Using TrueSpeed™ VNF to Test TCP Throughput in a Call Center Environment

TrueSpeed VNF provides network operators and enterprise users with repeatable, standards-based testing to resolve complaints about poor network performance. Based on IETF RFC 6349 TCP throughput testing methodology, TrueSpeed VNF performance tests serve as a neutral, third-party evaluation of network quality.

One of the most common challenges to offering broadband connectivity services is the measurement of actual achieved throughput. Customers have throughput expectations that are set by the contractual bandwidth they signed up for with their service provider. Designed as a virtualized test suite, TrueSpeed VNF lets carriers and their call center agents identify, understand, and solve throughput problems very easily and efficiently.

This application note briefly describes how TrueSpeed VNF leverages RFC 6349 and explains the steps required to use the solution in a carrier’s call center environment.

RFC 6349 and TrueSpeed VNF

RFC 6349 specifies a practical methodology for measuring end-to-end TCP throughput in a managed IP network with a goal of providing a better indication of the user experience. In the RFC 6349 framework, TCP and IP parameters are also specified to optimize TCP throughput.

RFC 6349 specifies conducting these three test steps:

- Path MTU detection (per RFC 4821) to verify the network maximum transmission unit (MTU) with active TCP segment size testing to ensure that the TCP payload remains unfragmented
- Baseline round-trip delay and bandwidth to predict the optimal TCP window size for automatically calculating the TCP bandwidth delay product (BDP)
- Single and multiple TCP connection throughput tests to verify TCP window size predictions that enable automated “full pipe” TCP testing
RFC 6349 TCP specifies these results and metrics:

- TCP transfer time measures the time it takes to transfer a block of data across simultaneous TCP connections and compares that result with the ideal TCP transfer time, which is derived from the network path bottleneck bandwidth and the various Layer 1/2/3 overheads. TCP efficiency measures the percentage of bytes that do not need to be retransmitted in the transfer and provides insight into packet loss in the network.

- BDP measures the increase in RTT during a TCP throughput test from the baseline RTT, which provides an indication of network congestion during test.

For more information on the RFC 6349 test methodology and an explanation of the test steps and test metrics, please refer to: http://www.viavisolutions.com/sites/default/files/technical-library-items/rfc6349-wp-tfs-tm-ae.pdf.

TrueSpeed is the industry’s first completely automated implementation of RFC 6349. Figure 1 illustrates a traditional scenario using the Viavi Solutions TrueSpeed test.

The advent of virtualized network functions gives network operators increased flexibility when deploying test solutions. TrueSpeed VNF virtualizes TrueSpeed test capability so operators can leverage their existing field test instruments while putting a central TrueSpeed server on commercial off the shelf (COTS) hardware. This enables quick evaluations of customer experience and provides actionable information to resolve any problems discovered. Figure 3 illustrates a typical use case scenario for TrueSpeed VNF.
Client/Server Testing in a Call Center

If a customer calls a service provider customer care call center complaining of low network throughput, the customer care technician can initiate a TrueSpeed VNF test to determine if the network is operating as expected or not. The test process consists of five steps:

1. A business services customer calls the service provider customer care with a complaint.

2. A customer care technician creates a customized TrueSpeed test with an encoded URL.

3. The business customer enters the URL in their web browser and runs the test.

4. The business customer and customer care technician see a common view of test results.

5. Finger pointing ends!

Step 1. A Business Customer Complains

The customer (often an IT professional) may have perceived a problem with their network service due to slow downloads, slow file transfers between locations, sluggish business application performance, or by using a free bandwidth testing tool. Often, the next step that the customer takes is to call their service provider’s customer care for help resolving the problem.

Step 2. A Customer Care Technician Creates a Customized TrueSpeed VNF Test

Network operators typically have customized service offerings to best meet customer needs. This means that every customer may have a different information rate (throughput or CIR) and potentially different quality-of-service (QoS/ DSCP/TOS) parameters associated with their service. TrueSpeed VNF lets the customer care technician create a test with customized test parameters that match the characteristics of the customer’s specific service plan.

The call center technician or engineer enters test parameters for the test, such as customer ID and CIR, and clicks the Generate URL button to create an encoded URL that uniquely identifies the test parameters and the time duration for which the URL is valid. The customer care technician then sends this URL to the customer so that the customer can initiate the test when ready.
Figure 4 shows a TrueSpeed configuration page where a customer care technician creates a customized test. Table 1 shows configurable data for the test.

