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R. Bonica  
Juniper Networks  
S. Bryant  
Cisco Systems  
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RFC2544 Testing in Production Networks  
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## Abstract

This document considers the use of [RFC2544](#) type tests in an production network.

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Internet-Draft [RFC2544](#) Testing in Production Networks

October 2012

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[1.](#) Conventions used in the document

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 [RFC2119](#) [[RFC2119](#)].

[2.](#) Introduction

This document considers the issues related to conducting tests similar to [RFC2544](#) [[RFC2544](#)] in a production network.

[3.](#) Cautious of [RFC2544](#) in Production Networks

Some types of production network offer a high degree of assured isolation between the traffic of different users. An example of a network technique that provides this isolation is a pseudowire [[RFC3985](#)]. Some types of network, known as transport networks [[RFC5921](#)] are traffic engineered to the point where there is normally no resource contention between user traffic. The incautious use of unmodified [RFC2544](#) testing is NOT RECOMMENDED [[RFC2544](#)]. However provided suitable appropriate caution is applied the existing [RFC2544](#) tests may provide some useful information on the behaviour of such a network.

When using unmodified [RFC2544](#) tests on such a network the tester needs to be aware that the latency and latency variation will be significantly higher than in a laboratory environment, and that error rate and hence packet loss may be higher than in a laboratory environment. It is therefore necessary to repeat tests a number of times to be confident of the results and to present the outcome in a statistical rather than definitive form. It is also necessary to note that the results represent the behaviour of the system and network at the time of measurement and may not represent the behaviour at some other time in the past or in the future.

Unmodified [RFC2544](#) tests MUST NOT be conducted on a production network unless the tester is confident that the required degree of resource isolation is in place such that the tests will not be harmful to the network itself, other user traffic, or the performance applications using the network as a data path.

#### [4.](#) Real World

The following text does not seem useful as it is self evident and thus I propose to delete the section.

#### [2. Real world

In producing this document the authors attempted to keep in mind the requirement that apparatus to perform the described tests must actually be built. We do not know of "off the shelf" equipment available to implement all of the tests but it is our opinion that such equipment can be constructed.]

#### [5.](#) Test To Be Run

The advice in [\[RFC2544\] Section 3](#) regarding the applicability and usefulness of the tests applies to the situation considered in this document

#### [6.](#) Evaluating the Results

As noted in [RFC2544](#) [\[RFC2544\] Section 4](#) the test will produce a great deal of data, more so in the case when the tests are conducted on a production network, since it is advisable to repeat the tests to ensure that the results are statically representative of the behaviour of the devices and network path at the time of the test. In particular behavior such as latency variation or packet loss needs to be properly characterised. Automation of the instrumentation and improvements in display and visualization since [RFC2544](#) was written should assist with this.

As noted in [RFC2544](#) the selection of the to be run and evaluation of

the test data must therefore be done with an understanding of generally accepted testing practices regarding repeatability, variance, the statistical significance of small numbers of trials and the nature of the production network.

## 7. Requirements

An implementation is not compliant if it fails to satisfy one or more of the MUST requirements for the protocols it implements. An implementation that satisfies all the MUST and all the SHOULD requirements for its protocols is said to be "unconditionally compliant"; one that satisfies all the MUST requirements but not all the SHOULD requirements for its protocols is said to be "conditionally compliant".

## 8. The Test Set Up

There are two cases to be considered when setting up a test. The first case is where the production network is providing an emulated physical or datalink service such as a pseudowire, and this service is the subject of the test. This is similar to the case shown in Figure 2 of [[RFC2544](#)] , noting that either the service emulation will need to be put in loopback, or a second service will need to be provisioned to return the test traffic to the tester.

The second case concerns where it is desired to determine the performance of a system that is handing off packets a packet equipment such as a Router (or a label switched router (LSR)), such as when testing a virtual private network (VPN) service. This is similar to the case shown in Figure 3 of [RFC2544](#).

In both cases it should be noted that measurements taken will be subject to impairment on both the outward path and the return path, and that it is not possible to easily determine the degree of impairment attributable to each path. It will be the case that the path that is the subject of the test will, other than under pathological conditions, exhibit a performance that is at least as

good as the measurements taken.

