FLUKE networks

Application Note

Verifying Network Bandwidth

"My current project is to install a new Gigabit link between the datacenter and Smith Hall on the far side of the campus," says Joe Homes, the network administrator for a Pacific Northwest university. "A new fiber cable was buried between the buildings and I placed and configured new switches at each end of the link. Professors and students in Smith Hall are able to access the servers in the datacenter but how do I know if I really have Gigabit bandwidth between the buildings? My supervisor wants proof of this before he will sign-off that this project is complete."

Can you empathize with Joe? Are you an IT professional responsible for a university or business campus network? Alternatively, maybe you work for a service provider and your objective is to provide a minimum amount of bandwidth to a remote business or residence. Your needs are similar – a method of proving that your network is capable of delivering the promised bandwidth between two points within that network. Fortunately, there are tools available that can assist you with this task.

Throughput test

The most frequently deployed technique for verifying network bandwidth is the throughput test. In a typical throughput test, you send traffic from one networked device to another, at a rate and for a duration you select. The receiving device counts the number of frames received over the duration of the test. It then calculates the receive rate, also called the throughput rate.

The throughput rate is equal to the transmit rate if no frames are lost. If there is a bottleneck between the two test points, then frames will be lost and the throughput rate will be less than the transmit rate. If you want to know the maximum throughput rate, or bandwidth, of a link, start with the maximum theoretical transmit rate and decrease the rate until no frames are lost at the receiving device.

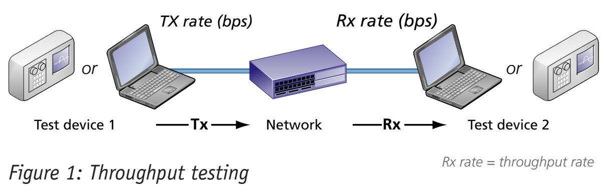

Figure 1: Throughput testing

Throughput testing is a two-ended test with one device serving as the main or server and a second device acting as a remote or client. The main test device sends traffic and the remote test device receives and measures it. The test devices could be dedicated test instruments or notebook PCs with appropriate application software. Throughput testing is equally effective when testing local area networks (LANs) and wide area networks (WANs). Figures 2 and 3 illustrate typical LAN and WAN test configurations, respectively.

When testing throughput, you are testing the entire network link consisting of several elements: the end devices and any network devices between them (hubs, switches, access points, and routers). Each element is comprised of various components such as network interface cards or ports, motherboards, and operating systems. Changing any component or network element could influence the throughput rate.

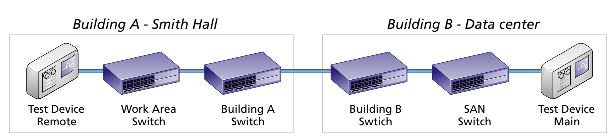

Figure 2: Typical LAN test configuration

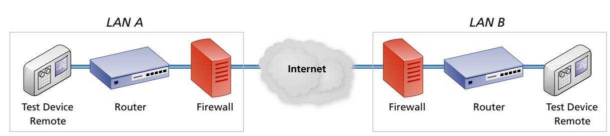

Figure 3: Typical WAN test configuration

EtherScope™ Network Assistant

Instant visibility into network throughput

EtherScope Network Assistant (ES-PRO-I)

The type of traffic sent can affect the throughput rate. Smaller sized frames (e.g. 64 bytes) require more processing by switches and routers, resulting in slower throughput rates if they cannot keep up. Frame content (all 1s, all 0s, random bits) can affect throughput because of differences in circuitry and algorithms used by various NICs, switches and routers. The duration of the test affects the maximum throughput rate. A piece of networking gear with greater processing power and larger buffers would be able to keep up with a high rate of traffic for a longer period of time than a less capable device. Finally, the transmission protocol affects the throughput rate. The Transmission Control Protocol (TCP) rate is less than the User Datagram Protocol (UDP) rate because TCP uses sequenced acknowledgments and retransmits packets when necessary.

Consider the selection of the service port before running a throughput test. The default port may vary depending upon the particular test application you run. Make sure your firewall does not block the port you select and that both main and remote devices employ the same port.

If you are testing throughput on a live network, be aware that the test results indicate the bandwidth at a particular moment in time. Occasional collisions and lost frames are normal on a live, busy network. Your test results may vary significantly over time due to normal network activity. To establish the baseline performance of a live network, you could test throughput at regular time intervals over a long period to document network behavior with varying network utilization.