Table 1. Configurable data for a TrueSpeed VNF configuration page

<table>
<thead>
<tr>
<th>Customer information</th>
<th>Test request information</th>
<th>Test parameters to customize the test to match the customer’s service parameters</th>
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<td>Name, e-mail address, phone number, and company; this data will be used in the test report for tracking purposes.</td>
<td>Technician name, technician ID, and test name; this data will be used in the test report for tracking purposes</td>
<td>Upstream and downstream committed information rate (CIR) are configured to match the throughput parameter for the customer’s service; upstream and downstream CIR can be configured independently</td>
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<td>Test creation date and expiration date to determine the time when the test will be valid; the TrueSpeed VNF server will deny test requests initiated after the expiration date; admin users can configure the default test life and whether or not standard users (such as customer care technicians) can modify test expiration dates</td>
<td>TCP port sets the destination TCP port number for the test traffic sent from the client on the customer’s computer to TrueSpeed VNF; this parameter can be customized to ensure proper traversal of firewalls and NATs</td>
<td>Number of window walks configures how many different target throughput rates will be used in the test; setting this parameter to 1 will create a test with a single target throughput that is equal to the CIR; setting this parameter to 2 or higher will add additional tests with lower target throughputs</td>
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<td>Connection count runs the test with either a specified number of TCP connections (such as 1 for a data backup application) or lets the TrueSpeed VNF server pick the optimal number of TCP connections to simulate multiple users on the service</td>
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Step 3: The Business Customer Runs the Test
Together with the actual URL to run the test, the call center technician provides the business customer with hardware performance requirements of the laptop/desktop computer depending on the CIR to be tested. Supported OSs include Windows XP, Windows 7/8, and LINUX. The business customer then enters the URL into a standard web browser (Internet Explorer, FireFox, Chrome).

The business customer does not need to configure or change any parameters on the test. In addition, once the business customer has the URL, the customer care technician does not need to intervene to change any test parameters.

The TrueSpeed VNF client user interface does not require configuration of any test parameters—these are already encoded in the URL. Upon initiation by the business customer, the TrueSpeed VNF client conducts standard RFC 6349 tests. First, the client and server will measure RTT and MTU size on the link between them and uses them to calculate the associated BDP. It then runs one or more “walk the window” tests, with each test filling the transport pipe to a certain, configurable degree. For each window test, retransmission and RTT statistics are collected and displayed in the detailed test report on the server. The information provided indicates the window size at which any potential problems arise. A window test might pass according to throughput achieved, but if retransmissions start to occur, a shaper/buffer may need tuning.
Step 4. Business Customer and Customer Care Technician See a Common View of Test Results

The results displayed on the client side show a basic view of the RFC 6349 results, providing a very easy-to-read dashboard. Results include:

- Measured maximum segment size (MSS)
- Measured round trip time (RTT)
- Measured throughput vs. target throughput for each window walk

Much more detailed result data appear at the TrueSpeed VNF server at the end of a test. These results are stored in a database for future use or can be accessed as PDF reports. Also, pertinent client computer configuration OS settings such as TCP window settings and a snapshot of simultaneously-running processes are sent back to the server. This client-side configuration data is very valuable since it can provide further insight into possible client-side configuration issues that affect performance.

![Final test status screen on client computer](image)

![Portion of final test report shared with the customer](image)
Table 2. Information reported to customer care technician

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<th>Common view of client results</th>
<th>Information shown to business customer</th>
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<tr>
<td>Results diagnosis</td>
<td>The analytics engine interprets results to determine if the network is performing as expected and indicates the likely source of a problem</td>
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<tr>
<td>Detailed results</td>
<td>Laptop information such as the CPU type, operating system, maximum processor utilization, and a list of processes used to rule in or out poor laptop performance as the cause of poor test results</td>
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<tr>
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<td>Server information such as the CPU type, operating system and maximum processor utilization used to rule in or out poor performance on the server as a cause of poor test results</td>
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<tr>
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<td>Information on each window walk including actual vs. target throughput, buffer delay, TCP efficiency, and graphs of throughput vs. RTT and throughput vs. TCP efficiency over the course of the test</td>
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Step 5. Finger Pointing Ends

The common view of test results lets both the business services customer and the service provider’s customer care technician identify if the network is performing as expected or if there is indeed a problem. If a problem exists, both parties can work together on identifying a solution.

Simple for the customer
Simple for the call center
Objective, pass/fail results

Figure 8. Final test report shown to customer care technician
Problem Scenario Examples
This section shows how TrueSpeed VNF analyzes various problem scenarios, diagnoses causes, and recommends possible solutions covering:

- Policed Traffic Issues — problems caused by a policer when end-user traffic is unshaped
- Network Over-Buffering — due to over-subscription or lower-speed hops
- Inadequate End-Host CPU Resources — where the client laptop is resource-constrained

Policed Traffic Issues
When TCP traffic is sent into a network policer without first being traffic shaped (or conditioned), the resulting throughput can be much lower than the committed information rate (CIR). A traffic policer allows bursts to occur up to the committed burst size (CBS) and drops packets which exceed the contracted CIR and CBS limits. Since unshaped TCP traffic, such as in a Gigabit Ethernet (GE) enterprise network, is inherently bursty, the TCP traffic may experience serious packet drops. This causes TCP to repeatedly enter slow start congestion avoidance.

