



Using Chariot® for Switch and Router Performance Testing

Application Note

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Introduction

Comparing the performance of switches and routers is a daunting task because it suggests reproducing, in a controlled environment, the network traffic patterns that a router or switch would experience in the real world. The simulated network, along with many willing users, would have to be perfectly reproduced to provide true user-generated network application traffic. To further complicate this scenario, a set of measurement tools would have to be deployed to gather comparative data about the bandwidth and latency of the traffic.

Reproducing the production network and convincing users to generate network traffic for the test is an obvious waste of resources. Fortunately, NetIQ's Chariot provides the perfect solution—by generating real application traffic with real systems, along with a tool for gathering the metrics you need to compare products. This application note describes scenarios for testing various features of routers and switches with real world traffic—not just lab-generated packets from a sterile traffic generator.

Test Methodology

First, let's define a router and a switch. The most common definition of a switch is a device that forwards packets using MAC addresses. This is known as Layer 2 switching. Layer 2 refers to the second layer of the seven layer OSI Reference Model. A router forwards packets using network addresses at Layer 3 of the OSI Reference Model. So for the sake of discussion, this application note will refer to a "Layer 2 switch" as a "switch" and a "Layer 3 switch" as a "router."

The Switch and Router performance tests described in this application note are:

- Switch pairwise forwarding rate and response time
- Switch mesh forwarding rate and response time
- Router pairwise forwarding rate and response time
- Router mesh forwarding rate and response time.

Quality of Service (QoS) and multicast features were intentionally omitted from the above list. QoS and multicast are covered in other application notes and are outside the scope of this application note.

The tests listed above are executed using PCs and workstations with NetIQ Performance Endpoints installed on them. Each test that targets the above features includes a description of the network topology, network addressing, and device configuration. The routers or switches to be compared are substituted in various runs of the tests. The results from testing the different devices can be compared to determine their relative performance.

The end result of this application note is to give you a blueprint for testing routers and switches using NetIQ's Chariot. The Chariot configuration and network topologies are described in detail.

The Testing Environment

Each of the tests follows a similar pattern of defining a network topology. In each of the tests, the router or switch is the core of the network. It is conceivable that one endpoint for each port of the device under test would create enough load to approach port transmission rate. This is not always the case. The workstations used to generate the traffic may not be able to sustain enough network traffic to completely fill a Fast Ethernet or Gigabit Ethernet. Therefore endpoints may need be aggregated through a hub to connect them to one port of the device under test.

For the purposes of this application note, it is assumed that only one endpoint will be connected to a port of the device under test. Note that it is a simple matter to modify the tests to increase the number of endpoints per port of the device under test. Also note that the tests can be extended to define the device under test as a network made of multiple routers and switches and not simply as one device.

The following sections describe tests to characterize the network device performance of the testing objectives listed above.

Switch Pairwise Forwarding Rate and Response Time

This scenario tests a switch's ability to forward packets by MAC address. The type of traffic to be forwarded by a switch should mimic your network environment, so we recommend generating a combination of transaction types from the endpoints.

Testing a switch's forwarding rate involves more than testing the bit per second throughput of the device. The switch must process the MAC header of each frame to determine which physical port the frame should be

switched to. This processing is done once whether the frame is large or small. Therefore, the switch must work harder to forward smaller frames for a given bandwidth than for larger packets. Testing the switch with only minimum size frames would be a worst-case performance test of the device, and is not a realistic representation of typical network traffic. Therefore, a mix of traffic types would more accurately represent typical traffic patterns.

The following list is an example of a representative mix of traffic. This traffic mix spans a spectrum of frame sizes and transaction types. The Chariot scripts used for each transaction type are named in parentheses.

- Large file (10MB) FTP transaction (filesndl.scr)
- Small HTML file (1kB) HTTP transaction (httptext.scr)
- Database transaction (dbasel.scr)

The small HTML file and database transaction scripts can be used in their default form. The large file transaction must be modified. The default value for `file_size` of the `filesndl.scr` script is 100KB. This value should be increased to 10MB. The following illustration shows how to change the value of `file_size`.