Test scenarios

Let us examine a few scenarios to illustrate the application of throughput testing. In these scenarios, we will use two Fluke Networks EtherScope Network Assistants as test devices. A throughput test is an option available on the EtherScope analyzer. The name of this option is the Internetwork Throughput Option (ITO). We can test throughput at rates up to 1000 Mbps using two EtherScope analyzers as end devices. Unlike most test devices that measure throughput in only one direction (from main-to-remote), an EtherScope analyzer functions as both a main and a remote test device. This facilitates bi-directional testing so we can measure throughput in both directions without having to swap or reconfigure end devices – a significant time savings.

Scenario 1

In our first scenario, we want to verify that we have 1 Gbps of bandwidth between two points in our LAN as in Figure 2.

Scenario 1 objective: verify 1 Gbps of bandwidth between the work area switch in Smith Hall and the SAN switch in the datacenter

Pass criteria: zero lost frames at a 1 Gbps transmit rate, in both directions

Main test device: EtherScope Network Assistant with ITO

Remote test device: EtherScope Network Assistant[1]

Network link under test with switches listed in order from main to remote: Cisco Systems model 2950T,
Extreme Networks model Summit 48,
Extreme Networks model Summit 48,
Extreme Networks model Summit 7i

Network: isolated (traffic only from the test devices)

Traffic type: all 1s

1 When using an EtherScope analyzer as the main device, a second EtherScope Network Assistant, OneTouch Series II Network Assistant or an OptiView Integrated Network Analyzer are compatible remote throughput devices. The maximum throughput rate differs by remote device type.

The first step is to configure the main EtherScope analyzer. We enter the IP address of the remote EtherScope analyzer[2]. We use the default 3842 service port that is compatible with our security system. We define the traffic: a sweep of frame sizes from 64 to 1518 bytes and frame content all 1s. We set a 10-second test duration for each frame size. We temporarily remove all the other hosts from the network to ensure that only the test devices generate traffic during the testing. Finally, we set the data rate to 1000 Mbps. Configuration of the remote EtherScope analyzer is not required. *See Figure 4.*

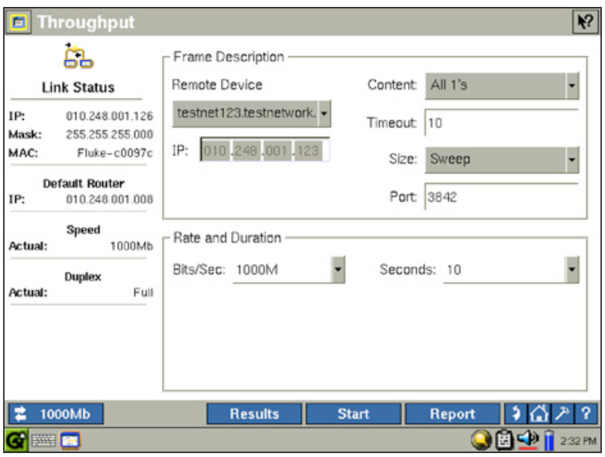

Figure 4: Scenario 1 test configuration

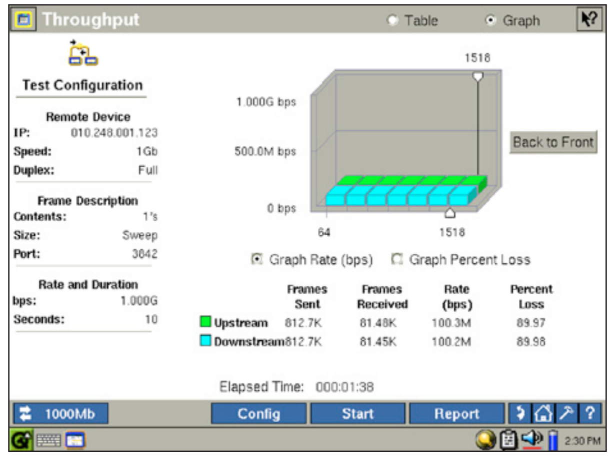

Figure 6: Scenario 1 test results graphically

Next, we start the test. From both main-to-remote and remote-to-main directions, the EtherScope analyzer provides the following information: size of frames sent, number of frames sent, number of frames received, actual throughput rate, and percent of frames lost. *See Figures 5 and 6.*

2 The EtherScope analyzer will automatically discover all compatible throughput remote devices within the same subnet. Enter the IP address manually if the remote device resides in a different subnet.