Figure 9 shows a client laptop and TrueSpeed VNF server communicating through a 100 Mbps CIR and CBS policed network. In this example, the client and server each have GE connections to the switches and the switch WAN is GE as well (but policed to 100 Mbps CIR).

The VNF test is conducted in the manner described in the previous sections and the results are very poor, as seen in the summary report in Figure 10.

![Figure 9. Policed network without traffic shaping](image-url)

![Figure 10. Summary results from a TrueSpeed VNF test](image-url)
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Figure 11 shows the summary results. Throughput was much lower than the target throughput or the Layer 4 CIR (94.93 Mbps). The diagnosis in the network provider report clearly shows that the RFC 6349 TCP efficiency was poor and a possible diagnosis is policer drops (amongst several others).

Figure 11. TCP efficiency points to packet loss

Further examination confirms the extent of the loss as shown in Figure 12, the throughput versus retransmission loss graph.

Network Over-Buffering

Another example problem scenario is the case of network over-subscription. This can result from a “downshift” in network capacity and induced network queuing. Figure 13 shows a WAN network at 100 Mbps link speed with no traffic policing. Client traffic is sent at GE rate and the network is over-subscribed such that egress queuing occurs as the traffic enters the 100 Mbps ports of the Ethernet switches.

Figure 13. Network with lower speed (100 Mbps) WAN

Summary results again show that throughput was much lower than the target throughput or the Layer 4 CIR (94.93 Mbps). The diagnosis in the network provider report shows that the RFC 6349 buffer delay was high. A possible diagnosis, shown in Figure 14, is a slower hop.

Figure 14. Buffer delay points to a slow hop
Further examination confirms the extent of the RTT increase as shown in the throughput versus RTT graph in Figure 15. Notice the relationship of increased RTT to a decrease in TCP throughput and that the buffer delay is nearly 50% over the course of the entire test.

The summary results again show that throughput was much lower than the target throughput or the Layer 4 CIR (94.93 Mbps). The diagnosis in the network provider report shows that the RFC 6349 buffer delay was high. In this case, there are no slower-speed hops so network queuing is not an issue. The diagnosis also shows that the RFC 6349 buffer delay was high, so other possible diagnoses are investigated (Figure 17).

In situations of high buffer delay but good TCP efficiency (100% TCP efficiency means there was no loss), smaller queue settings on interfaces should be considered. Also, link speeds should be verified; sometimes weak links exist due to auto negotiation issues or an old switch that hasn’t been upgraded.

**Inadequate End-Host CPU Resources**

Another problem scenario is the case of end-host CPU resource issues which can either be the result of under-powered hardware or other applications consuming too much CPU. The network configuration shown in Figure 16 is used and in this example, notice that the network is pure GE with no policer and no lower-speed hops. The client traffic test is configured for a target of 100 Mbps CIR.

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Since TrueSpeed VNF is an agent on the client PC, the detailed report shows the model of the client laptop and most importantly the CPU utilization during the test (Figures 18 and 19).
Not only does TrueSpeed VNF indicate that CPU utilization was excessive during the test, it also provides a list of processes running during the test. Virus scanners, replication services, and such can be culprits. In this example, "CPUSTRESS.EXE" was the issue.

In each of these scenarios, the key point is that with TrueSpeed VNF the network provider has unprecedented visibility into network performance characteristics and client-side configuration/resource consumption. No additional interaction with the end customer is required, eliminating time-consuming communications (and miscommunications).

**Conclusion**

TrueSpeed VNF provides network operators and enterprise users with a repeatable, standards-based test methodology to resolve complaints about poor network performance.

With TrueSpeed VNF, operators can leverage their installed base of commercial off the shelf (COTS) server resources to quickly evaluate customer experience of their network and provide actionable information to resolve any problems discovered. Based on IETF RFC 6349 TCP throughput testing methodology, TrueSpeed VNF performance tests serve as a neutral third-party evaluation of network quality. Operating as a virtual network function in conjunction with software hypervisors, Red Hat Linux, and x86 compute resources, TrueSpeed VNF deploys quickly and tests reliably in all parts of an operator or enterprise network.

It enables carriers and their call center agents to identify, understand, and solve Layer 4 throughput problems very easily and efficiently, reducing costs and increasing customer satisfaction.

Moreover, this new virtual approach is leveraging the large installed base of T-BERD/MTS instruments supporting TrueSpeed VNF as well. Together with the well understood RFC 6349 standard, they are building a foundation for useful TCP throughput measurements.