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On the implementation of the TCP urgent mechanism
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Abstract

This document analyzes how current TCP implementations process TCP urgent indications, and how the behavior of some widely-deployed middle-boxes affect how urgent indications are processed by end systems. This document updates the relevant specifications such that they accommodate current practice in processing TCP urgent indications, provides advice to applications that make use of the urgent mechanism, and raises awareness about the reliability of TCP urgent indications in the current Internet.

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On the TCP urgent mechanism

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[1.](#) Introduction

This document analyzes how some current TCP implementations process TCP urgent indications, and how the behavior of some widely-deployed middle-boxes affect the processing of urgent indications by hosts. This document updates [RFC 793](#) [[RFC0793](#)], [RFC 1011](#) [[RFC1011](#)], and [RFC 1122](#) [[RFC1122](#)] such that they accommodate current practice in processing TCP urgent indications, provides advice to applications using the urgent mechanism, and raises awareness about the reliability of TCP urgent indications in the current Internet.

[Section 2](#) describes what the current IETF specifications state with respect to TCP urgent indications. [Section 3](#) describes how some current TCP implementations actually process TCP urgent indications. [Section 4](#) updates [RFC 793](#) [[RFC0793](#)], [RFC 1011](#) [[RFC1011](#)], and [RFC 1122](#) [[RFC1122](#)], such that they accommodate current practice in processing TCP urgent indications. [Section 5](#) provides advice to to new applications employing TCP, with respect to the TCP urgent mechanism. [Section 6](#) provides advice to existing applications that use or rely on the TCP urgent mechanism.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC 2119](#) [[RFC2119](#)].

[2.](#) Specification of the TCP urgent mechanism

[2.1.](#) Semantics of urgent indications

TCP incorporates an "urgent mechanism" that allows the sending user to stimulate the receiving user to accept some "urgent data" and to permit the receiving TCP to indicate to the receiving user when all the currently known urgent data have been received by the user.

The TCP urgent mechanism permits a point in the data stream to be designated as the end of urgent information. Whenever this point is in advance of the receive sequence number (RCV.NXT) at the receiving TCP, that TCP must tell the user to go into "urgent mode"; when the receive sequence number catches up to the urgent pointer, the TCP must tell user to go into "normal mode" [[RFC0793](#)]. This means, for example, that data that were received as "normal data" might become "urgent data" if an urgent indication is received in some successive TCP segment before those data are consumed by the TCP user.

The URG control flag indicates that the "Urgent Pointer" field is meaningful and must be added to the segment sequence number to yield the urgent pointer. The absence of this flag indicates that there is

no urgent data outstanding [[RFC0793](#)].

The TCP urgent mechanism is NOT a mechanism for sending "out-of-band" data: the so-called "urgent data" should be delivered "in-line" to the TCP user.

[2.2](#). Semantics of the Urgent Pointer

There is some ambiguity in [RFC 793](#) [[RFC0793](#)] with respect to the semantics of the Urgent Pointer. [Section 3.1](#) (page 17) of [RFC 793](#) [[RFC0793](#)] states that the Urgent Pointer "communicates the current value of the urgent pointer as a positive offset from the sequence number in this segment. The urgent pointer points to the sequence number of the octet following the urgent data. This field is only be interpreted in segments with the URG control bit set". However, [Section 3.9](#) (page 56) of [RFC 793](#) [[RFC0793](#)] states, when describing the processing of the SEND call in the ESTABLISHED and CLOSE-WAIT states, that "If the urgent flag is set, then $SND.UP \leftarrow SND.NXT-1$ and set the urgent pointer in the outgoing segments".

[RFC 1011](#) [[RFC1011](#)] clarified this ambiguity in [RFC 793](#) stating that "Page 17 is wrong. The urgent pointer points to the last octet of

urgent data (not to the first octet of non-urgent data)". [RFC 1122](#) [[RFC1122](#)] formally updated [RFC 793](#) by stating, in [Section 4.2.2.4](#) (page 84), that "the urgent pointer points to the sequence number of the LAST octet (not LAST+1) in a sequence of urgent data."