## 9. DUT set up

The advice in [section 7 of \[RFC2544\]](#) applies, with the exception that protocols and protocol modes not supported by the production network MUST NOT be configured or tested. The protocol profile tested MUST be included or referenced in ant test report.

## 10. Frame Formats

The advice in [Section 8 of \[RFC2544\]](#) regarding Frame Formats applies. Given the evolution of network technology since 1999, some additional frame formats will be required, but these are out of scope for this document.

## 11. Frame Sizes.

The advice in [Section 9 of \[RFC2544\]](#) regarding frame size should be followed.

Since the publication of [RFC2544](#) the maximum packet size supported on Ethernet [anything else??] has increased with the introduction of

jumbo frames. The set of frame sizes tested SHOULD include the maxium size supported by the network. The maximum size tested MUST be included in the test report. This maximum size may be set by configuration, or may be determined by the tester automatically using a discovery technique. Such a discovery technique should preferable be log n efficient such as a binary chop search. The discovered maximum packet size should be verified a number of times (at least five times is RECOMMENDED) until a consistant result is achieved.

## 12. Verifying received frames

The advice in [Section 10 of \[RFC2544\]](#) SHOULD be followed regarding verification of frames

## 13. Modifiers

The advice in [Section 10 of \[RFC2544\]](#) SHOULD be followed regarding verification of frames

[ We might want to update the following, although that really needs to be aligned with more modern advice on the lab version of this specification

The rest of [section 13](#) to be deleted

It might be useful to know the DUT performance under a number of conditions; some of these conditions are noted below. The reported results SHOULD include as many of these conditions as the test equipment is able to generate. The suite of tests SHOULD be first run without any modifying conditions and then repeated under each of the conditions separately. To preserve the ability to compare the results of these tests any frames that are required to generate the modifying conditions (management queries for example) will be included in the same data stream as the normal test frames in place of one of the test frames and not be supplied to the DUT on a separate network port.

### 11.1 Broadcast frames

In most router designs special processing is required when frames addressed to the hardware broadcast address are received. In bridges (or in bridge mode on routers) these broadcast frames must be flooded to a number of ports. The stream of test frames SHOULD be augmented with 1% frames addressed to the hardware broadcast address. The frames sent to the broadcast address should be of a type that the router will not need to process. The aim of this test is to

determine if there is any effect on the forwarding rate of the other data in the stream. The specific frames that should be used are included in the test frame format document. The broadcast frames SHOULD be evenly distributed throughout the data stream, for example, every 100th frame.

The same test SHOULD be performed on bridge-like DUTs but in this case the broadcast packets will be processed and flooded to all

outputs.

It is understood that a level of broadcast frames of 1% is much higher than many networks experience but, as in drug toxicity evaluations, the higher level is required to be able to gage the effect which would otherwise often fall within the normal variability of the system performance. Due to design factors some test equipment will not be able to generate a level of alternate frames this low. In these cases the percentage SHOULD be as small as the equipment can provide and that the actual level be described in the report of the test results.

## 11.2 Management frames

Most data networks now make use of management protocols such as SNMP. In many environments there can be a number of management stations sending queries to the same DUT at the same time.

The stream of test frames SHOULD be augmented with one management query as the first frame sent each second during the duration of the trial. The result of the query must fit into one response frame. The response frame SHOULD be verified by the test equipment. One example of the specific query frame that should be used is shown in [Appendix C](#).

## 11.3 Routing update frames

The processing of dynamic routing protocol updates could have a significant impact on the ability of a router to forward data frames. The stream of test frames SHOULD be augmented with one routing update frame transmitted as the first frame transmitted during the trial.

Routing update frames SHOULD be sent at the rate specified in [Appendix C](#) for the specific routing protocol being used in the test. Two routing update frames are defined in [Appendix C](#) for the TCP/IP over Ethernet example. The routing frames are designed to change the routing to a number of networks that are not involved in the forwarding of the test data. The first frame sets the routing table state to "A", the second one changes the state to "B". The frames MUST be alternated during the trial.

