SPIRENT Communications

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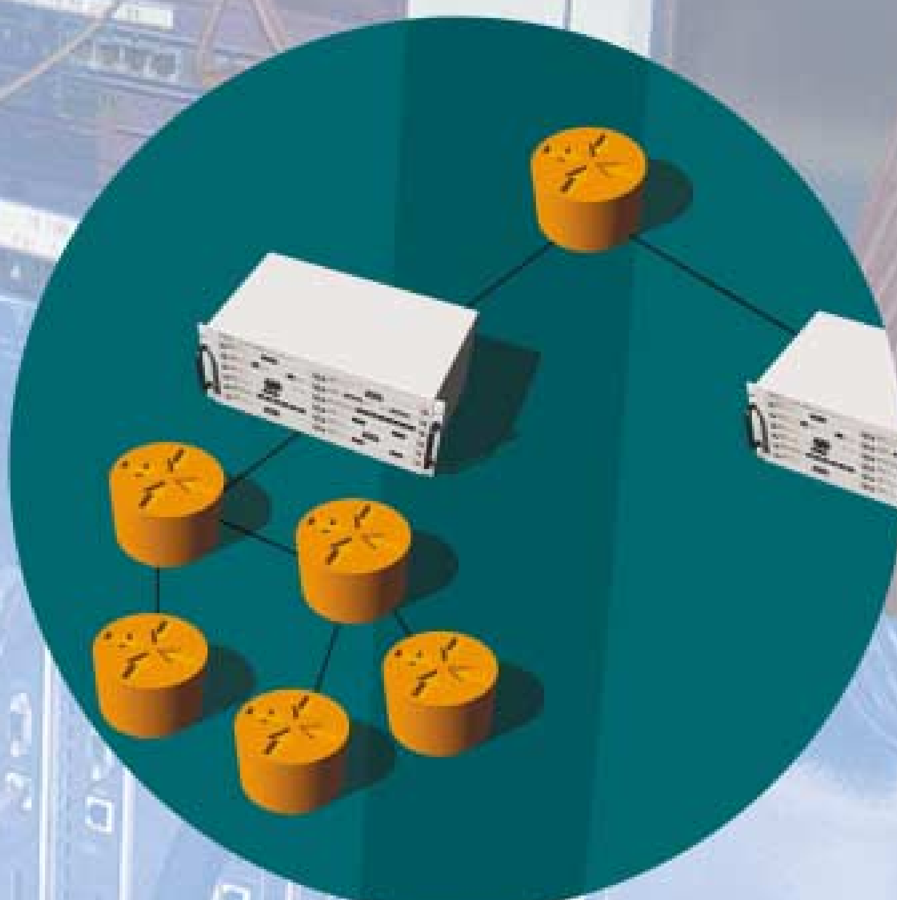
# Test Methodology Journal

## IMIX (Internet Mix) Journal

**March 2006**



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## IMIX (Internet Mix) Journal

# Overview

While IMIX, short for Internet Mix, is not officially defined by a standards organization, it has become an increasingly popular concern in the networking test arena. Its origins are derived in part out of a need to identify and simulate Internet network traffic according to frame size usage. Network performance in terms of throughput, latency, and packet loss can vary greatly depending on the traffic mix, thereby affecting the effectiveness of computer applications and ultimately the end user experience. Studies indicate that Internet traffic consists of fixed percentages of different frame sizes at a given point and time.
For example, according to the publication “Trends in Wide Area IP Traffic Patterns -A View from Ames Internet Exchange”, from Cooperative Association for Internet Data Analysis (CAIDA)[1], the majority of the packets seen were one of three sizes:

- 40 byte packets (the minimum packet size for TCP), which carry TCP acknowledgments but no payload
- 1500 byte packets (the maximum Ethernet payload size) from TCP implementations that use path MTU discovery
- 552 byte and 576 byte packets from TCP implementations that do not use path MTU discovery

Note that these are frame sizes that exclude the 18-byte Ethernet header.

In February 2001 the Measurement & Operations Analysis Team with the National Library for Applied Network Research (NLANR) provided results of Internet data they collected as part of a project with the National Science Foundation NLARR. This data is representative of general Internet consumption at the time of data collection. Data collected since then, and by other organizations, may be more reflective of certain types of user traffic. In any case, while there is no discreet set of IMIX frames sizes, the general notion is that modeled data can be used to approximate the distribution observed for real Internet traffic.
Through sampling, organizations can measure the makeup of Internet traffic and determine what mixture of frame sizes occur at different points on the network for a given period of time. Alternatively, some other usage/transmission pattern of certain frame sizes relative to one another can be used based on a “prescription” of frame sizes through other sources.

## Correlation Value

IMIX simulation may include a handful of the most popular frame sizes. For completeness and better accuracy, the mix may be expanded to include more, even dozens, of frame sizes, including a random range of frame sizes with a minimum and maximum frame size boundary.

The degree to which the packet mix correlates to a given Internet mix has been categorized with terms such as “simple” and “complete”. With more coverage of specific frame sizes and their ratios, the more likely the higher correlation value. For example, a “simple” mix with only a few frame sizes may correlate to an observed Internet mix with a factor of .883. A “complete” mix with more frame sizes could have a factor of .984. An even more granular mix that contains even more frame sizes, along a random range of sizes, may have a correlation factor of .999, and provide the most accurate simulation.

Mixes that promote the largest correlation factor typically contain more frame sizes, and a random frame size range compared to mixes with a smaller factor. Just as there is no standard for IMIX (currently), there is no standard that dictates the need for a particular correlation factor. However, with a larger correlation factor a more realistic mix compared to the depicted data set may be introduced to the Device Under Test (DUT).

[1] Sean McCreary and KC Claffy, CAIDA, San Diego Supercomputer Center, University of California, San Diego. http://www.caida.org/outreach/papers/2000/AIX0005/

## Variations in IMIX

IMIX traffic may allow you to test your device under more realistic conditions than with many other standard benchmark tests. IMIX frame sizes can be based on samples from organizations that measure the makeup of Internet traffic. Alternatively, you may want to simulate some other usage or transmission patterns thereby comprising a more meaningful mix.