[2.3.](#) Allowed length of urgent data

[RFC 793](#) [[RFC0793](#)] allows TCP peers to send urgent data of any length, as the TCP urgent mechanism simply provides a pointer to an interesting point in the data stream. In this respect, [Section 4.2.2.4](#) (page 84) of [RFC 1122](#) explicitly states that "A TCP MUST support a sequence of urgent data of any length".

[3.](#) Current implementation practice of TCP urgent data

[3.1.](#) Semantics of urgent indications

As discussed in [Section 1](#), the TCP urgent mechanism simply permits a point in the data stream to be designated as the end of urgent information, but does NOT provide a mechanism for sending out of band data.

Unfortunately, virtually all TCP implementations process TCP urgent data differently. By default, the last byte of "urgent data" is delivered "out of band" to the application. That is, it is not

delivered as part of the normal data stream. For example, the "out of band" byte is read by an application when a `recv(2)` system call with the `MSG_OOB` flag set is issued.

Most implementations provide a socket option (`SO_OOBINLINE`) that allows an application to override the (broken) default processing of urgent data, so that they are delivered "in band" to the application, thus providing the semantics intended by the IETF specifications.

[3.2.](#) Semantics of the Urgent Pointer

All the popular implementations that the authors of this document have been able to test interpret the semantics of the TCP Urgent Pointer as specified in [Section 3.1 of RFC 793](#). This means that even when [RFC 1122](#) officially updated [RFC 793](#) to clarify the ambiguity in

the semantics of the Urgent Pointer, this clarification was never reflected into actual implementations (i.e., virtually all implementations default to the semantics of the urgent pointer specified in [Section 3.1 of RFC 793](#)).

Some operating systems provide a system-wide toggle to override this behavior, and interpret the semantics of the Urgent Pointer as clarified in [RFC 1122](#). However, this system-wide toggle has been found to be inconsistent. For example, Linux provides the `sysctl "tcp_stdurg"` (i.e., `net.ipv4.tcp_stdurg`) that, when set, supposedly changes the system behavior to interpret the semantics of the TCP Urgent Pointer as specified in [RFC 1122](#). However, this `sysctl` changes the semantics of the Urgent Pointer only for incoming segments, but not for outgoing segments. This means that if this `sysctl` is set, an application might be unable to interoperate with itself if both the TCP sender and the TCP receiver are running on the same host.

[3.3](#). Allowed length of urgent data

While [Section 4.2.2.4](#) (page 84) of [RFC 1122](#) explicitly states that "A TCP MUST support a sequence of urgent data of any length", in practice all those implementations that interpret TCP urgent indications as a mechanism for sending out-of-band data keep a buffer of a single byte for storing the "last byte of urgent data". Thus, if successive indications of urgent data are received before the application reads the pending "out of band" byte, that pending byte will be discarded (i.e., overwritten by the new byte of urgent data).

In order to avoid urgent data from being discarded, some implementations queue each of the received "urgent bytes", so that even if another urgent indication is received before the pending urgent data are consumed by the application, those bytes do not need

to be discarded. Some of these implementations have been known to fail to enforce any limits on the amount of urgent data that they queue, thus resulting vulnerable to trivial resource exhaustion attacks [[CPNI-TCP](#)].

It should be reinforced that the aforementioned implementations are broken. The TCP urgent mechanism is not a mechanism for delivering out-of-band data.

3.4. Interaction of middle-boxes with TCP urgent indications

As a result of the publication of Network Intrusion Detection (NIDs) evasion techniques based on TCP urgent indications [[phrack](#)], some middle-boxes clear the urgent indications by clearing the URG flag and setting the Urgent Pointer to zero. This causes the "urgent data" to become "in line" (that is, accessible by the read(2) call or the recv(2) call without the MSG_OOB flag) in the case of those TCP implementations that implement the urgent mechanism as out-of-band data (as described in [Section 3.1](#)). An example of such a middle-box is the Cisco PIX firewall [[Cisco-PIX](#)]. This should discourage applications from depending on urgent indications for their correct operation, as urgent indications may not be not reliable in the current Internet.