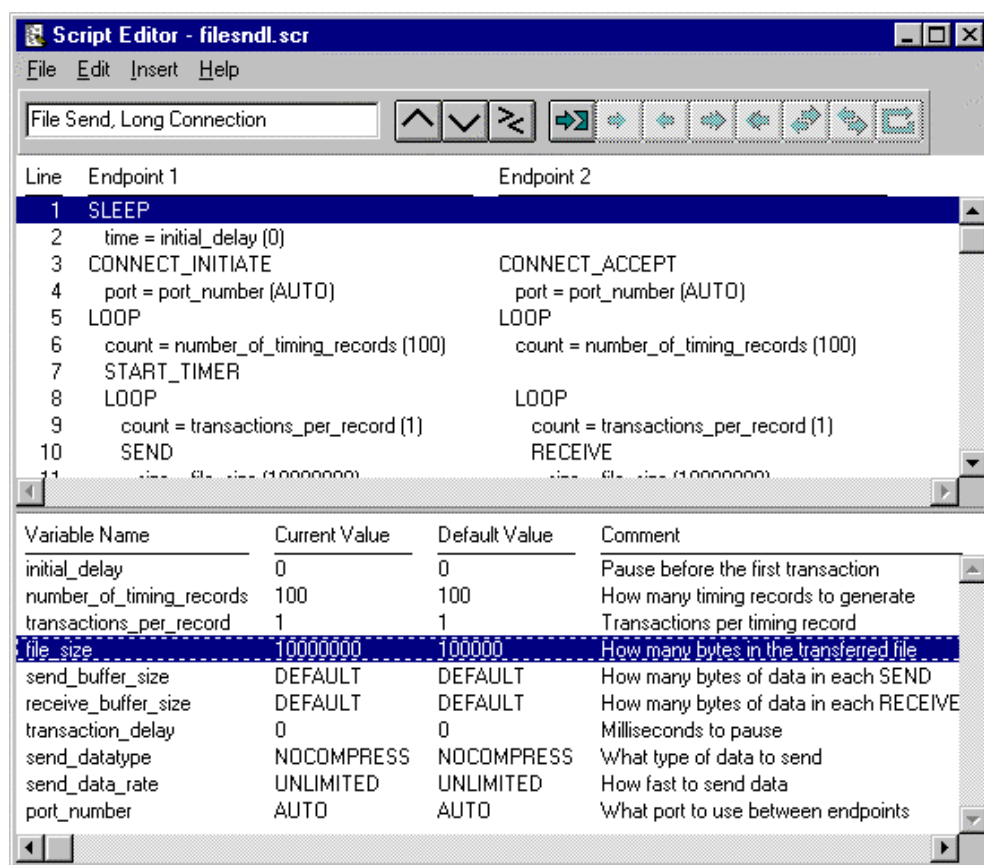


Figure 1: Filesndl.scr Modification

The network topology is simple. Connect one computer running a NetIQ Performance Endpoint to different ports of the switch until the switch is full. The following diagram shows the network topology for the test. See a later section called "Testing Tips" for hints on how to incorporate the Console computer into the test bed.

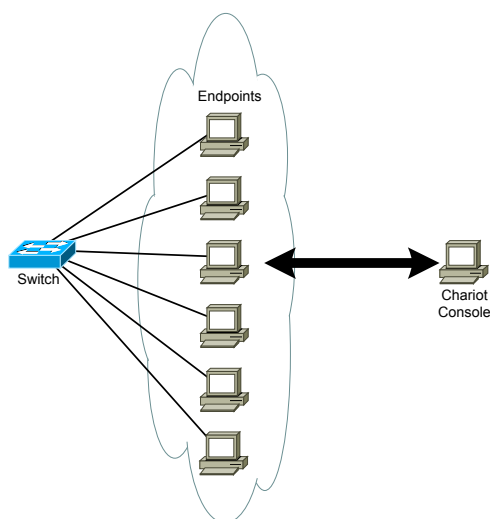


Figure 2: Switch Test Topology

The endpoint pairs should be set up in a pairwise fashion through the switch. For example, an endpoint running on a host connected to port 1 of the Layer 2 switch should send its traffic to an endpoint running on a host connected to port 2 of the switch. The transactions should also be set up in a bi-directional manner. With the three traffic types listed above sent bidirectionally between two endpoints, each endpoint should be included in six pairs.