Internet usage obviously varies by user so a single mix of packet sizes is not typical for all classes of users. For example, users over Virtual Private Networks (VPN), and those using IPSec or SSL, typically engage enterprise applications. So an IMIX model based on general Internet traffic will lose correlation significance for VPN users. Enterprise and E-commerce traffic typically contains a mix that when, compared to general IMIX, includes larger packets and very small packets for terminal-like transactions.

## How IMIX Test Tools Work

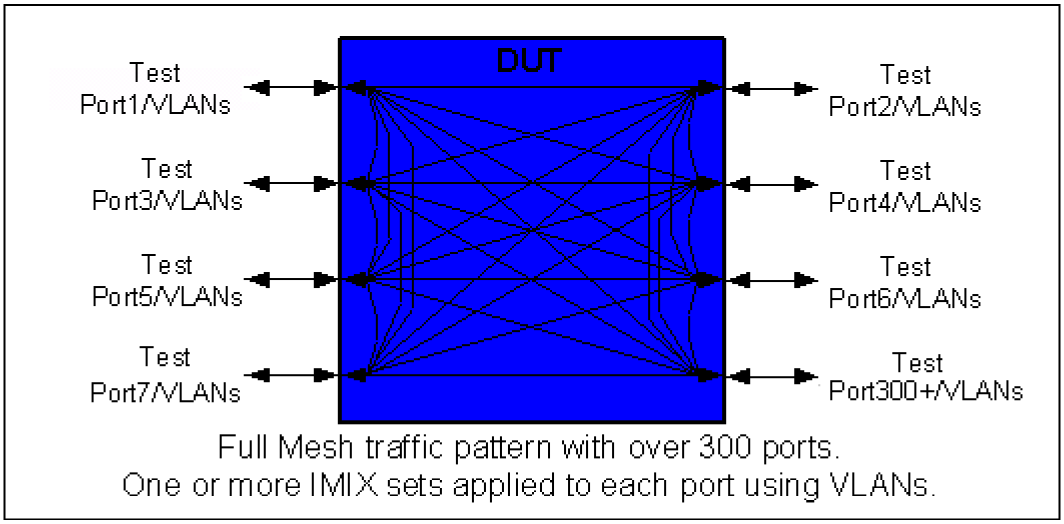
One form of IMIX, deterministic IMIX, provides a repeatable pattern with known relative counts or percentages of each frame size.

The frame sizes within a traffic flow, and their percentage of occurrence relative to the total flows, determine bandwidth utilization. Tests tool internally compute the necessary bandwidth to achieve the percentages of frame sizes in a given IMIX. This conversion from relative percentage to bandwidth utilization is necessary because larger frame sizes take up more bandwidth than smaller frame sizes. Therefore the proportion of total of each frame size is not usually equal to the bandwidth consumed for a given frame size.

Key considerations for testing IMIX and verifying that the customer experience closely resembles the source of the model data:

- Correlation to actual data that reflects the expected operational use of the DUT.
- Proper distribution of packet sizes with automatic bandwidth calculation.
- Interleaving of packets. The order in which the frames in a given flow are transmitted may be different depending on the network usage (application) for that flow. For example, to mimic real work conditions, packets within an IMIX should most likely not be sent in a burst fashion in which an abundance of packets, or even all packets, for a given frame size are transmitted before other frames sizes. They instead should be interleaved to achieve the bandwidth corresponding to each frame size.
- Multiple mixes in a single test that can be assigned across ports and different traffic types: IPv4, IPv6, Unicast, and Multicast. This provides the ability to simulate multiple types of users and network activity in which the frame size composition varies, as well as the ingress and egress ports on which given users' mix operates.
- Mix background traffic, including throttled traffic into the test bed. This allows you to see the effects to the IMIX traffic under varying and less than ideal conditions.
- Tailor the traffic flows with VLAN tags. Not only can IMIX be applied to a particular physical port, but also to logical ports that use VLAN tags. Multiple users on a port segregated by VLAN tags may have their own unique set of IMIX.
- Apply Quality of Service (QoS) by setting bandwidth limits, IP priority, and Differentiated Service through DSCP. When combined with IMIX, QoS can tell you if the higher priority flows within a mix actually take priority in a congested network, or one that uses queuing algorithms or Access Control Lists (ACL).
- Comprehensive metrics reporting on the IMIX set as a group, and also, individually by frame size within each set.
- Scalability of flows and ports to ensure that the device under test is challenged to its full capacity:

## Scalability Demands of IMIX




IMIX traffic may traverse multiple ports in many traffic patterns. Each port may emulate its own unique mix of Internet traffic. When applied to VLAN-tagged ports IMIX patterns emulate traffic from logical interfaces.

# Throughput Testing

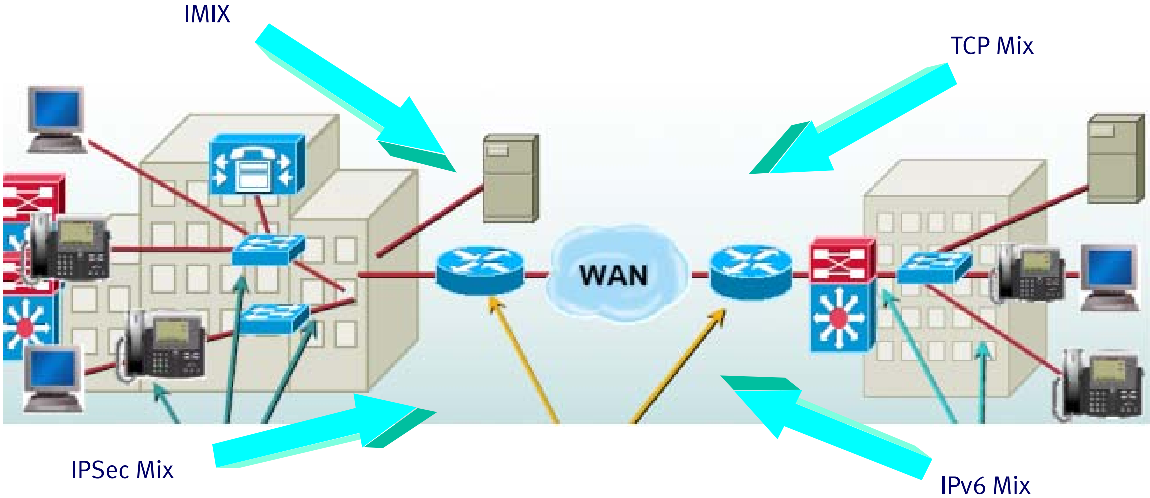
### Associated RFCs

- RFC 2544 Benchmarking Methodology for Network Interconnect Devices
- RFC 1242 Benchmarking Terminology for Network Interconnection Devices

### Objective

The Throughput test determines the maximum transmission rate at which the Device Under Test (DUT) can forward IP traffic with no frame loss, or at a user-specified acceptable frame loss. On Quality of Service (QoS) enabled networks, prioritization may not be visible until there is congestion and thus frame loss, or when queuing algorithms or Access Control Lists (ACL) are challenged. The Throughput test, when used with the IMIX traffic, allows the DUT to be tested under more realistic conditions.