4. Updating [RFC 793](#), [RFC 1011](#), and [RFC 1122](#)

Considering that as long as both the TCP sender and the TCP receiver implement the same semantics for the Urgent Pointer there is no functional difference in having the Urgent Pointer point to "the sequence number of the octet following the urgent data" vs. "the last octet of urgent data", and since all known implementations interpret the semantics of the Urgent Pointer as pointing to "the sequence number of the octet following the urgent data", we hereby update [RFC 793](#) [[RFC0793](#)], [RFC 1011](#) [[RFC1011](#)], and [RFC 1122](#) [[RFC1122](#)], such that "the urgent pointer points to the sequence number of the octet following the urgent data" (in segments with the URG control bit set), thus accommodating virtually all existing TCP implementations.

5. Advice to new applications employing TCP

As a result of the issues discussed in [Section 3.2](#) and [Section 3.4](#), new applications SHOULD NOT employ the TCP urgent mechanism. However, TCP implementations MUST still include support for the urgent mechanism such that existing applications can still use it.

6. Advice to applications that make use of the urgent mechanism

Even though applications SHOULD NOT employ the urgent mechanism, applications that still decide to employ it MUST set the SO_OOBINLINE socket option, such that "urgent data" are delivered inline, as intended by the IETF specifications.

7. Security Considerations

Given that there are two different interpretations of the semantics of the Urgent Pointer in current implementations (e.g., depending on the value of the tcp_stdurg sysctl), and that middle-boxes (such as packet scrubbers) or the end-systems themselves could cause the urgent data to be processed "in band", there exists ambiguity in how "urgent data" sent by a TCP will be processed by the intended recipient. This might make it difficult for a Network Intrusion Detection System (NIDS) to track the application-layer data transferred to the destination system, and thus lead to false negatives or false positives in the NIDS [[CPNI-TCP](#)].

Probably the best way to avoid the security implications of TCP urgent data is to avoid having applications use the TCP urgent mechanism altogether. Packet scrubbers could probably be configured to clear the URG bit, and set the Urgent Pointer to zero. This would basically cause the urgent data to be put "in band". However, this might cause interoperability problems or undesired behavior in the applications running on top of TCP.

8. IANA Considerations

This document has no actions for IANA.

9. Acknowledgements

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10.1. Normative References

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[Appendix A](#). Survey of the processing of TCP urgent indications by some popular TCP implementations

[A.1](#). FreeBSD

FreeBSD 8.0 [[FreeBSD](#)] interprets the semantics of the urgent pointer as specified in [Section 4](#) of this document. It does not provide any `sysctl` to override this behavior.

FreeBSD provides the `SO_00BINLINE` socket option that, when set, causes TCP "urgent data" to remain "in band". That is, it will be accessible by the `read(2)` call or the `recv(2)` call without the `MSG_00B` flag.

FreeBSD supports only one byte of urgent data. That is, only the byte preceding the Urgent Pointer is considered as "urgent data".

[A.2](#). Linux

Linux 2.6.15-53-386 [[Linux](#)] interprets the semantics of the urgent pointer as specified in [Section 4](#) of this document. It provides the `net.ipv4.tcp_stdurg` `sysctl` to override this behavior to interpret the Urgent Pointer as specified in [RFC 1122](#) [[RFC1122](#)]. However, this `sysctl` only affects the processing of incoming segments (the Urgent Pointer in outgoing segments will still be set as specified in [Section 4](#) of this document).

Linux provides the `SO_00BINLINE` socket option that, when set, causes TCP "urgent data" to remain "in band". That is, it will be accessible by the `read(2)` call or the `recv(2)` call without the `MSG_00B` flag.

