                 IMIX Genome: Specification of Variable Packet Sizes
                            for Additional Testing

Abstract

   Benchmarking methodologies have always relied on test conditions with
   constant packet sizes, with the goal of understanding what network
   device capability has been tested. Tests with a constant packet size
   reveal device capabilities but differ significantly from the
   conditions encountered in operational deployment, so additional tests
   are sometimes conducted with a mixture of packet sizes, or "IMIX"
   ("Internet Mix"). The mixture of sizes a networking device will
   encounter is highly variable and depends on many factors. An IMIX
   suited for one networking device and deployment will not be
   appropriate for another. However, the mix of sizes may be known, and
   the tester may be asked to augment the fixed-size tests. To address
   this need and the perpetual goal of specifying repeatable test
   conditions, this document defines a way to specify the exact
   repeating sequence of packet sizes from the usual set of fixed sizes
   and from other forms of mixed-size specification.

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Table of Contents

1. Introduction

   This memo defines a method to unambiguously specify the sequence of
   packet sizes used in a load test.

   Benchmarking methodologies [RFC2544] have always relied on test
   conditions with constant packet sizes, with the goal of understanding
   what network device capability has been tested. Tests with the
   smallest size stress the header processing capacity, and tests with
   the largest size stress the overall bit-processing capacity. Tests
   with sizes in between may determine the transition between these two
   capacities.

   Streams of constant packet size differ significantly from the
   conditions encountered in operational deployment, so additional tests
   are sometimes conducted with a mixture of packet sizes. The set of
   sizes used is often called an Internet Mix, or "IMIX" [Spirent]
   [IXIA] [Agilent].

   The mixture of sizes a networking device will encounter is highly
   variable and depends on many factors. An IMIX suited for one
   networking device and deployment will not be appropriate for another.
   However, the mix of sizes may be known, and the tester may be asked
   to augment the fixed-size tests. The references above cite the
   original studies and their methodologies. Similar methods can be
   used to determine new size mixes present on a link or network. We
   note that the architecture for IP Flow Information Export [RFC5470]
   provides one method to gather packet-size information on private
   networks.

   To address this need and the perpetual goal of specifying repeatable
   test conditions, this memo proposes a way to specify the exact
   repeating sequence of packet sizes from the usual set of fixed sizes:
   the IMIX Genome. Other, less exact forms of size specification are
   also recommended for extremely complicated or customized size mixes.
   We apply the term "genome" to infer that the entire test packet-size
   sequence can be replicated if this information is known -- a parallel
   to the information needed for biological replication.

   This memo takes the position that it cannot be proven for all
   circumstances that the sequence of packet sizes does not affect the
   test result; thus, a standardized specification of sequence is
   valuable.

2. 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].

3. Scope and Goals

   This memo defines a method to unambiguously specify the sequence of
   packet sizes that have been used in a load test, assuming that a
   relevant mix of sizes is known to the tester and the length of the
   repeating sequence is not very long (<100 packets).

   The IMIX Genome will allow an exact sequence of packet sizes to be
   communicated as a single-line name, resolving the current ambiguity
   with results that simply refer to "IMIX". This aspect is critical
   because no ability has been demonstrated to extrapolate results from

one IMIX to another IMIX -- and certainly no ability to extrapolate
results to other circumstances -- even when the mix varies only
slightly from another IMIX.

While documentation of the exact sequence is ideal, the memo also
covers the case where the sequence of sizes is very long or may be
generated by a pseudorandom process.

It is a colossal non-goal to standardize one or more versions of the
IMIX. This topic has been discussed on many occasions on the BMWG
mailing list [IMIXonList]. The goal is to enable customization with
minimal constraints while fostering repeatable testing once the
fixed-size testing is complete. Thus, the requirements presented in
this specification, expressed in [RFC2119] terms, are intended for
those performing/reporting laboratory tests to improve clarity and
repeatability.

4. Specification of the IMIX Genome

The IMIX Genome is specified in the following format:

IMIX - 123456...x

where each number is replaced by the letter corresponding to the size
of the packet at that position in the sequence. The following table
gives the letter encoding for the [RFC2544] standard sizes (64, 128,
256, 512, 1024, 1280, and 1518 bytes) and "jumbo" sizes (2112, 9000,
and 16000 bytes). Note that the 4-octet Ethernet frame check
sequence may fail to detect bit errors in the larger jumbo frames
[Jumbo1] [Jumbo2].

```
             +--------------+--------------------+
             | Size (Bytes) | Genome Code Letter |
             +--------------+--------------------+
             | 64           | a                  |
             | 128          | b                  |
             | 256          | c                  |
             | 512          | d                  |
             | 1024         | e                  |
             | 1280         | f                  |
             | 1518         | g                  |
             | 2112         | h                  |
             | 9000         | i                  |
             | 16000        | j                  |
             | MTU          | z                  |
             +--------------+--------------------+
```

For example, a five-packet sequence with sizes 64,64,64,1280,1518
would be designated:

IMIX - aaafg

If z (MTU) is used, the tester MUST specify the length of the MTU in
the report.