By increasing or decreasing the transmission rate at specified levels, the capacity of the DUT can be determined. A binary search, or a step algorithm, is used to determine the zero-loss throughput rate.



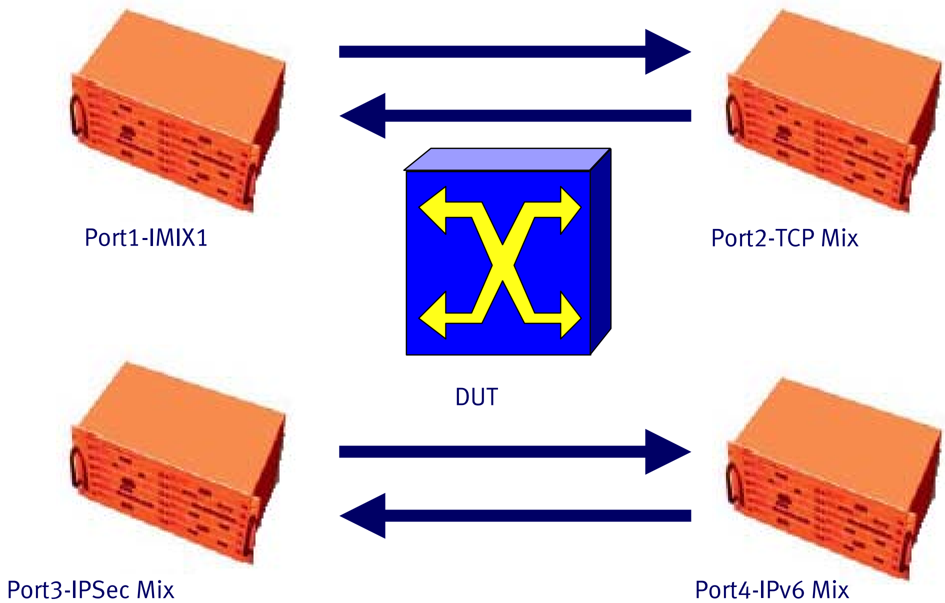

A realistic mixture of packet sizes will be classified into 4 different IMIX-oriented sets. For ease of data management and troubleshooting, the "simple" IMIX approach will be used in the first test. Once the throughout rate is determined, subsequent tests in the next section will expand upon an IMIX set and add frame sizes and random ranges.

## Test Parameters

- Iteration/trial duration in seconds. (Minimum of 60 seconds if you are following RFC 2544 guidelines. You may want to start out with a shorter duration, and assure the tests are configured properly.)
- Multiple IMIX sets that are assigned across multiple ports
- Traffic pattern: port pair, partial mesh, or full mesh
- Optional VLAN tags per port or per subnet and QoS attributes such as DSCP
- Traffic direction: bi-directional, unidirectional from input to output, and unidirectional from output to input.
- Initial rate (load). This is often expressed as a percent of theoretical maximum. Typically 10% or 100%. The % bandwidth of each IMIX frame will be based on the current port load per iteration.
- Maximum rate. This may also be expressed as a percent of theoretical maximum. Typically 100%.
- Minimum rate. This may also be expressed as a percent of theoretical maximum. Typically 1%.

- Precision/resolution. This may also be expressed as a percent of theoretical maximum. Typically 1%.
- Test port to DUT port mapping, including IP addresses.
- Test port configuration including speed, duplex, auto negotiation, and ARP options.
- IP addresses to be used in test traffic. Alternatively, DHCP may be enabled if the flow source addresses information is to be obtained from a DHCP server, rather than statically within the test tool.
- Advanced scheduler options to achieve the proper interleaving of packets, and reduce bursts within a particular frame size.
- Burst size. This identifies the number of frames sent with minimum inter frame gap as a "burst" to simulate real-world traffic.

## Setup




### Port Pair, Full Mesh, or Partial Mesh Traffic

In the following example the Throughput test uses a port pair configuration. Each port transmits its own unique set of IMIX-oriented set of frame sizes to a corresponding port.

## Test Steps

1. Create four IMIX sets using an IMIX editor.

IMIX1

IMIX List
IMIX 1

| Frame Size | IP Total Length(tot) | Packet % |
|---|---|---|
| 58 | 40 | 58.67000 |
| 62 | 44 | 2.00000 |
| 594 | 576 | 23.66000 |
| 1518 | 1500 | 15.67000 |

IMIX1 contains a flow that reflects a commonly used IMIX set of frame sizes based on analysis of Internet routers.

TCP Mix

IMIX List
IMIX 1
TCP Mix

| Frame Size | IP Total Length(tot) | Packet % |
|---|---|---|
| 90 | 72 | 58.67000 |
| 92 | 74 | 2.00000 |
| 594 | 576 | 23.66000 |
| 1518 | 1500 | 15.67000 |

This TCP Mix contains TCP-based flows, which more realistically emulate real-world traffic. Traffic with Layer-4 TCP headers resembles TCP-based protocols such as SMTP, HTTP, and POP.