The test SHOULD verify that the routing update was processed by the

DUT.

#### 11.4 Filters

Filters are added to routers and bridges to selectively inhibit the forwarding of frames that would normally be forwarded. This is usually done to implement security controls on the data that is accepted between one area and another. Different products have different capabilities to implement filters.

The DUT SHOULD be first configured to add one filter condition and the tests performed. This filter SHOULD permit the forwarding of the test data stream. In routers this filter SHOULD be of the form:

forward input\_protocol\_address to output\_protocol\_address

In bridges the filter SHOULD be of the form:

forward destination\_hardware\_address

The DUT SHOULD be then reconfigured to implement a total of 25 filters. The first 24 of these filters SHOULD be of the form:

block input\_protocol\_address to output\_protocol\_address

The 24 input and output protocol addresses SHOULD not be any that are represented in the test data stream. The last filter SHOULD permit the forwarding of the test data stream. By "first" and "last" we mean to ensure that in the second case, 25 conditions must be checked before the data frames will match the conditions that permit the forwarding of the frame. Of course, if the DUT reorders the filters or does not use a linear scan of the filter rules the effect of the sequence in which the filters are input is properly lost.

The exact filters configuration command lines used SHOULD be included with the report of the results.

##### 11.4.1 Filter Addresses

Two sets of filter addresses are required, one for the single filter case and one for the 25 filter case.

The single filter case should permit traffic from IP address 198.18.1.2 to IP address 198.19.65.2 and deny all other traffic.

The 25 filter case should follow the following sequence.

```
deny aa.ba.1.1 to aa.ba.100.1 deny aa.ba.2.2 to aa.ba.101.2 deny
aa.ba.3.3 to aa.ba.103.3 ... deny aa.ba.12.12 to aa.ba.112.12 allow
aa.bc.1.2 to aa.bc.65.1 deny aa.ba.13.13 to aa.ba.113.13 deny
aa.ba.14.14 to aa.ba.114.14 ... deny aa.ba.24.24 to aa.ba.124.24 deny
all else
```

All previous filter conditions should be cleared from the router before this sequence is entered. The sequence is selected to test to see if the router sorts the filter conditions or accepts them in the order that they were entered. Both of these procedures will result in a greater impact on performance than will some form of hash coding.]

#### [14.](#) Protocol Addresses

Where the test traffic is fully isolated from production traffic, for example when running over a PW, the advice in [Section 12 of \[RFC2544\]](#) MAY be followed.

Where the test traffic shares the network with the production traffic, the addresses used MUST be those that are correctly routed to the designated test traffic receiver. Correct routing of this traffic at a low data rate MUST be verified prior to running tests that subject the test receiver to a significant load.

#### [15.](#) Route Set up

Where the test traffic is fully isolated from production traffic, for example when running over a PW, the advice in [Section 12 of \[RFC2544\]](#) MAY be followed.

Where the test traffic shares the network with production traffic, the existing routing protocols SHOULD be used to set up the routed path between the test traffic source and the test traffic destination.

#### [16.](#) Bidirectional traffic

The advice on traffic bidirectionality in [Section 14 of \[RFC2544\]](#) SHOULD be followed.

#### [17.](#) Single Stream Path

The advice on stream selection in [Section 15 of \[RFC2544\]](#) SHOULD be

followed.

#### [18.](#) Multi-port

The advice on exercising the ability of the DUT to concurrently receive packets for the same destination port given in [Section 16 of \[RFC2544\]](#) SHOULD be followed.

#### [19.](#) Multiple Protocols

The advice on multiple protocols given in [Section 17 of \[RFC2544\]](#) SHOULD be followed.

#### [20.](#) Multiple frame sizes

The advice on multiple frame sizes given in [Section 18 of \[RFC2544\]](#) SHOULD be followed.

