Network Working Group   S. Bradner
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Updates: 2544 (if approved)   K. Dubray
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Expires: March 22, 2013   J. McQuaid
                                                         Turnip Video
                                                           A. Morton
                                                            AT&T Labs
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RFC 2544 Applicability Statement:
Use on Production Networks Considered Harmful
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Abstract

   Benchmarking Methodology Working Group (BMWG) has been developing key
   performance metrics and laboratory test methods since 1990, and
   continues this work at present. The methods described in RFC 2544
   are intended to generate traffic that overloads network device
   resources in order to assess their capacity. Overload of shared
   resources would likely be harmful to user traffic performance on a
   production network, and there are further negative consequences
   identified with production application of the methods. This memo
   clarifies the scope of RFC 2544 and other IETF BMWG benchmarking work
   for isolated test environments only, and encourages new standards
   activity for measurement methods applicable outside that scope.

Status of this Memo

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Table of Contents

1. Introduction

   This memo clarifies the scope and use of IETF Benchmarking
   Methodology Working Group (BMWG) tests including [RFC2544], which
   discusses and defines several tests that may be used to characterize
   the performance of a network interconnecting device. All readers of
   this memo must read and fully understand [RFC2544].

   Benchmarking methodologies (beginning with [RFC2544]) have always
   relied on test conditions that can only be produced and replicated
   reliably in the laboratory. These methodologies are not appropriate
   for inclusion in wider specifications such as:

   1. Validation of telecommunication service configuration, such as
       the Committed Information Rate (CIR).

   2. Validation of performance metrics in a telecommunication Service
       Level Agreement (SLA), such as frame loss and latency.

   3. Telecommunication service activation testing, where traffic that
       shares network resources with the test might be adversely
       affected.

   Above, we distinguish "telecommunication service" (where a network
   service provider contracts with a customer to transfer information
   between specified interfaces at different geographic locations) from
   the generic term "service". Below, we use the adjective "production"
   to refer to networks carrying live user traffic. [RFC2544] used the
   term "real-world" to refer to production networks and to
   differentiate them from test networks.

   Although RFC 2544 has been held up as the standard reference for such
   testing, we believe that the actual methods used vary from [RFC2544]
   in significant ways. Since the only citation is to [RFC2544], the
   modifications are opaque to the standards community and to users in
   general.

   Since applying the test traffic and methods described in [RFC2544] on
   a production network risks causing overload in shared resources there
   is direct risk of harming user traffic if the methods are misused in
   this way. Therefore, IETF BMWG developed this Applicability
   Statement for [RFC2544] to directly address the situation.

1.1. Requirements Language

   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. Scope and Goals

   This memo clarifies the scope of [RFC2544] with the goal to provide
   guidance to the industry on its applicability, which is limited to
   laboratory testing.

3. The Concept of an Isolated Test Environment

   An Isolated Test Environment (ITE) used with [RFC2544] methods (as
   illustrated in Figures 1 through 3 of [RFC2544]) has the ability to:

   o contain the test streams to paths within the desired set-up

   o prevent non-test traffic from traversing the test set-up

   These features allow unfettered experimentation, while at the same
   time protecting lab equipment management/control LANs and other
   production networks from the unwanted effects of the test traffic.

4. Why RFC 2544 Methods are intended only for ITE

   The following sections discuss some of the reasons why [RFC2544]
   methods are applicable only for isolated laboratory use, and the
   consequences of applying these methods outside the lab environment.

4.1. Experimental Control and Accuracy

   All of the tests described in RFC 2544 require that the tester and
   device under test are the only devices on the networks that are
   transmitting data. The presence of other traffic (unwanted on the
   ITE network) would mean that the specified test conditions have not
   been achieved and flawed results are a likely consequence.

   If any other traffic appears and the amount varies over time, the
   repeatability of any test result will likely depend to some degree on
   the amount and variation of the other traffic.

   The presence of other traffic makes accurate, repeatable, and
   consistent measurements of the performance of the device under test
   very unlikely, since the complete details of test conditions will not
   be reported.

   For example, the RFC 2544 Throughput Test attempts to characterize a
   maximum reliable load, thus there will be testing above the maximum
   that causes packet/frame loss. Any other sources of traffic on the
   network will cause packet loss to occur at a tester data rate lower

than the rate that would be achieved without the extra traffic.

4.2. Containing Damage

[RFC2544] methods, specifically to determine Throughput as defined in
[RFC1242] and other benchmarks, may overload the resources of the
device under test, and may cause failure modes in the device under
test. Since failures can become the root cause of more wide-spread
failure, it is clearly desirable to contain all test traffic within
the ITE.