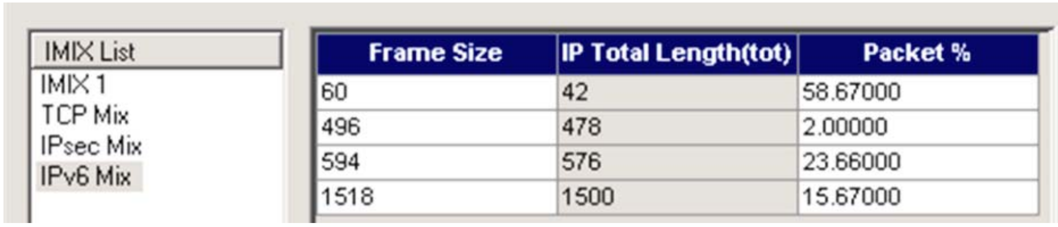
IPsec Mix

IMIX List
IMIX 1
TCP Mix
IPsec Mix

| Frame Size | IP Total Length(tot) | Packet % |
|---|---|---|
| 90 | 72 | 58.67000 |
| 92 | 74 | 2.00000 |
| 594 | 576 | 23.66000 |
| 1418 | 1400 | 15.67000 |

This IPSec Mix emulates traffic from VPN users using the IPsec protocol. For this case, to avoid fragmentation, the maximum packet size has been reduced to 1,418 bytes.

IPv6 Mix




| Frame Size | IP Total Length(tot) | Packet % |
|---|---|---|
| 60 | 42 | 58.67000 |
| 496 | 478 | 2.00000 |
| 594 | 576 | 23.66000 |
| 1518 | 1500 | 15.67000 |

This IPv6 Mix uses similar packet sizes as IMIX1 but is adjusted based on IPv6 traffic observations. IPv6 flows will be transmitted and will be properly received, even on an IPv4 port, as long as an IPv6 to IPv4 mechanism (or dual stack) is functional on the DUT.

The frame size column on the left includes the 18-byte Ethernet header, which is excluded from the IP Total length in the middle column.

2. Set the initial port load to the maximum rate for the interface used.

3. Set each port MAC, IP and network (subnet) addresses to map with to the DUT port mapping. Flows subsequently created will automatically have unique addresses on the correct network. (Alternatively, use DHCP for automatic address assignment.)

4. Configure VLANs using a VLAN wizard if the DUT expects flows with VLAN tags. IMIX can be assigned on a per port-basis, and on a per logical interface that uses VLANs.

5. Choose the traffic type: IPv4, IPv6, Unicast, or Multicast.

6. Configure the proper traffic pattern: port pair, partial mesh, or full mesh. For this test a port pair pattern will be used. This illustration shows the following port pair pattern used in this test:

   - Port 1=›Port 2
   - Port 2=›Port1
   - Port 3=›Port4
   - Port 4=›Port3

7. Assign an IMIX set to each port pair by using a “group” wizard that allows automatic assignment of a defined mix. Set Layer 3 and Layer 4 protocols such as IP and TCP in the Next Header field. At this point you may also want to assign QoS-related attributes such as IP priority or DSCP.

8. Run the Throughput test, which will send packets of a fixed size from all sources to all destinations. At the completion of this iteration, the test tool will report the number of packets transmitted and received on all streams. If packet loss occurs, the test tool will reduce the load and run another iteration.

   If using the binary search technique, the test tool will continue to increase or decrease the offered load in subsequent iterations until the difference in offered load between successful and failed tests is less than the resolution for the test. This is the zero-loss throughput rate.

   When a step search is used the test starts at a specified initial rate. During each trial, the transmission rate increases according to a specified step rate. The test continues until the current rate reaches a specified max rate, or the test fails if there is packet loss at a given iteration. Throughput is determined based on the last passing rate.

## Test Outcome

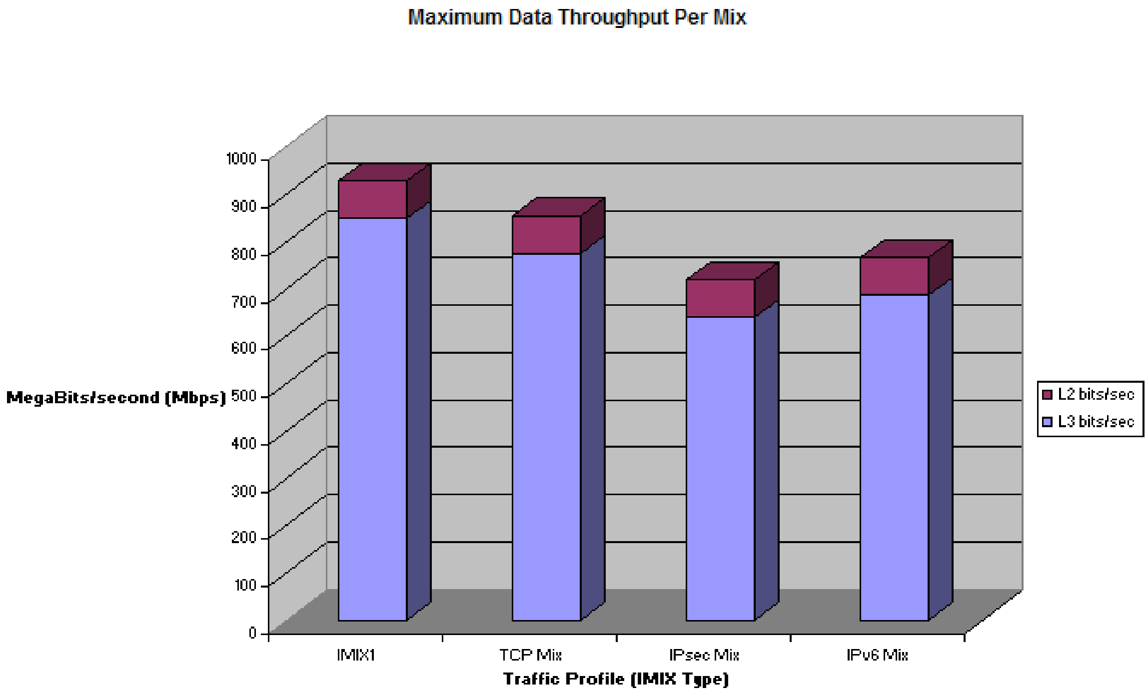
- Report the maximum transmission rate at which the DUT can forward IMIX-enabled traffic with zero frame loss in table and graphic form.
- Provide detailed results for each IMIX set and for each frame size including: load, transmit frames, received frames, lost, lost %, throughput. Report the transmit rate in bps, fps, Kbps, and Mbps. Report and graph the receive rate in bps, fps, Kbps, and Mbps for the entire frame and also for only the IP portion of the frame.
- Report stray frames that are received on the wrong port, CRC and data integrity errors.