IP addressing is simple. Since there is no routing in this test network, place all the endpoints in one IP subnet. The switch will be able to pass the resulting ARP packets. If the endpoint computers are configured to be in separate IP subnets, there is no device in the test bed network to act as a gateway and provide logical connectivity.

The following table shows the IP addressing scheme for this test. Assume that the IP subnet mask is 255.255.255.0.

Endpoint	IP Address
Endpoint 1	10.0.0.1
Endpoint 2	10.0.0.2
Endpoint 3	10.0.0.3
Endpoint 4	10.0.0.4
Endpoint n	10.0.0.n

Table 1: Switch Test IP Addressing Scheme

The following diagram shows the Chariot Console configuration for two endpoints.

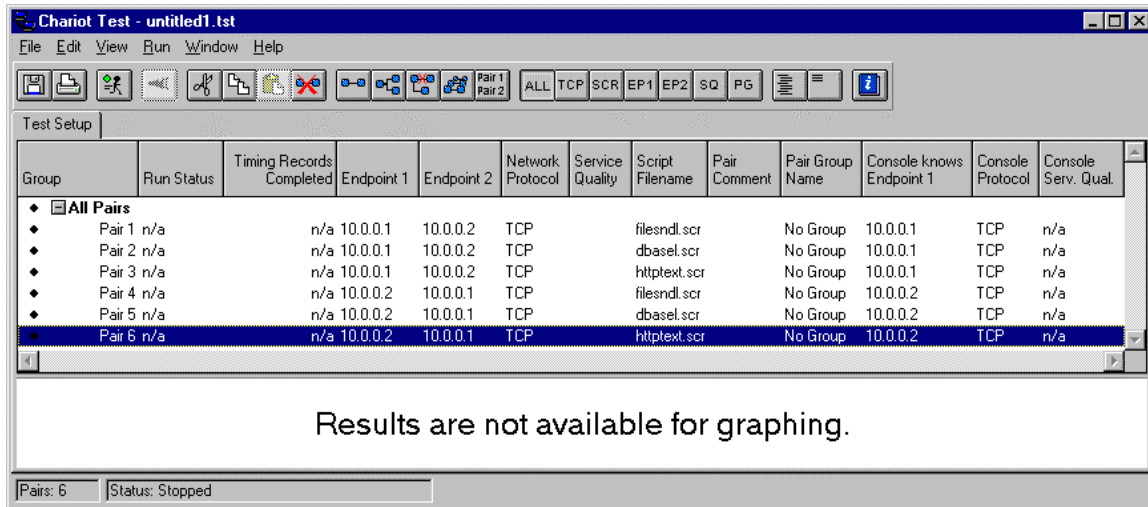


Figure 3: Switch Pairwise Test Console Configuration

Run the test for a duration of 5 minutes to make sure that many of transactions of all types are executed to obtain a good average. The average aggregate throughput and average response time represent the overall performance of the switch being tested. Individual endpoint pair results can be analyzed to ensure all switch ports are forwarding at the same rate with similar response times

Switch Mesh Forwarding Rate and Response Time

This test evaluates the switch's ability to forward packets from any switch port to any switch port using MAC addresses. The type of traffic to be forwarded by a switch should mimic your network environment, but we recommend generating a combination of packet sizes from the endpoints.

Use the same traffic mix, script modification, IP addressing, and network topology as was

described in the Switch Pairwise Forwarding Rate and Response Time test.

The network topology is the same as for the above Switch Pairwise Unicast Forwarding and Latency test.

The endpoint pairs should be set up in a mesh fashion where each endpoint communicates with every other endpoint pair. For example, an endpoint running on a host connected to port 1 of the switch should send its traffic to an endpoint running on a host connected to port 2 of the switch, port 2 of the switch, and so on including all ports of the switch. The transactions should also be set up in a bi-directional manner. With the three traffic types listed above sent bidirectionally between N endpoints, each endpoint should be included in $3*(N-1)$ pairs. The following diagram shows the Chariot Console configuration for three fully meshed endpoints.

