(0). It is essential that any such change in ECN congestion marking behavior be counterbalanced by use of a different IETF-

approved congestion response to CE marks at the sender, e.g., as proposed in [ECN-L4S].

Section 5 of RFC 3168 specifies that "Routers treat the ECT(0) and ECT(1) codepoints as equivalent."

This memo updates RFC 3168 to allow routers to treat the ECT(0) and ECT(1) codepoints differently, provided that the changes from RFC 3168 are documented in an Experimental RFC in the IETF document stream. The specific change to RFC 3168 is to insert the words "unless otherwise specified by an Experimental RFC in the IETF document stream" at the end of the above sentence.

When an AQM is configured to use ECN congestion indications to maintain a very shallow queue, congestion indications are marked on packets that would not have been dropped if ECN was not in use. Section 5 of RFC 3168 specifies that:

> For a router, the CE codepoint of an ECN-Capable packet SHOULD only be set if the router would otherwise have dropped the packet as an indication of congestion to the end nodes. When the router's buffer is not yet full and the router is prepared to drop a packet to inform end nodes of incipient congestion, the router should first check to see if the ECT codepoint is set in that packet's IP header. If so, then instead of dropping the packet, the router MAY instead set the CE codepoint in the IP header.

This memo updates RFC 3168 to allow congestion indications that are not equivalent to drops, provided that the changes from RFC 3168 are documented in an Experimental RFC in the IETF document stream. The specific change is to change "For a router" to "Unless otherwise specified by an Experimental RFC in the IETF document stream" at the beginning of the first sentence of the above paragraph.

A larger update to RFC 3168 is necessary to enable sender usage of ECT(1) to request network congestion marking behavior that maintains very shallow queues at network nodes. When using loss as a congestion signal, the number of signals provided should be reduced to a minimum; hence, only the presence or absence of congestion is communicated. In contrast, ECN can provide a richer signal, e.g., to indicate the current level of congestion, without the disadvantage of a larger number of packet losses. A proposed experiment in this area, Low Latency Low Loss Scalable throughput (L4S) [ECN-L4S], significantly increases the CE marking probability for traffic marked as ECT(1) in a fashion that would interact badly with existing sender congestion response functionality because that functionality assumes that the network marks ECT packets as frequently as it would drop Not-ECT packets. If network traffic that uses such a conventional

sender congestion response were to encounter L4S's increased marking probability (and hence rate) at a network bottleneck queue, the resulting traffic throughput is likely to be much less than intended for the level of congestion at the bottleneck queue.

This memo updates RFC 3168 to remove that interaction for ECT(1). The specific update to Section 5 of RFC 3168 is to replace the following two paragraphs:

> Senders are free to use either the ECT(0) or the ECT(1) codepoint to indicate ECT, on a packet-by-packet basis.
>
> The use of both the two codepoints for ECT, ECT(0) and ECT(1), is motivated primarily by the desire to allow mechanisms for the data sender to verify that network elements are not erasing the CE codepoint, and that data receivers are properly reporting to the sender the receipt of packets with the CE codepoint set, as required by the transport protocol. Guidelines for the senders and receivers to differentiate between the ECT(0) and ECT(1) codepoints will be addressed in separate documents, for each transport protocol. In particular, this document does not address mechanisms for TCP end-nodes to differentiate between the ECT(0) and ECT(1) codepoints. Protocols and senders that only require a single ECT codepoint SHOULD use ECT(0).

with this paragraph:

> Protocols and senders MUST use the ECT(0) codepoint to indicate ECT unless otherwise specified by an Experimental RFC in the IETF document stream. Protocols and senders MUST NOT use the ECT(1) codepoint to indicate ECT unless otherwise specified by an Experimental RFC in the IETF document stream. Guidelines for senders and receivers to differentiate between the ECT(0) and ECT(1) codepoints will be addressed in separate documents, for each transport protocol. In particular, this document does not address mechanisms for TCP end-nodes to differentiate between the ECT(0) and ECT(1) codepoints.