In addition, such testing can have a negative effect on any traffic
that shares resources with the test stream(s) since, in most cases,
the traffic load will be close to the capacity of the network links.

Appendix C.2.2 of [RFC2544] (as adjusted by errata) gives the private
IPv4 address range for testing:

"...The network addresses 198.18.0.0 through 198.19.255.255 have been
assigned to the BMWG by the IANA for this purpose. This assignment
was made to minimize the chance of conflict in case a testing device
were to be accidentally connected to part of the Internet. The
specific use of the addresses is detailed below."

In other words, devices operating on the Internet may be configured
to discard any traffic they observe in this address range, as it is
intended for laboratory ITE use only. Thus, if testers using the
assigned testing address ranges are connected to the Internet and
test packets are forwarded across the Internet, it is likely that the
packets will be discarded and the test will not work.

We note that a range of IPv6 addresses has been assigned to BMWG for
laboratory test purposes, in [RFC5180] (as amended by errata).

See the Security Considerations Section below for further
considerations on containing damage.

5. Advisory on RFC 2544 Methods in Production Networks

The tests in [RFC2544] were designed to measure the performance of
network devices, not of networks, and certainly not production
networks carrying user traffic on shared resources. There will be
undesirable consequences when applying these methods outside the
isolated test environment.

One negative consequence stems from reliance on frame loss as an
indicator of resource exhaustion in [RFC2544] methods. In practice,

link-layer and physical-layer errors prevent production networks from
operating loss-free. The [RFC2544] methods will not correctly assess
Throughput when loss from uncontrolled sources is present. Frame
loss occurring at the SLA levels of some networks could affect every
iteration of Throughput testing (when each step includes sufficient
packets to experience facility-related loss). Flawed results waste
the time and resources of the testing service user and of the service
provider when called to dispute the measurement. These are
additional examples of harm that compliance with this advisory should
help to avoid. See the Appendix for an example.

The methods described in [RFC2544] are intended to generate traffic
that overloads network device resources in order to assess their
capacity. Overload of shared resources would likely be harmful to
user traffic performance on a production network. These tests MUST
NOT be used on production networks and as discussed above. The tests
will not produce a reliable or accurate benchmarking result on a
production network.

[RFC2544] methods have never been validated on a network path, even
when that path is not part of a production network and carrying no
other traffic. It is unknown whether the tests can be used to
measure valid and reliable performance of a multi-device, multi-
network path. It is possible that some of the tests may prove valid
in some path scenarios, but that work has not been done or has not
been shared with the IETF community. Thus, such testing is contra-
indicated by the BMWG.

6. Considering Performance Testing in Production Networks

The IETF has addressed the problem of production network performance
measurement by chartering a different working group: IP Performance
Metrics (IPPM). This working group has developed a set of standard
metrics to assess the quality, performance, and reliability of
Internet packet transfer services. These metrics can be measured by
network operators, end users, or independent testing groups. We note
that some IPPM metrics differ from RFC 2544 metrics with similar
names, and there is likely to be confusion if the details are
ignored.

IPPM has not yet standardized methods for raw capacity measurement of
Internet paths. Such testing needs to adequately consider the strong
possibility for degradation to any other traffic that may be present
due to congestion. There are no specific methods proposed for
activation of a packet transfer service in IPPM at this time. Thus,
individuals who need to conduct capacity tests on production networks
should actively participate in standards development to ensure their

methods receive appropriate industry review and agreement, in the
IETF or in alternate standards development organizations.

Other standards may help to fill gaps in telecommunication service
testing. For example, the IETF has many standards intended to assist
with network operation, administration and maintenance (OAM), and
ITU-T Study Group 12 has a Recommendation on service activation test
methodology [Y.1564].

The world will not spin off axis while waiting for appropriate and
standardized methods to emerge from the consensus process.

7. Security Considerations

This Applicability Statement intends to help preserve the security of
the Internet by clarifying that the scope of [RFC2544] and other BMWG
memos are all limited to testing in a laboratory ITE, thus avoiding
accidental Denial of Service attacks or congestion due to high
traffic volume test streams.

All Benchmarking activities are limited to technology
characterization using controlled stimuli in a laboratory
environment, with dedicated address space and the other constraints
[RFC2544].

The benchmarking network topology will be an independent test setup
and MUST NOT be connected to devices that may forward the test
traffic into a production network, or misroute traffic to the test
management network.

Further, benchmarking is performed on a "black-box" basis, relying
solely on measurements observable external to the device under test/
system under test (DUT/SUT).

Special capabilities SHOULD NOT exist in the DUT/SUT specifically for
benchmarking purposes. Any implications for network security arising
from the DUT/SUT SHOULD be identical in the lab and in production
networks.