## Detail - Multi Mix Throughput Results per Test Iteration

| Name | ILoad | TxFrames | RxFrames | LostFrames | Lost (%) | Throughput | Tx fps | Tx bps | Rx fps | Rx L3 bps | Rx L2 bps |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IPv6 Mix 4->3-F4 | 45.89608 | 398,865 | 398,865 | 0 | 0.00000 | N/A | 39,887 | 458,854,296 | 39,887 | 446,728,800 | 458,854,296 |
| Total | 93.81250 | 10,530,089 | 9,939,796 | 590,293 | 5.60577 | 87.62500 | 1,053,009 | 3,700,756,779 | 993,980 | 3,192,134,474 | 3,494,304,272 |
| IMIX Group | 93.81250 | 2,681,951 | 2,482,616 | 199,335 | 7.43246 | 87.62500 | 268,195 | 938,087,266 | 248,262 | 792,864,846 | 868,336,373 |
| TCP Mix Group | 93.81250 | 2,588,335 | 2,496,226 | 92,109 | 3.55862 | 87.62500 | 258,834 | 937,986,416 | 249,623 | 828,813,704 | 904,698,974 |
| IPsec Mix Group | 93.81250 | 2,560,492 | 2,466,900 | 93,592 | 3.65524 | 87.62500 | 256,049 | 895,789,966 | 246,690 | 787,951,006 | 862,944,766 |
| IPv6 Mix Group | 93.81250 | 2,699,311 | 2,494,054 | 205,257 | 7.60405 | 87.62500 | 269,931 | 928,893,131 | 249,405 | 782,504,917 | 858,324,158 |
| IMIX 1->2-F1 | 10.57392 | 1,573,685 | 1,456,752 | 116,933 | 7.43052 | N/A | 157,369 | 105,751,632 | 145,675 | 53,608,474 | 97,893,734 |
| IMIX 1->2-F2 | 0.36045 | 53,517 | 49,541 | 3,976 | 7.42941 | N/A | 5,352 | 3,596,342 | 4,954 | 1,823,109 | 3,329,155 |
| IMIX 1->2-F3 | 31.16909 | 634,502 | 587,330 | 47,172 | 7.43449 | N/A | 63,450 | 311,667,382 | 58,733 | 270,641,664 | 288,496,496 |
| IMIX 1->2-F4 | 51.70902 | 420,247 | 388,993 | 31,254 | 7.43705 | N/A | 42,025 | 517,071,909 | 38,899 | 466,791,600 | 478,616,987 |
| TCP Mix 2->1-F1 | 13.36347 | 1,518,870 | 1,464,715 | 54,155 | 3.56548 | N/A | 151,887 | 133,660,560 | 146,472 | 84,367,584 | 128,894,920 |
| TCP Mix 2->1-F2 | 0.46382 | 51,655 | 49,811 | 1,844 | 3.56984 | N/A | 5,166 | 4,628,288 | 4,981 | 2,948,811 | 4,463,066 |
| TCP Mix 2->1-F3 | 30.08110 | 612,305 | 590,561 | 21,744 | 3.55117 | N/A | 61,231 | 300,764,216 | 59,056 | 272,130,509 | 290,083,563 |
| TCP Mix 2->1-F4 | 49.90408 | 405,505 | 391,139 | 14,366 | 3.54274 | N/A | 40,551 | 498,933,352 | 39,114 | 469,366,800 | 481,257,426 |
| IPsec Mix 3->4-F1 | 13.84224 | 1,502,549 | 1,447,749 | 54,800 | 3.64714 | N/A | 150,255 | 132,224,312 | 144,775 | 83,390,342 | 127,401,912 |
| IPsec Mix 3->4-F2 | 0.48044 | 51,101 | 49,239 | 1,862 | 3.64376 | N/A | 5,110 | 4,578,650 | 4,924 | 2,914,949 | 4,411,814 |
| IPsec Mix 3->4-F3 | 31.15881 | 605,710 | 583,519 | 22,191 | 3.66363 | N/A | 60,571 | 297,524,752 | 58,352 | 268,885,555 | 286,624,533 |
| IPsec Mix 3->4-F4 | 48.33099 | 401,132 | 386,393 | 14,739 | 3.67435 | N/A | 40,113 | 461,462,253 | 38,639 | 432,760,160 | 444,506,507 |
| IPv6 Mix 4->3-F1 | 10.74671 | 1,583,923 | 1,463,404 | 120,519 | 7.60889 | N/A | 158,392 | 106,439,626 | 146,340 | 53,853,267 | 98,340,749 |
| IPv6 Mix 4->3-F2 | 2.25040 | 53,867 | 49,767 | 4,100 | 7.61134 | N/A | 5,387 | 22,236,298 | 4,977 | 19,030,901 | 20,543,818 |
| IPv6 Mix 4->3-F3 | 31.67842 | 638,587 | 590,061 | 48,526 | 7.59896 | N/A | 63,859 | 313,673,934 | 59,006 | 271,900,109 | 289,837,963 |
| IPv6 Mix 4->3-F4 | 49.13696 | 422,934 | 390,822 | 32,112 | 7.59267 | N/A | 42,293 | 486,543,274 | 39,082 | 437,720,640 | 449,601,629 |
| Total | 90.71875 | 10,325,021 | 10,325,021 | 0 | 0.00000 | 90.71875 | 1,032,502 | 3,627,950,883 | 1,032,502 | 3,314,070,245 | 3,627,950,883 |

The Throughput test provides results for each group mix, I.E., TCP Group, and also, for individual frame sizes (flows) within each group.

Throughput results are easily graphed to show received Mbps for each mix. L3 bits/sec (Rx L3 bps) is contrasted to L2 bps/sec (Rx L2 bps):




The test results demonstrate that IPSec and IPv6 traffic performance is less efficient than IMIX and TCP. The DUT may be capable of delivering a broad range of IP services; however Enterprise applications, IPv6 deployments, and QOS may be compromised.