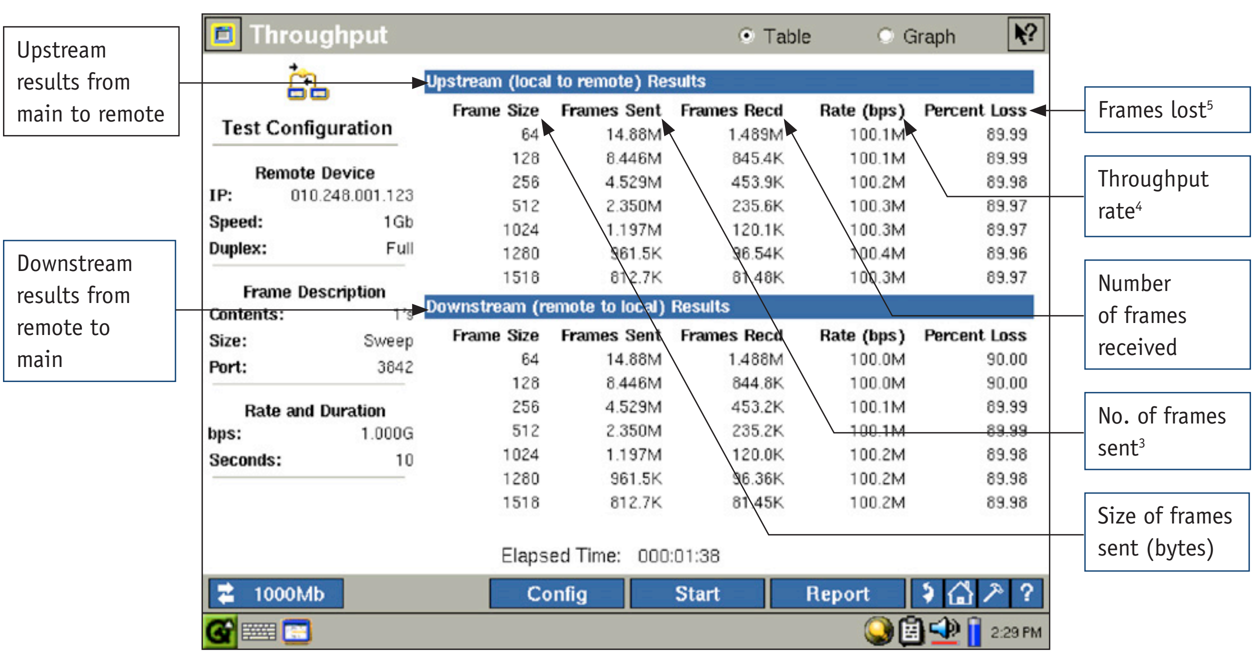

Figure 5: Scenario 1 test results

3 Frames sent = rate (b/s) x duration (s) / frame size (B/f) / 8 (b/B) {note: add 20B to frame size for inter-frame gap (12B/f), pre-amble (7B/f) and start frame delimiter (1B/f)}

4 Throughput rate = frames received (f) x frame size (B/f) x 8 (b/B) / duration (s) {note: add 20B to frame size}

5 Percent loss = (frames sent – frames received) / frames sent

What did we learn? We learned we do not have gigabit bandwidth between the work area switch in Smith Hall and the SAN switch in the datacenter. The actual throughput rate was 100 Mbps. Why? The test devices both linked at 1 Gbps so the bottleneck lies between the switches. We can isolate the cause of the bottleneck by moving one of the test devices to another switch in the network link, re-running the test, and repeating this process until we identify the cause. In this scenario, the port on the Extreme Networks switch that connects to the Cisco Systems switch was configured for 100 Mbps. After correcting this switch configuration issue and running the test, we successfully verified a 1 Gps link between the two locations. *See Figure 7.* It is easy to document these results with the EtherScope analyzer's built-in reporting feature.