8. IANA Considerations

This memo makes no requests of IANA.

9. Acknowledgements

   Thanks to Matt Zekauskas, Bill Cerveny, Barry Constantine, Curtis
   Villamizar, David Newman, and Adrian Farrel for suggesting
   improvements to this memo.

   Specifically, Al Morton would like to thank his co-authors, who
   constitute the complete set of Chairmen-Emeritus of the BMWG, for
   returning from other pursuits to develop this statement and see it
   through to approval. This has been a rare privilege; one that likely
   will not be matched in the IETF again:

      Scott Bradner   served as Chairman from 1990 to 1993
      Jim McQuaid   served as Chairman from 1993 to 1995
      Kevin Dubray   served as Chairman from 1995 to 2006

   It's all about the band.

10. Appendix - Example of RFC 2544 method failure in production network
     measurement

   This Appendix provides an example illustrating how [RFC2544] methods
   applied on production networks can easily produce a form of harm from
   flawed and misleading results.

   The [RFC2544] Throughput benchmarking method usually includes the
   following steps:

   a. Set the offered traffic level, less than max of the ingress
   link(s).

   b. Send the test traffic through the device under test (DUT) and
   count all frames successfully transferred.

   c. If all frames are received, increment traffic level and repeat
   step b.

   d. If one or more frames are lost, the level is in the DUT-overload
   region (Step b may be repeated at a reduced traffic level to more
   exactly determine the maximum rate at which none of the frames are
   dropped by the DUT, defined as the Throughput [RFC1242]).

   e. Report the Throughput values, the x-y of graph of frame size and
   Throughput, and other information in accordance with [RFC2544].

   In this method, frame loss is the sole indicator of overload and
   therefore the determining factor in the measurement of Throughput

using the [RFC2544] methodology (even though the results may not
report frame loss per se).

Frame loss is subject to many factors in addition to operating above
the Throughput traffic level. These factors include optical
interference (which may be due to dirty interfaces, cross-over from
other signals, fiber bend and temperature, etc.) and electrical
interference (caused by local sources of radio signals, electrical
spikes, solar particles, etc.). In the laboratory environment many
of these issues can be carefully controlled through cleaning and
isolation. Since [RFC2544] methodologies are primarily intended to
test devices and not paths, the total length of path, the number of
interfaces, and compound risk of random frame loss can be kept to a
minimum.

In a production network, however, there will be many interfaces and
many kilometres of path under test. This considerably increases the
risk of random frame loss.

The risk of frame loss caused by outside effects is significantly
higher in production networks, and significantly higher with long
paths (both those with long physical path lengths, and those with
large numbers of interfaces in the path). Thus, the risk of falsely
low reported Throughput using an [RFC2544] methodology test is
considerably increased in a production network.

Therefore, to successfully conduct tests with similar objectives to
those in [RFC2544] in a production network, it will be necessary to
develop modifications to the methodologies defined in [RFC2544] and
standards to describe them.

11. References

11.1. Normative References

[RFC1242]   Bradner, S., "Benchmarking terminology for network
            interconnection devices", RFC 1242, July 1991.

[RFC2119]   Bradner, S., "Key words for use in RFCs to Indicate
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[RFC2544]   Bradner, S. and J. McQuaid, "Benchmarking Methodology for
            Network Interconnect Devices", RFC 2544, March 1999.

[RFC5180]   Popoviciu, C., Hamza, A., Van de Velde, G., and D.
            Dugatkin, "IPv6 Benchmarking Methodology for Network
            Interconnect Devices", RFC 5180, May 2008.

11.2. Informative References

   [Y.1564]   ITU-T Recommendation Y.1564, "Ethernet Service Activation
               Test Methodology", March 2011.

Authors' Addresses

   Scott Bradner
   Harvard University
   29 Oxford St.
   Cambridge, MA 02138
   USA

   Phone: +1 617 495 3864
   Fax:
   Email: sob@harvard.edu
   URI: http://www.sobco.com

   Kevin Dubray
   Juniper Networks

   Phone:
   Fax:
   Email: kdubray@juniper.net
   URI:

   Jim McQuaid
   Turnip Video
   6 Cobbleridge Court
   Durham, North Carolina 27713
   USA

   Phone: +1 919-619-3220
   Fax:
   Email: jim@turnipvideo.com
   URI: www.turnipvideo.com

    Al Morton
    AT&T Labs
    200 Laurel Avenue South
    Middletown,, NJ 07748
    USA

    Phone: +1 732 420 1571
    Fax: +1 732 368 1192
    Email: acmorton@att.com
    URI: http://home.comcast.net/~acmacm/