# Advanced Measurements Testing – Jumbo Test

## Objective

Advanced measurements produce a variety of metrics in a single test pass, and are available by simulating more real world traffic. The SmartFlow Jumbo test on SmartBits provides these advanced metrics.

The accuracy of the test packet mix can be increased the more it correlates to the real world traffic. One means to achieve this is to increase the number of frame sizes in a mix that represent the common modal lengths. Another approach is to add an even distribution of other packet sizes by using a random range.

The following chart displays a list of frame sizes resembling those from network observations by NLANR, and provides a greater correlation value than the smaller IMIX sets in the previous test.

IMIX based on per NLANR Data

| Ethernet Frame Size (bytes) | IP Total Length (bytes) | Packet % (Proportion of Total) | Bandwidth (Load %) |
|---|---|---|---|
| 56 | 38 | 1.20% | 0.08% |
| 58 | 40 | 35.50% | 3.51% |
| 62 | 44 | 2.00% | 0.22% |
| 66 | 48 | 2.00% | 0.24% |
| 70 | 52 | 3.50% | 0.45% |
| 570 | 552 | 0.80% | 1.10% |
| 594 | 576 | 11.50% | 16.40% |
| 646 | 628 | 1.00% | 1.50% |
| 1438 | 1420 | 3.00% | 10.50% |
| 1518 | 1500 | 10.00% | 37.10% |
| 58-1518 (range) | 40 - 1500 (range) | 29.50% | 28.90% |

## Test Parameters

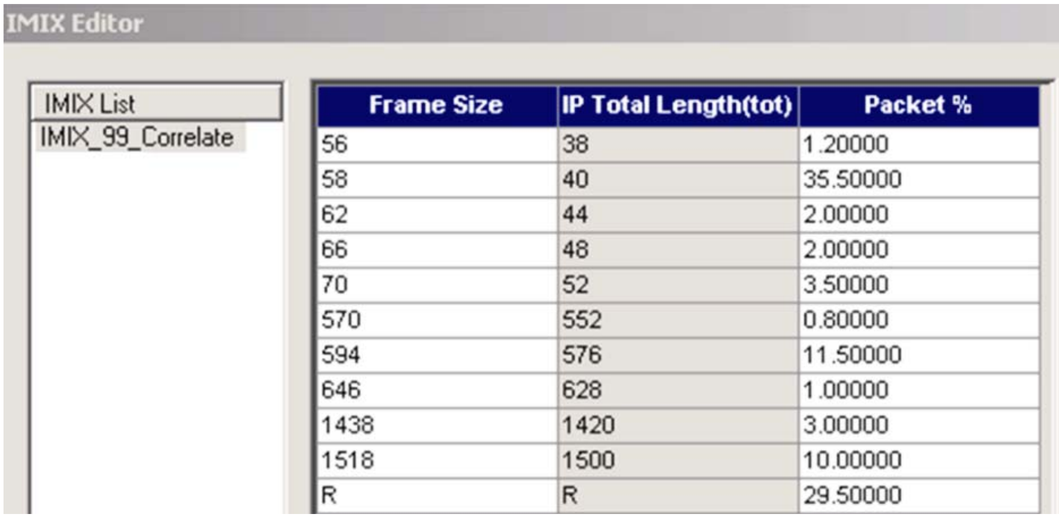
- Iteration/Trial duration in seconds.
- Offered Load (Oload)– This allows the actual transmit rate to be reported rather than just the intended load (Iload). Offered load is particularly useful when the Device Under Test (DUT) uses flow control such that the transmitting test ports may send less packets than are configured (intended) by the test setup.
- Multiple IMIX sets that are assigned across multiple ports
- Traffic pattern: port pair, partial mesh, or full mesh
- Optional VLAN tags per port or per subnet and QoS attributes such as DSCP.
- Traffic direction: bi-directional, unidirectional from input to output, and unidirectional from output to input.
- Port loads per test iteration. Typically expressed as a %. The % bandwidth of each IMIX frame will be based on the current port load per iteration. As compared with the Throughput test in which multiple iterations are controlled by the search algorithm, the SmartFlow Jumbo tests may be run with user-specified port loads across multiple iterations. The resulting bandwidth per frame sizes then becomes a function of the individual port loads.
- Test port to DUT port mapping, including IP addresses.
- Test port configuration including speed, duplex, auto negotiation, and ARP options.
- IP addresses to be used in test traffic. Alternatively, DHCP may be enabled if the flow source addresses information is to be obtained from a DHCP server, rather than statically within the test tool.
- Advanced scheduler options to achieve the proper interleaving of packets, and reduce bursts within a particular frame size.
- Burst size. This identifies the number of frames sent with minimum inter frame gap as a "burst" to simulate real-world traffic.

## Setup

Use either the port pair pattern in the test above, or another pattern such as the full mesh pattern, in which all test ports send and receive traffic from all other ports.

## Test Steps

1. Create the IMIX sets using an IMIX editor in a similar fashion as described in Throughput Testing above. (Re-use the previous configuration by saving it to a new filename.) For this test instead of using IMIX1, create IMIX_99_Correlate and add additional frame sizes and their associated relative percentages known to exist in the mix to be transmitted. You may want to use the IMIX per NLANR as an example set in lieu of having any pre-identified sets of your own. Also, add a random range with an upper and lower boundary such as 58 and 1518 bytes.




| Frame Size | IP Total Length(tot) | Packet % |
|---|---|---|
| 56 | 38 | 1.20000 |
| 58 | 40 | 35.50000 |
| 62 | 44 | 2.00000 |
| 66 | 48 | 2.00000 |
| 70 | 52 | 3.50000 |
| 570 | 552 | 0.80000 |
| 594 | 576 | 11.50000 |
| 646 | 628 | 1.00000 |
| 1438 | 1420 | 3.00000 |
| 1518 | 1500 | 10.00000 |
| R | R | 29.50000 |

The total percentages of all frame sizes should equal one hundred.

2. Set each port MAC, IP and network (subnet) addresses to map with to the DUT port mapping. Flows subsequently created will automatically have unique addresses on the correct network. (Alternatively, use DHCP for automatic address assignment.)