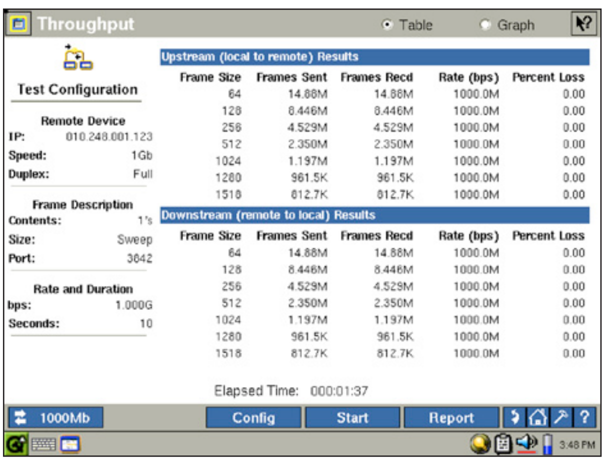

Figure 7: Scenario 1 test results with new switch configuration

Scenario 2

In our second scenario, we want to prove that we have a T1 (1.544 Mpbs) link between the LAN in our corporate headquarters and a remote office LAN as in Figure 3. This is what our internet service provider guarantees.

Scenario 2 objective: verify 1.544 Mbps (T1) of bandwidth between LAN A in our headquarters and LAN B in our remote office

Pass criteria: zero lost frames at 1.544 Mbps transmit rate in both directions

Main test device: EtherScope Network Assistant with ITO

Remote test device: EtherScope Network Assistant

Network link under test:

Cisco Systems model 7204 router,

Cisco Systems model 2821 router

Network: live but quiet

Traffic type: typical

Again, we configure the main EtherScope analyzer. We enter the IP address of the remote EtherScope analyzer. We use the default 3842 service port that is compatible with our firewall. We define the traffic: a sweep of frame sizes and frame content consisting of random bits. We set a 10-second test duration. We will run the test early in the morning on a weekend when there is very little network traffic. Finally, we set the data rate to 1.544 Mpbs. *See Figure 8.*

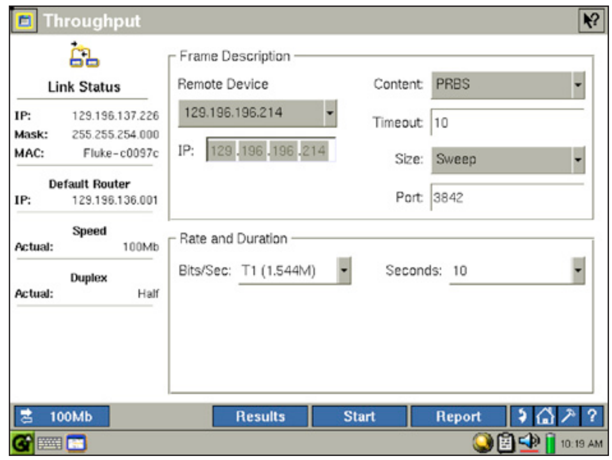

Figure 8: Scenario 2 test configuration

What did we learn after running the test? That we have T1 bandwidth between the two LANs. Our internet service provider is delivering the bandwidth they promised. *See Figure 9.*

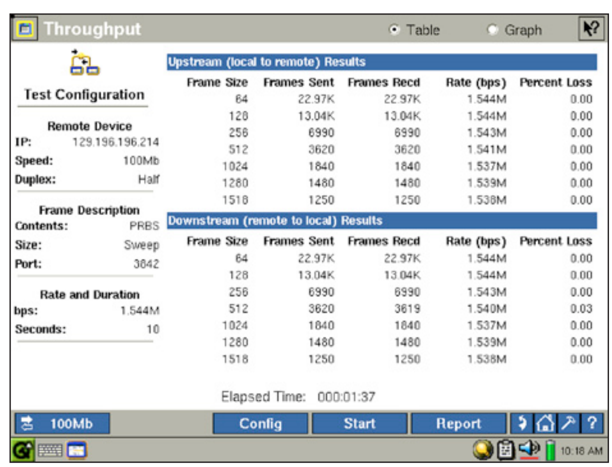

Figure 9: Scenario 2 test results

Scenario 3

In our final scenario, we want to see how traffic affects bandwidth. We have a WAN link between two local networks as in Figure 3. Will changing the frame size change the throughput rate?