Group	Run Status	Timing Records Completed	Endpoint 1	Endpoint 2	Network Protocol	Service Quality	Script Filename	Pair Comment	Pair Group Name	Console knows Endpoint 1	Console Protocol	Console Serv. Qual.
• All Pairs												
• Pair 1	n/a		n/a 10.0.0.1	10.0.0.2	TCP		filesndl.scr		No Group	10.0.0.1	TCP	n/a
• Pair 2	n/a		n/a 10.0.0.1	10.0.0.2	TCP		dbasel.scr		No Group	10.0.0.1	TCP	n/a
• Pair 3	n/a		n/a 10.0.0.1	10.0.0.2	TCP		httptext.scr		No Group	10.0.0.1	TCP	n/a
• Pair 4	n/a		n/a 10.0.0.1	10.0.0.3	TCP		filesndl.scr		No Group	10.0.0.1	TCP	n/a
• Pair 5	n/a		n/a 10.0.0.1	10.0.0.3	TCP		dbasel.scr		No Group	10.0.0.1	TCP	n/a
• Pair 6	n/a		n/a 10.0.0.1	10.0.0.3	TCP		httptext.scr		No Group	10.0.0.1	TCP	n/a
• Pair 7	n/a		n/a 10.0.0.2	10.0.0.1	TCP		filesndl.scr		No Group	10.0.0.2	TCP	n/a
• Pair 8	n/a		n/a 10.0.0.2	10.0.0.1	TCP		dbasel.scr		No Group	10.0.0.2	TCP	n/a
• Pair 9	n/a		n/a 10.0.0.2	10.0.0.1	TCP		httptext.scr		No Group	10.0.0.2	TCP	n/a
• Pair 10	n/a		n/a 10.0.0.2	10.0.0.3	TCP		filesndl.scr		No Group	10.0.0.2	TCP	n/a
• Pair 11	n/a		n/a 10.0.0.2	10.0.0.3	TCP		dbasel.scr		No Group	10.0.0.2	TCP	n/a
• Pair 12	n/a		n/a 10.0.0.2	10.0.0.3	TCP		httptext.scr		No Group	10.0.0.2	TCP	n/a
• Pair 13	n/a		n/a 10.0.0.3	10.0.0.1	TCP		filesndl.scr		No Group	10.0.0.3	TCP	n/a
• Pair 14	n/a		n/a 10.0.0.3	10.0.0.1	TCP		dbasel.scr		No Group	10.0.0.3	TCP	n/a
• Pair 15	n/a		n/a 10.0.0.3	10.0.0.1	TCP		httptext.scr		No Group	10.0.0.3	TCP	n/a
• Pair 16	n/a		n/a 10.0.0.3	10.0.0.2	TCP		filesndl.scr		No Group	10.0.0.3	TCP	n/a
• Pair 17	n/a		n/a 10.0.0.3	10.0.0.2	TCP		dbasel.scr		No Group	10.0.0.3	TCP	n/a
• Pair 18	n/a		n/a 10.0.0.3	10.0.0.2	TCP		httptext.scr		No Group	10.0.0.3	TCP	n/a

Results are not available for graphing.

Pairs: 18 Status: Stopped

Figure 4: Switch Mesh Test Console Configuration

Run the test for a duration of 5 minutes to make sure that many of transactions of all types are executed to obtain a good average. The average aggregate throughput and average response time represent the overall performance of the switch being tested. Compare the results of this test with the results of the Switch Pairwise Forwarding Rate and Response Time test. The results should be similar.

Router Pairwise Forwarding Rate and Response Time

This scenario tests the switch's ability to forward packets using network addresses (in this case IP addresses). The router must do more than simply determine the output port. To properly forward a packet at Layer 3, the router must determine the output port based on the destination IP address, decrement the TTL field of the IP header, and replace the destination MAC address with the MAC address of the next hop. As in testing switches, the type of traffic to be forwarded by a router should mimic your network environment, but we recommend generating a

combination of packet sizes from the endpoints.

The principles of testing the packet-processing rate of routers are similar to the switch testing discussed above. Testing a router's forwarding rate involves more than testing the bit-per-second throughput of the device. The router must process the IP header of each packet to determine which physical port the frame should be switched to, as well as perform packet modifications (TTL and destination MAC address changes). This processing is done once whether the frame is large or small. Therefore, the router must work harder to forward smaller frames for a given bandwidth than for larger packets.