3. Set the initial port load to the maximum rate for the interface used. Alternatively, set the initial load to a lower rate and step up to the maximum rate over multiple test iterations.

4. Configure VLANs using a VLAN wizard if the DUT expects flows with VLAN tags. IMIX can be assigned on a per port-basis, and on a per logical interface that uses VLANs.

5. Choose the traffic type: IPv4, IPv6, Unicast, or Multicast.

6. Configure the proper traffic pattern: port pair, partial mesh, or full mesh.

7. Assign an IMIX set to each port by using a “group” wizard that allows automatic assignment of a defined mix. Set Layer 3 and Layer 4 protocols such as IP and TCP in the Next Header field. At this point you may also want to assign QoS-related attributes such as IP priority or DSCP.

   Run the SmartFlow Jumbo test. Monitor the port counters and results for each of the load iteration while the test is running.

## Test Outcome

- Report load, transmit frames, received frames, lost frames, lost %, store-and-forward and cut through minimum, average, maximum latency, standard deviation of latency, latency distribution, and sequencing all in a single test pass. Measure what happens to latency while monitoring frame loss.
- Report in and out of sequence frames that could likely produce upper layer re-transmits.
- Determine how traffic flow latency is distributed for each load, and how the latencies vary from one to another. Define which groups to analyze and the bit buckets of time to monitor for subsequently running the latency over time test.
- Correlate the results across each IMIX set and across each frame size within an IMIX. This lets you see problem areas for individual frame sizes within an IMIX.
- Show the bandwidth utilization per flow. Report the transmit rate in bps, fps, Kbps, and Mbps. Report and graph the receive rate in bps, fps, Kbps, and Mbps for the entire frame and also only for the IP portion of the frame.
- Report stray frames that are received on the wrong port, and CRC and data integrity errors.

## Detail – Jumbo Test Results with Advanced Metrics

| Name | LostFrames | StdDeviation | MinLatency | AveLatency | MaxLatency | InSequence | OutOfSequence | Tx fps | Tx Mbps | Rx fps | Rx L3 Mbps | Rx L2 Mbps |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IMIX_99_Correlate 1-1->1-2-F11 | 0 | 0.00 | 0.20 | 0.269 | 0.40 | 430,957 | 0 | 43,096 | N/A | 43,096 | N/A | N/A |
| Total | 572,089 | 0.00 | 0.20 | 0.265 | 0.40 | 7,643,467 | 23 | 821,558 | N/A | 764,349 | N/A | N/A |
| TCP Mix Group | 208,176 | 0.00 | 0.20 | 0.264 | 0.30 | 2,550,871 | 4 | 275,905 | 1,000 | 255,088 | 847 | 847 |
| IPsec Mix Group | 101,431 | 0.00 | 0.20 | 0.251 | 0.30 | 1,903,386 | 4 | 200,482 | 701 | 190,339 | 608 | 608 |
| IPv6 Mix Group | 216,524 | 0.00 | 0.20 | 0.275 | 0.40 | 1,927,318 | 4 | 214,385 | 738 | 192,732 | 605 | 605 |
| IMIX_99_Correlate Group | 45,958 | 0.00 | 0.20 | 0.275 | 0.40 | 1,261,892 | 11 | 130,786 | N/A | 126,190 | N/A | N/A |
| TCP Mix 2->1-F1 | 122,031 | 0.00 | 0.20 | 0.264 | 0.30 | 1,496,984 | 1 | 161,902 | 142 | 149,699 | 86 | 86 |
| TCP Mix 2->1-F2 | 4,148 | 0.00 | 0.20 | 0.264 | 0.30 | 50,912 | 1 | 5,506 | 5 | 5,091 | 3 | 3 |
| TCP Mix 2->1-F3 | 49,301 | 0.00 | 0.20 | 0.264 | 0.30 | 603,401 | 1 | 65,270 | 321 | 60,340 | 278 | 278 |
| TCP Mix 2->1-F4 | 32,696 | 0.00 | 0.20 | 0.264 | 0.30 | 399,574 | 1 | 43,227 | 532 | 39,958 | 479 | 479 |
| IPsec Mix 3->4-F1 | 59,536 | 0.00 | 0.20 | 0.251 | 0.30 | 1,117,024 | 1 | 117,656 | 104 | 111,703 | 64 | 64 |
| IPsec Mix 3->4-F2 | 2,025 | 0.00 | 0.20 | 0.251 | 0.30 | 37,990 | 1 | 4,002 | 4 | 3,799 | 2 | 2 |
| IPsec Mix 3->4-F3 | 23,989 | 0.00 | 0.20 | 0.251 | 0.30 | 450,232 | 1 | 47,422 | 233 | 45,023 | 207 | 207 |
| IPsec Mix 3->4-F4 | 15,881 | 0.00 | 0.20 | 0.251 | 0.30 | 298,140 | 1 | 31,402 | 361 | 29,814 | 334 | 334 |
| IPv6 Mix 4->3-F1 | 127,076 | 0.00 | 0.20 | 0.289 | 0.40 | 1,130,979 | 1 | 125,806 | 85 | 113,098 | 42 | 42 |
| IPv6 Mix 4->3-F2 | 4,322 | 0.00 | 0.20 | 0.257 | 0.30 | 38,463 | 1 | 4,279 | 18 | 3,846 | 15 | 15 |
| IPv6 Mix 4->3-F3 | 51,215 | 0.00 | 0.20 | 0.257 | 0.30 | 455,931 | 1 | 50,715 | 249 | 45,593 | 210 | 210 |
| IPv6 Mix 4->3-F4 | 33,911 | 0.00 | 0.20 | 0.257 | 0.30 | 301,945 | 1 | 33,586 | 386 | 30,195 | 338 | 338 |
| IMIX_99_Correlate 1-1->1-2-F1 | 537 | 0.00 | 0.30 | 0.325 | 0.40 | 15,056 | 1 | 1,559 | 1 | 1,506 | 1 | 1 |
| IMIX_99_Correlate 1-1->1-2-F2 | 16,337 | 0.00 | 0.20 | 0.292 | 0.40 | 448,178 | 1 | 46,452 | 31 | 44,818 | 16 | 16 |
| IMIX_99_Correlate 1-1->1-2-F3 | 907 | 0.00 | 0.20 | 0.260 | 0.30 | 25,184 | 1 | 2,609 | 2 | 2,519 | 1 | 1 |
| IMIX_99_Correlate 1-1->1-2-F4 | 907 | 0.00 | 0.20 | 0.260 | 0.30 | 25,184 | 1 | 2,609 | 2 | 2,519 | 1 | 1 |
| IMIX_99_Correlate 1-1->1-2-F5 | 1,603 | 0.00 | 0.20 | 0.261 | 0.30 | 44,119 | 1 | 4,572 | 3 | 4,412 | 2 | 2 |
| IMIX_99_Correlate 1-1->1-2-F6 | 367 | 0.00 | 0.20 | 0.260 | 0.30 | 10,039 | 1 | 1,041 | 5 | 1,004 | 4 | 4 |
| IMIX_99_Correlate 1-1->1-2-F7 | 5,294 | 0.00 | 0.20 | 0.261 | 0.30 | 145,130 | 1 | 15,043 | 74 | 14,513 | 67 | 67 |
| IMIX_99_Correlate 1-1->1-2-F8 | 454 | 0.00 | 0.20 | 0.260 | 0.30 | 12,591 | 1 | 1,305 | 7 | 1,259 | 6 | 6 |
| IMIX_99_Correlate 1-1->1-2-F9 | 1,365 | 0.00 | 0.20 | 0.260 | 0.30 | 37,863 | 1 | 3,923 | 46 | 3,786 | 43 | 43 |
| IMIX_99_Correlate 1-1->1-2-F10 | 4,599 | 0.00 | 0.20 | 0.260 | 0.30 | 126,196 | 1 | 13,080 | 161 | 12,620 | 151 | 151 |
| IMIX_99_Correlate 1-1->1-2-F11 | 13,588 | 0.00 | 0.20 | 0.269 | 0.40 | 372,352 | 1 | 38,594 | N/A | 37,235 | N/A | N/A |