Linux supports only one byte of urgent data. That is, only the byte

preceding the Urgent Pointer is considered as "urgent data".

[A.3.](#) NetBSD

NetBSD 5.0.1 [[NetBSD](#)] interprets the semantics of the urgent pointer as specified in [Section 4](#) of this document. It does not provide any `sysctl` to override this behavior.

NetBSD provides the `SO_00BINLINE` socket option that, when set, causes

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TCP "urgent data" to remain "in band". That is, they will be accessible by the `read(2)` call or the `recv(2)` call without the `MSG_00B` flag.

NetBSD supports only one byte of urgent data. That is, only the byte preceding the Urgent Pointer is considered as "urgent data".

[A.4.](#) OpenBSD

OpenBSD 4.2 [[OpenBSD](#)] interprets the semantics of the urgent pointer as specified in [Section 4](#) of this document. It does not provide any `sysctl` to override this behavior.

OpenBSD provides the `SO_00BINLINE` socket option that, when set, causes TCP urgent data to remain "in band". That is, they will be accessible by the `read(2)` or `recv(2)` calls without the `MSG_00B` flag.

OpenBSD supports only one byte of urgent data. That is, only the byte preceding the Urgent Pointer is considered as "urgent data".

[A.5.](#) Cisco IOS software

Cisco IOS Software Releases 12.2(18)SXF7, 12.4(15)T7 interpret the semantics of the urgent pointer as specified in [Section 4](#) of this document.

The behavior is consistent with having the `SO_00BINLINE` socket option turned on, i.e. the data is processed "in band".

[A.6.](#) Microsoft Windows 2000, Service Pack 4

Microsoft Windows 2000 [[Windows2000](#)] interprets the semantics of the

urgent pointer as specified in [Section 4](#) of this document. It provides the `TcpUseRFC1122UrgentPointer` system-wide variable to override this behavior, interpreting the Urgent Pointer as specified in [RFC 1122](#) [[RFC1122](#)].

Tests performed with a sample server application compiled using the cygwin environment has shown that the default behavior is to return the urgent data "in band".

[A.7.](#) Microsoft Windows 2008

Microsoft Windows 2008 interprets the semantics of the urgent pointer as specified in [Section 4](#) of this document.

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[A.8.](#) Microsoft Windows 95

Microsoft Windows 95 interprets the semantics of the urgent pointer as specified in [Section 4](#) of this document. It provides the `BSDUrgent` system-wide variable to override this behavior, interpreting the Urgent Pointer as specified in [RFC 1122](#) [[RFC1122](#)]. Windows 95 supports only one byte of urgent data. That is, only the byte preceding the Urgent Pointer is considered as "urgent data". [[Windows95](#)]

[Appendix B.](#) Changes from previous versions of the draft (to be removed by the RFC Editor before publishing this document as an RFC)

[B.1.](#) Changes from [draft-ietf-tcpm-urgent-data-03](#)

- o Addresses feedback sent by David Borman, and nit pointed out by John Heffner.

[B.2.](#) Changes from [draft-ietf-tcpm-urgent-data-02](#)

- o Addresses WGLC feedback submitted by Michael Welzl, Anantha Ramaiah, and Wesley Eddy.

B.3. Changes from [draft-ietf-tcpm-urgent-data-01](#)

- o Fixes reference to Cisco IOS Software (layer 8+ stuff ;-)).
- o Cleaned-up [Appendix A.5](#).

B.4. Changes from [draft-ietf-tcpm-urgent-data-00](#)

- o Minor editorial changes.
- o Incorporated the specific changes/advice stated in <http://www.ietf.org/mail-archive/web/tcpm/current/msg04548.html> in different sections ([Section 4](#), [Section 5](#), [Section 6](#)).

B.5. Changes from [draft-gont-tcpm-urgent-data-01](#)

- o Draft resubmitted as [draft-ietf](#), as a result of wg consensus on adopting the document as a tcpm wg item.

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