Use the same traffic mix, script modification, and network topology as described in the Switch Pairwise Forwarding Rate and Response Time test. For each endpoint connected to the router, make sure that the IP address is in the same subnet as the router port. Use the router port IP address as the default gateway in the endpoint computer.

The following table shows an example IP addressing scheme. Assume the IP subnet mask is 255.255.255.0.

Endpoint	IP Address
Endpoint 1	10.0.0.1
Endpoint 2	10.0.1.1
Endpoint 3	10.0.2.1
Endpoint 4	10.0.3.1
Endpoint n	10.0.(n-1).1

Table 2: IP Addressing for Router Testing

The endpoint pairs should be set up in a pairwise fashion through the switch. For example,

an endpoint running on a host connected to port 1 of the router should send its traffic to an endpoint running on a host connected to port 2 of the router. The transactions should also be set up in a bi-directional manner. With the three traffic types listed above sent bi-directionally between two endpoints, each endpoint should have six transactions. The following diagram shows the Chariot Console configuration for two endpoints.

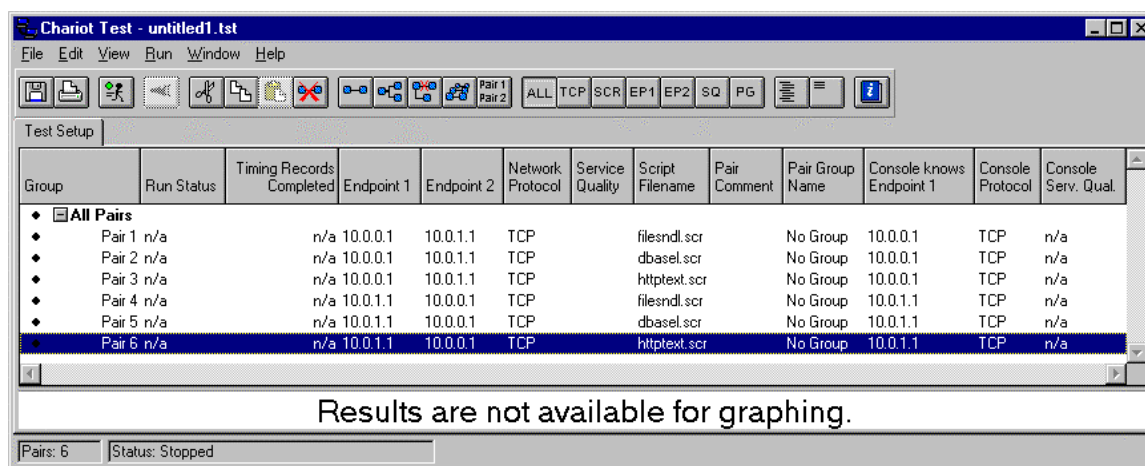


Figure 5: Router Pairwise Test Console Configuration

Run the test for a duration of 5 minutes to make sure that many of transactions of all types are executed to obtain a good average. The average aggregate throughput and average response times represent the overall performance of the switch being tested. The relative transaction rates of the various traffic types can shed light on how the switch performs with different packet sizes. If the database transaction rates are lower from one router to another, this may imply a packet rate limitation of one router. These results can be used to compare the results obtained with another router.

Router Mesh Forwarding Rate and Response Time

This scenario tests the switch's ability to forward packets using network addresses (in this case IP addresses). The router must do more than simply determine the output port. To properly forward a packet at Layer 3, the router must determine the output port based on the destination IP address, decrement the

TTL field of the IP header, and replace the destination MAC address with the MAC address of the next hop. As in testing switches, the type of traffic to be forwarded by a router should mimic your network environment, but we recommend generating a combination of packet sizes from the endpoints.

Use the same traffic mix, script modification, IP addressing, and network topology as in the Router Pairwise Forwarding Rate and Response Time test described above.

The endpoint pairs should be set up in a mesh fashion through the switch. For example, an endpoint running on a host connected to port 1 of the switch should send its traffic to an endpoint running on a host connected to port 2 of the switch. The transactions should also be set up in a bi-directional manner. With the three traffic types listed above sent bidirectionally between two endpoints, each endpoint should have six transactions. The following diagram shows the Chariot Console configuration for two endpoints.