The Jumbo test provides results for both the entire group mix, I.E., IMIX_99 Group, and also, for individual frame sizes (flows).

## Average Latency– Jumbo Test Results with Advanced Metrics

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| IMIX_99_Correlate 1-1->1-2-F1 | 11/13/05 09:55:52 | 56 | 0.13080 | 15,594 | 15,057 | 537 | 0.00 | 0.30 | 0.325 |
| IMIX_99_Correlate 1-1->1-2-F2 | 11/13/05 09:55:52 | 58 | 3.86962 | 464,516 | 448,179 | 16,337 | 0.00 | 0.20 | 0.292 |
| IMIX_99_Correlate 1-1->1-2-F3 | 11/13/05 09:55:52 | 62 | 0.21801 | 26,092 | 25,185 | 907 | 0.00 | 0.20 | 0.260 |
| IMIX_99_Correlate 1-1->1-2-F4 | 11/13/05 09:55:52 | 66 | 0.22320 | 26,092 | 25,185 | 907 | 0.00 | 0.20 | 0.260 |
| IMIX_99_Correlate 1-1->1-2-F5 | 11/13/05 09:55:52 | 70 | 0.40876 | 45,723 | 44,120 | 1,603 | 0.00 | 0.20 | 0.261 |
| IMIX_99_Correlate 1-1->1-2-F6 | 11/13/05 09:55:52 | 570 | 0.61250 | 10,407 | 10,040 | 367 | 0.00 | 0.20 | 0.260 |
| IMIX_99_Correlate 1-1->1-2-F7 | 11/13/05 09:55:52 | 594 | 9.16278 | 150,425 | 145,131 | 5,294 | 0.00 | 0.20 | 0.261 |
| IMIX_99_Correlate 1-1->1-2-F8 | 11/13/05 09:55:52 | 646 | 0.86424 | 13,046 | 12,592 | 454 | 0.00 | 0.20 | 0.260 |
| IMIX_99_Correlate 1-1->1-2-F9 | 11/13/05 09:55:52 | 1438 | 5.67596 | 39,229 | 37,864 | 1,365 | 0.00 | 0.20 | 0.260 |
| IMIX_99_Correlate 1-1->1-2-F10 | 11/13/05 09:55:52 | 1518 | 19.95801 | 130,796 | 126,197 | 4,599 | 0.00 | 0.20 | 0.260 |
| IMIX_99_Correlate 1-1->1-2-F11 | 11/13/05 09:55:52 | N/A | 58.87612 | 385,941 | 372,353 | 13,588 | 0.00 | 0.20 | 0.269 |

Results can be filtered to display details specific to an individual mix.

# Glossary

**ACL** – (Access Control Lists) Used to give access to an object depending on certain aspects of the process which is making the request, used as a security measure.

**DSCP –** (Differentiated Services) A way to try and guarantee Quality of Service (QoS) on a network.

**DUT** – (Device Under Test) The device which is currently having a test ran on it. Sometimes also referred to as a System Under Test).

**IMIX** – (Internet Mix) Generally used to describe a ratio of common frame sizes transmitted across the Internet.

**Jumbo Test** – An industry-unique test in SmartFlow that combines many tests info one. Allowing you to measure what happens to latency while monitoring frame loss. This test, which uses time saving histograms, shows latency distributions, latency, packet loss, sequencing, and correlates the results. The test also shows bandwidth utilization per flow.

**Multicast –** Used to deliver data from one source to many destinations.

**QoS** – (Quality of Service) The ability of a network to meet a certain traffic contract.

**Unicast –** Used to deliver data from one source to one destination.

**VPN** – (Virtual Private Network) A VPN is a network that uses a public telecommunications infrastructure, such as the Internet, to provide remote offices or individual users with secure access to their organizations network.

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Spirent Communications is a worldwide provider of integrated performance analysis and service assurance systems for next-generation network technologies. Our solutions accelerate the profitable development and deployment of network equipment and services by emulating real-world conditions in the lab and assuring end-to-end performance of large-scale networks.

Spirent performance analysis solutions include instruments and systems that measure and analyze the performance of network equipment, particularly the devices that route voice and data messages to their destination. Our service assurance solutions include remote test, fault and performance management systems that let network service providers quickly identify network faults and monitor real-time performance.

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