Scenario 3 objective: observe throughput rate changes when varying frame sizes
Main test device: EtherScope Network Assistant with ITO
Remote test device: EtherScope Network Assistant
Network link under test:
Cisco Systems model 7204 router,
Cisco Systems model 2821 router
Network: live traffic
Traffic type: typical

We configure the main EtherScope analyzer. We enter the IP address of the remote and use the default 3842 service port. We define the traffic: a sweep of frame sizes and frame content consisting of random bits. We set a 5-second test duration. Then we set the data rate to 20 Mbps, a rate fast enough that we should see some frame lost. *See Figure 10.*

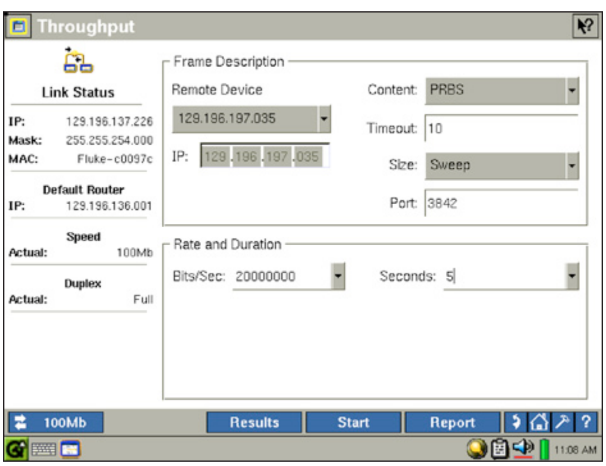

Figure 10: Scenario 3 test configuration

The test results clearly indicate that smaller frame sizes yield slower throughput rates at high transmit rates. *See Figure 11.* A router can only process frames so fast and cannot keep up when there too many frames. In this example, the main test device in the upstream direction transmits 148,800 64-byte frames within 5 seconds at the 20 Mbps rate. For the same duration and rate, the main test device transmits 9615 1280-byte frames – 6.5% of the number of 64-byte frames. The network lost 86% of the 64-byte frames in the main-to-remote direction but no 1280-byte frames. It is also

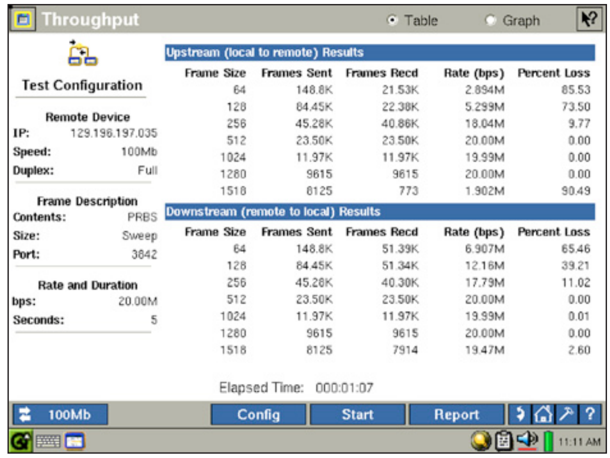

Figure 11: Scenario 3 test results

interesting to observe that frame lost increased with 1518-byte frames. This could be due to the various routing-related information that may be added to the frame depending upon the network configuration, pushing the frame size above 1518. This in turn causes frame fragmentation or discarding of frames, depending upon the configuration. We also see that the main-to-remote throughput rate is different from the remote-to-main throughput rate. There are many potential reasons including differences in infrastructure, networking gear, and the configuration of routers and firewalls.

Note that we ran this test on a live network in the presence of normal network traffic. These results represent the throughput at a particular moment in time, like a snapshot. To get a better understanding of network performance, we recommend repeating the test over time, plotting the results and observing trends. You will be better able to identify problems once you obtain a baseline of normal performance. An isolated network, where only test traffic is present, would yield repeatable results.

Application Note

A throughput test is an effective tool for verifying network bandwidth. For both LAN and WAN links, you can verify that the network can support a given data rate or you can determine the maximum data rate for a network link. You can observe how changes in the network hardware, software or configuration affect throughput. You can see how different traffic types and traffic loads impact throughput. You can plot throughput rates over time to gain a more thorough understanding of network performance and health.

Different test devices are available to test throughput. Before selecting a test device, check out the EtherScope Network Assistant. It tests throughput bi-directionally at rates up to 1 Gbps. It features a simple and intuitive user-interface and built-in reporting, all in a tough, compact and portable platform. Visit **www.flukenetworks.com/etherscope** and take a virtual tour of the EtherScope Network Assistant.

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