#### [21.](#) Testing performance beyond a single DUT.

[Section 19 of \[RFC2544\]](#) discusses testing of multiple systems. This is the normal case in a production network. As noted in [RFC2544](#) such tests require care in interpretation. Unlike the laboratory benchmrk case however, the test will be exercising the network in the expected configuration, and thus is representative of the operation of the system with the background traffic load of the time. It is RECOMMENDED that the test be repeated a number of times to gauge the effect of variation of background traffic over both short and long term time frames. The times of the test SHOULD be logged, and the results presented in such a way that the statistical nature of the test be clear to the reviewer. It should be noted whether the type of production network was such that it would or not it would be anticipated that the test would be repeatable within the statistical significance of the measurements.

## [22.](#) Maximum frame rate

The advice on maximum frame rate given in [Section 20 of RFC2544](#) [[RFC2544](#)] SHOULD be followed.

## [23.](#) Bursty Traffic

The advice in [Section 21 of \[RFC2544\]](#) on bursty traffic SHOULD be followed.

Editor's Note Do we need to recomemnd larger burst sizes?

## [24.](#) Rings

[This is probably obselete now - suggest we delete the section

Although it is possible to configure some token ring and FDDI interfaces to transmit more than one frame each time that the token is received, most of the network devices currently available transmit only one frame per token. These tests SHOULD first be performed while transmitting only one frame per token.

Some current high-performance workstation servers do transmit more than one frame per token on FDDI to maximize throughput. Since this may be a common feature in future workstations and servers, interconnect devices with FDDI interfaces SHOULD be tested with 1, 4, 8, and 16 frames per token. The reported frame rate SHOULD be the average rate of frame transmission over the total trial period.]

## [25.](#) Trial description

If the prodcuton network is providing a layer 1 or layer 2 service, then the test may be conducted as described in [Section 23 of \[RFC2544\]](#). If the production network is providing a layer 3 service care MUST be taken to ensure that any routes intruduced may be safely

announced by the DUT without causing disruption to production traffic, and at such a volume that the route processors in the production network are not overloaded.

## [26.](#) Trial duration

The advice in [Section 24 of \[RFC2544\]](#) on trial duration is applicable.

## [27.](#) Address resolution

As stated in [Section 25 of \[RFC2544\]](#), the DUT SHOULD be able to respond to address resolution requests sent by the DUT wherever the protocol requires such a process.

## [28.](#) Benchmarking tests

### [28.1.](#) Throughput

The throughput test described in [Section 26.1 of \[RFC2544\]](#) applies. However the reporting of a single number is NOT RECOMMENDED. If a single is reported, it must be measured at a time during the busy period, and the value of the lower decile SHOULD be reported.

### [28.2.](#) Latency

The latency testing described in [Section 26.1 of \[RFC2544\]](#) applies. Measurements SHOULD be carried out during the busy period. The statistical averaging approach is for further study.

### [28.3.](#) Frame loss rate

The frame loss procedure described in [Section 26.3 of \[RFC2544\]](#) is modified as follows:

The test should be repeated a number of times at each frame rate. The number of repeats SHOULD be configured by the tester and reported with the results. The default value is 10 (pulled out of a hat). The exit criteria of loss free transmissions SHOULD be configured by the tester and reported with the results. The default value is 10

(also pulled out of a hat).

#### [28.4.](#) Back-to-back frames

The advice on back-to-back frames provided in [Section 26.4 of \[RFC2544\]](#) applies.

#### [28.5.](#) System Recovery

The advice on system recovery frames provided in [Section 26.5 of \[RFC2544\]](#) applies.

#### [28.6.](#) Reset

The advice provided in [Section 26.6 of \[RFC2544\]](#) on reset SHOULD be followed, except that the test MUST NOT be carried out on a DUT that is being used for production traffic unless a specific decision is made that disruption of the user traffic is acceptable. This test MAY be carried out during the quiet period.

#### [29.](#) IANA considerations

There are no IANA considerations which arise from this document.

#### [30.](#) Security considerations

To be provided in a future version.

#### [31.](#) Acknowledgments

The Authors of [\[RFC2544\]](#) are acknowledged.

#### [32.](#) Informative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate

Requirement Levels", [BCP 14](#), [RFC 2119](#), March 1997.