While this approach allows some flexibility, there are also
constraints.

o Packet sizes not defined by RFC 2544 would need to be approximated
   by those available in the table.

o The genome for very long sequences can become undecipherable by
   humans.

Some questions testers must ask and answer when using the IMIX Genome
are:

1. Multiple source-destination address pairs: Is the IMIX sequence
    applicable to each pair, across multiple pairs in sets, or across
    all pairs?

2. Multiple tester ports: Is the IMIX sequence applicable to each
    port, across multiple ports in sets, or across all ports?

The chosen configuration would be expressed in the following general
form:

```
+------------------+-----------------------+--------------------+
| Source Address + | Destination Address + | Corresponding IMIX |
| Port AND/OR Blade | Port AND/OR Blade    |                    |
+------------------+-----------------------+--------------------+
| x.x.x.x Blade2   | y.y.y.y Blade3        | IMIX - aaafg       |
+------------------+-----------------------+--------------------+
```

where testers can specify the IMIX used between any two entities in
the test architecture (and "Blade" is a component in a multi-
component device chassis).

5. Specification of a Custom IMIX

   This section describes how to specify an IMIX with locally selected
   packet sizes.

   The custom IMIX is specified in the following format:

   CUSTOM IMIX - 123456...x

   where each number is replaced by the letter corresponding to the size
   of the packet at that position in the sequence. The tester MUST
   complete the following table, giving the letter encoding for each
   size used, where each set of three lower-case letters would be
   replaced by the integer size in octets.

```
                +-------------+-------------------+
                | Size (Bytes) | Custom Code Letter |
                +-------------+-------------------+
                | aaa         | A                 |
                | bbb         | B                 |
                | ccc         | C                 |
                | ddd         | D                 |
                | eee         | E                 |
                | fff         | F                 |
                | ggg         | G                 |
                | etc.        | up to Z           |
                +-------------+-------------------+
```

   For example, a five-packet sequence with sizes
   aaa=64,aaa=64,aaa=64,ggg=1020,ggg=1020 would be designated:

   CUSTOM IMIX - AAAGG

6. Reporting Long or Pseudorandom Packet Sequences

   When the IMIX Genome cannot be used (when the sheer length of the
   sequence would make the genome unmanageable), five options are
   possible, as noted in the following subsections.

6.1. Run-Length Encoding

   When a sequence can be decomposed into a series of short repeating
   sequences, then a run-length encoding approach MAY be specified as
   shown in the table below (using the single lower-case letter Genome
   Codes from Section 4):

```
         +-----------------------------+----------------------+
         | Count of Repeating Sequences | Packet-Size Sequence |
         +-----------------------------+----------------------+
         | 20                          | abcd                 |
         | 5                           | ggga                 |
         | 10                          | dcba                 |
         +-----------------------------+----------------------+
```

   The run-length encoding approach is also applicable to the custom
   IMIX as described in Section 5 (where the single upper-case letter
   Genome Codes would be used instead).

6.2. Table of Proportions

   When the sequence is designed to vary within some proportional
   constraints, a table simply giving the proportions of each size MAY
   be used instead.

```
         +-----------+--------------------+--------------------------+
         | IP Length | Percentage of Total | Length(s) at Other Layers |
         +-----------+--------------------+--------------------------+
         | 64        | 23                 | 82                       |
         | 128       | 67                 | 146                      |
         | 1000      | 10                 | 1018                     |
         +-----------+--------------------+--------------------------+
```

   Note that the table of proportions also allows non-standard packet
   sizes but trades the short genome specification and ability to
   specify the exact sequence for other flexibilities.

6.3. Deterministic Algorithm

   If a deterministic packet-size generation method is used (such as a
   monotonic increase by 1 octet from start value to MTU), then the
   generation algorithm SHOULD be reported.

6.4. Pseudorandom Length Algorithm

   If a pseudorandom length generation capability is used, then the
   generation algorithm SHOULD be reported with the results along with
   the seed value used. We also recognize the opportunity to randomize
   inter-packet spacing from a test sender as well as the size, and both
   spacing and length pseudorandom generation algorithms and seeds
   SHOULD be reported when used.

6.5. Pseudorandom Sequence Algorithm

   Finally, we note another possibility: a pseudorandom sequence
   generates an index to the table of packet lengths, and the generation
   algorithm SHOULD be reported with the results, along with the seed
   value if used.

7. Security Considerations

   Benchmarking activities as described in this memo are limited to
   technology characterization using controlled stimuli in a laboratory
   environment, with dedicated address space and 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
   (DUT) or System Under Test (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. Acknowledgements

   Thanks to Sarah Banks, Aamer Akhter, Steve Maxwell, and Scott Bradner
   for their reviews and comments. Ilya Varlashkin suggested the
   run-length encoding approach in Section 6.1.

9. References

9.1. Normative References

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