Congestion Marking Differences experiments SHOULD modify the network behavior for traffic marked as ECT(1) rather than ECT(0) if network behavior for only one ECT codepoint is modified. Congestion Marking Differences experiments MUST NOT modify the network behavior for traffic marked as ECT(0) in a fashion that requires changes to the sender congestion response to obtain desired network behavior. If a Congestion Marking Differences experiment modifies the network behavior for traffic marked as ECT(1), e.g., CE-marking behavior, in

a fashion that requires changes to the sender congestion response to obtain desired network behavior, then the Experimental RFC in the IETF document stream for that experiment MUST specify:

- The sender congestion response to CE marking in the network, and
- Router behavior changes, or the absence thereof, in forwarding CE-marked packets that are part of the experiment.

In addition, this memo updates RFC 3168 to remove discussion of the ECN nonce, as noted in Section 3 above.

4.3. TCP Control Packets and Retransmissions

With the successful use of ECN for traffic in large portions of the Internet, there is interest in extending the benefits of ECN to TCP control packets (e.g., SYNs) and retransmitted packets, e.g., as proposed by ECN++ [ECN-TCP].

RFC 3168 prohibits use of ECN for TCP control packets and retransmitted packets in a number of places:

- Section 5.2: "To ensure the reliable delivery of the congestion indication of the CE codepoint, an ECT codepoint MUST NOT be set in a packet unless the loss of that packet in the network would be detected by the end nodes and interpreted as an indication of congestion."
- Section 6.1.1: "A host MUST NOT set ECT on SYN or SYN-ACK packets"
- Section 6.1.4: "...pure acknowledgement packets (e.g., packets that do not contain any accompanying data) MUST be sent with the not-ECT codepoint."
- Section 6.1.5: "This document specifies ECN-capable TCP implementations MUST NOT set either ECT codepoint (ECT(0) or ECT(1)) in the IP header for retransmitted data packets, and that the TCP data receiver SHOULD ignore the ECN field on arriving data packets that are outside of the receiver’s current window."
- Section 6.1.6: "...the TCP data sender MUST NOT set either an ECT codepoint or the CWR bit on window probe packets.

This memo updates RFC 3168 to allow the use of ECT codepoints on SYN and SYN-ACK packets, pure acknowledgement packets, window probe packets, and retransmissions of packets that were originally sent with an ECT codepoint, provided that the changes from RFC 3168 are documented in an Experimental RFC in the IETF document stream. The

specific change to RFC 3168 is to insert the words "unless otherwise specified by an Experimental RFC in the IETF document stream" at the end of each sentence quoted above.

In addition, beyond requiring TCP senders not to set ECT on TCP control packets and retransmitted packets, RFC 3168 is silent on whether it is appropriate for a network element, e.g., a firewall, to discard such a packet as invalid. For this area of ECN experimentation to be useful, middleboxes ought not to do that; therefore, RFC 3168 is updated by adding the following text to the end of Section 6.1.1.1 on Middlebox Issues:

> Unless otherwise specified by an Experimental RFC in the IETF document stream, middleboxes SHOULD NOT discard TCP control packets and retransmitted TCP packets solely because the ECN field in the IP header does not contain Not-ECT. An exception to this requirement occurs in responding to an attack that uses ECN codepoints other than Not-ECT. For example, as part of the response, it may be appropriate to drop ECT-marked TCP SYN packets with higher probability than TCP SYN packets marked with Not-ECT. Any such exceptional discarding of TCP control packets and retransmitted TCP packets in response to an attack MUST NOT be done routinely in the absence of an attack and SHOULD only be done if it is determined that the use of ECN is contributing to the attack.

5. ECN for RTP Updates to RFC 6679

RFC 6679 [RFC6679] specifies use of ECN for RTP traffic; it allows use of both the ECT(0) and ECT(1) codepoints and provides the following guidance on use of these codepoints in Section 7.3.1:

> The sender SHOULD mark packets as ECT(0) unless the receiver expresses a preference for ECT(1) or for a random ECT value using the "ect" parameter in the "a=ecn-capable-rtp:" attribute.