- [RFC2544] Bradner, S. and J. McQuaid, "Benchmarking Methodology for Network Interconnect Devices", [RFC 2544](#), March 1999.
- [RFC3985] Bryant, S. and P. Pate, "Pseudo Wire Emulation Edge-to-Edge (PWE3) Architecture", [RFC 3985](#), March 2005.
- [RFC5921] Bocci, M., Bryant, S., Frost, D., Levrau, L., and L. Berger, "A Framework for MPLS in Transport Networks", [RFC 5921](#), July 2010.

## [Appendix A](#). Testing Considerations

This Appendix will be deleted or updated in next version. Text is a copy of [Appendix A of \[RFC2544\]](#)

### A.1 Scope Of This [Appendix](#)

[This](#) appendix discusses certain issues in the benchmarking methodology where experience or judgment may play a role in the tests selected to be run or in the approach to constructing the test with a particular DUT. As such, this [appendix](#) **MUST** not be read as an amendment to the methodology described in the body of this document but as a guide to testing practice.

1. Typical testing practice has been to enable all protocols to be tested and conduct all testing with no further configuration of protocols, even though a given set of trials may exercise only one

protocol at a time. This minimizes the opportunities to "tune" a DUT for a single protocol.

2. The least common denominator of the available filter functions should be used to ensure that there is a basis for comparison between vendors. Because of product differences, those conducting and evaluating tests must make a judgment about this issue.

3. Architectural considerations may need to be considered. For example, first perform the tests with the stream going between ports on the same interface card and then repeat the tests with the stream

going into a port on one interface card and out of a port on a second interface card. There will almost always be a best case and worst case configuration for a given DUT architecture.

4. Testing done using traffic streams consisting of mixed protocols has not shown much difference between testing with individual protocols. That is, if protocol A testing and protocol B testing give two different performance results, mixed protocol testing appears to give a result which is the average of the two.

5. Wide Area Network (WAN) performance may be tested by setting up two identical devices connected by the appropriate short-haul versions of the WAN modems. Performance is then measured between a LAN interface on one DUT to a LAN interface on the other DUT.

The maximum frame rate to be used for LAN-WAN-LAN configurations is a judgment that can be based on known characteristics of the overall system including compression effects, fragmentation, and gross link speeds. Practice suggests that the rate should be at least 110% of the slowest link speed. Substantive issues of testing compression itself are beyond the scope of this document.]

#### [Appendix B](#). Maximum frame rates refer

This Appendix will be updated looks updated in next version. Text is a copy of [Appendix B of \[RFC2544\]](#)

(Provided by Roger Beeman, Cisco Systems)

Size Ethernet 16Mb Token Ring FDDI (bytes) (pps) (pps) (pps)

64	14880	24691	152439	128	8445	13793	85616	256	4528	7326	45620	512
2349	3780	23585	768	1586	2547	15903	1024	1197	1921	11996	1280	961
1542	9630	1518	812	1302	8138							

Ethernet size Preamble 64 bits Frame 8 x N bits Gap 96 bits

16Mb Token Ring size SD 8 bits AC 8 bits FC 8 bits DA 48 bits SA 48 bits RI 48 bits ( 06 30 00 12 00 30 ) SNAP DSAP 8 bits SSAP 8 bits Control 8 bits Vendor 24 bits Type 16 bits Data 8 x ( N - 18 ) bits FCS 32 bits ED 8 bits FS 8 bits

Tokens or idles between packets are not included

FDDI size Preamble 64 bits SD 8 bits FC 8 bits DA 48 bits SA 48 bits SNAP

DSAP 8 bits SSAP 8 bits Control 8 bits Vendor 24 bits Type 16 bits  
Data 8 x ( N - 18) bits FCS 32 bits ED 4 bits FS 12 bits

## [Appendix C](#). Test Frame Formats

The considerations provided in Appendix C of [[RFC2544](#)] apply.

The requirement for any new frame formats will be considered in a future version.

### Authors' Addresses

Ronald Bonica  
Juniper Networks

Email: [rbonica@juniper.net](mailto:rbonica@juniper.net)

Stewart Bryant  
Cisco Systems  
Green Park, 250, Longwater Avenue,  
Reading RG2 6GB  
UK

Email: [stbryant@cisco.com](mailto:stbryant@cisco.com)