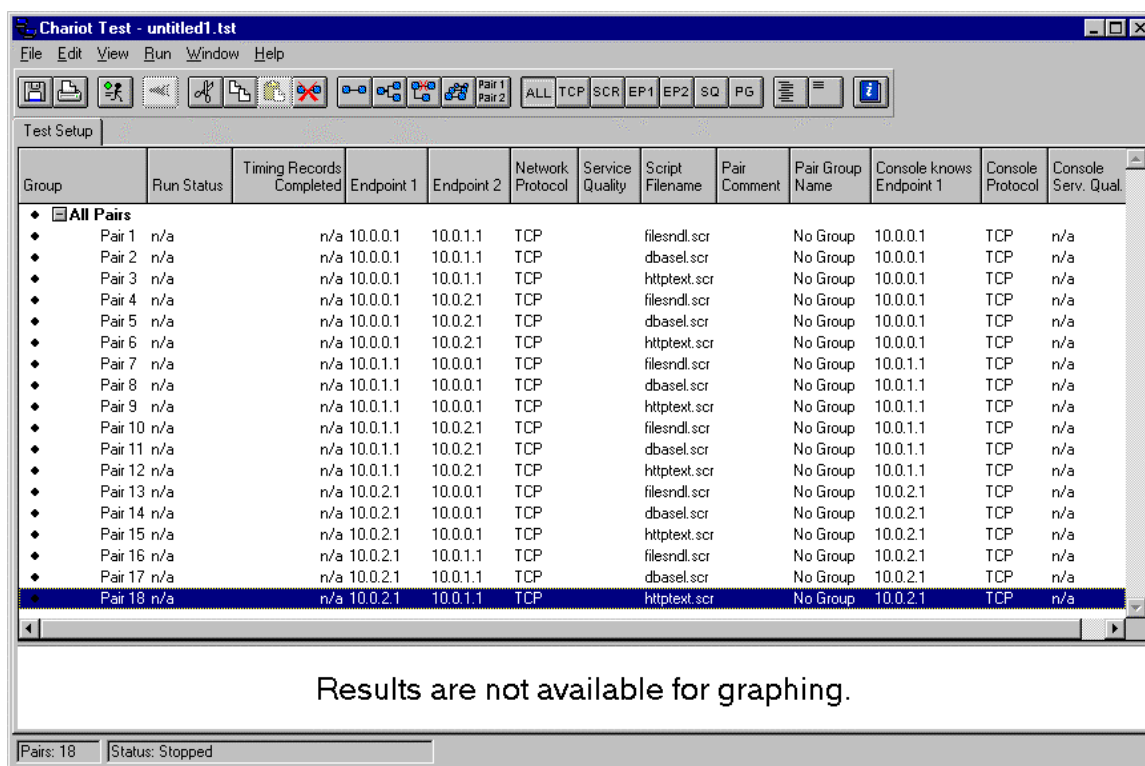


Figure 6: Router Mesh Test Console Configuration

Each of the hosts running an endpoint must be in the same subnet as the router ports they are connected to. Use the router port address as the gateway address for each of the endpoint computers.

Run the test for 5 minutes to make sure that many of transactions of all types are executed to obtain a good average. The average aggregate throughput and average latency represent the overall performance of the switch being tested. The relative transaction rates of the various traffic types can shed light on how the switch performs with different packet sizes. If the database transaction rates are lower from one router to another, this may imply a packet rate limitation of one router. These results can be used to compare the results obtained with another router.

Testing Tips

There are two options for connecting the Chariot Console to the network. The most inexpensive way to incorporate the console into the test environment is to connect the Console in-band. In this case, the Console

computer is connected to a hub along with another endpoint computer. This hub is then connected to one port of the switch. The Console is then able to control all endpoints through the switch. This topology may create problems if the switch is unable to forward all the traffic. The control information may be lost, which could compromise the results of the test. See the following diagram for an example of this topology.

Conclusion

The results of the testing described above provide the ability to measure the performance of a router or switch using real world traffic in a repeatable manner. Since the traffic is not synchronized across all ports of the router or switch, and the traffic is generated using real network stacks within the computer running the endpoint, the Chariot statistical performance results will mimic real world results more closely than is possible with other hardware-based network test equipment.