The Congestion Marking Differences area of experimentation increases the potential consequences of using ECT(1) instead of ECT(0); hence, the above guidance is updated by adding the following two sentences:

> Random ECT values MUST NOT be used, as that may expose RTP to differences in network treatment of traffic marked with ECT(1) and ECT(0) and differences in associated endpoint congestion responses. In addition, ECT(0) MUST be used unless otherwise specified in an Experimental RFC in the IETF document stream.

Section 7.3.3 of RFC 6679 specifies RTP's response to receipt of CE-marked packets as being identical to the response to dropped packets:

> The reception of RTP packets with ECN-CE marks in the IP header is a notification that congestion is being experienced. The default reaction on the reception of these ECN-CE-marked packets MUST be to provide the congestion control algorithm with a congestion notification that triggers the algorithm to react as if packet loss had occurred. There should be no difference in congestion response if ECN-CE marks or packet drops are detected.

In support of Congestion Response Differences experimentation, this memo updates this text in a fashion similar to RFC 3168 to allow the RTP congestion control response to a CE-marked packet to differ from the response to a dropped packet, provided that the changes from RFC 6679 are documented in an Experimental RFC in the IETF document stream. The specific change to RFC 6679 is to insert the words "Unless otherwise specified by an Experimental RFC in the IETF document stream" and reformat the last two sentences to be subject to that condition; that is:

> The reception of RTP packets with ECN-CE marks in the IP header is a notification that congestion is being experienced. Unless otherwise specified by an Experimental RFC in the IETF document stream:
>
> * The default reaction on the reception of these ECN-CE-marked packets MUST be to provide the congestion control algorithm with a congestion notification that triggers the algorithm to react as if packet loss had occurred.
>
> * There should be no difference in congestion response if ECN-CE marks or packet drops are detected.

The second sentence of the immediately following paragraph in Section 7.3.3 of RFC 6679 requires a related update:

> Other reactions to ECN-CE may be specified in the future, following IETF Review. Detailed designs of such alternative reactions MUST be specified in a Standards Track RFC and be reviewed to ensure they are safe for deployment under any restrictions specified.

The update is to change "Standards Track RFC" to "Standards Track RFC or Experimental RFC in the IETF document stream" for consistency with the first update.

6. ECN for DCCP Updates to RFCs 4341, 4342, and 5622

The specifications of the three DCCP Congestion Control IDs (CCIDs), 2 [RFC4341], 3 [RFC4342], and 4 [RFC5622], contain broadly the same wording as follows:

> each DCCP-Data and DCCP-DataAck packet is sent as ECN Capable with either the ECT(0) or the ECT(1) codepoint set.

This memo updates these sentences in each of the three RFCs as follows:

> each DCCP-Data and DCCP-DataAck packet is sent as ECN Capable. Unless otherwise specified by an Experimental RFC in the IETF document stream, such DCCP senders MUST set the ECT(0) codepoint.

In support of Congestion Marking Differences experimentation (as noted in Section 3), this memo also updates all three of these RFCs to remove discussion of the ECN nonce. The specific text updates are omitted for brevity.

7. IANA Considerations

To reflect the reclassification of RFC 3540 as Historic, IANA has updated the "Transmission Control Protocol (TCP) Header Flags" registry <https://www.iana.org/assignments/tcp-header-flags> to remove the registration of bit 7 as the NS (Nonce Sum) bit and add an annotation to the registry to state that bit 7 was used by Historic RFC 3540 as the NS (Nonce Sum) bit but is now Reserved.

8. Security Considerations

As a process memo that only relaxes restrictions on experimentation, there are no protocol security considerations, as security considerations for any experiments that take advantage of the relaxed restrictions are discussed in the documents that propose the experiments.

However, effective congestion control is crucial to the continued operation of the Internet; hence, this memo places the responsibility for not breaking Internet congestion control on the experiments and the experimenters who propose them. This responsibility includes the requirement to discuss congestion control implications in an Experimental RFC in the IETF document stream for each experiment, as stated in Section 2.1; review of that discussion by the IETF community and the IESG prior to RFC publication is intended to provide assurance that each experiment does not break Internet congestion control.

See Appendix C.1 of [ECN-L4S] for discussion of alternatives to the ECN nonce.

9. References

9.1. Normative References

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