

APPLICATION NOTE

Concurrent Connection and Connection Per Second Testing

How to do basic CC and CPS testing on a firewall.

Rev 3

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APPLICATION NOTE

Firewalls are stateful inline network devices. Unlike a switch/router, a firewall caches TCP session state information in a session table and tracks the session until the session ends.

Different firewalls have different capacities for concurrent TCP connections (TCP CC) due to the finite space in the memory, so this is an important test criterion. Establishing a TCP connection is usually costlier than tearing it down because the firewall must register a new entry into the session table. Thus, how fast a firewall can establish TCP connections (TCP CPS) is another important performance index to test. Firewalls are inline devices - they inspect and forward incoming packets to their intended destinations. If a firewall can't process all the traffic it receives, it will be a performance bottleneck or point of failure on the network. Verifying throughput is therefore also critical when it comes to firewall performance testing.

This Application Note describes how to test these three critical performance parameters for a firewall: TCP CC, TCP CPS, and throughput against different packet sizes.



BASIC CONCEPTS

This section describes the basic concepts that are used in a test configuration.

TCP CONNECTION

A TCP connection is defined by 4 parameters: {source IP address, source port number, destination IP address and destination port number}, e.g. 192.168.1.111:49152 $\leftarrow \rightarrow$ 21.2.3.40:8080.

Source IP address typically describe the IP address of a client, e.g. 192.168.1.111. Source port number describes the application running on the client, e.g. 49152. Destination IP address is the IP address of the server 21.2.3.40, which the client is establishes TCP connections to. Destination port number, 8080, describes the service on the server that listen from incoming TCP connections. Thus, the number of TCP connections is determined by:

 $N_{TCP} = N_{src_ip} \times N_{src_port} \times N_{dst_ip} \times N_{dst_port}$

LOAD PROFILE

A *load profile* describes the "shape" of your traffic load. As shown in the figure below, a basic load profile is defined by 4 parameters:

• Number of concurrent TCP connections

The number of concurrent TCP connections defines how many TCP connections you want your DUT to maintain at any time during the steady phase. Connections may close and open during the test but the total number of concurrent TCP connections is maintained. This parameter is typically related to the TCP CC testing.

• Ramp-up duration

Ramp-up duration defines the time duration for all TCP connections to be established. Increasing or decreasing the ramp-up duration results in a lower or higher connection establish rate. This parameter is typically related to the TCP CPS testing.

• Steady duration

Steady duration defines how long you want the converged traffic status to run on your DUT. Throughput is supposed to reach to the highest since all the TCP connections are established and the concurrent number of connections is maintained. This parameter is usually related to soak testing, where stability of the DUT is tested.

• Ramp-down duration

Ramp-up duration defines the time duration for all TCP connections to be closed. Increasing or decreasing the ramp-down duration results in a lower or higher connection close rate.



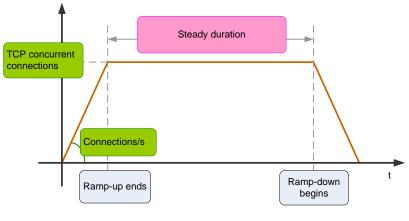


Figure 1. Concept of Load Profile

CONNECTION UPDATE

During the steady phase, connections can open and close at a fixed rate. In order to stabilize the number of concurrent TCP connections, the connection establish rate must equal to connection closure rate, as shown in the figure below.

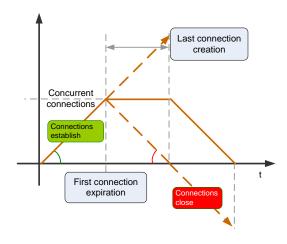


Figure 2. Concept of Connection Update

TCP CC AND CPS TESTING

The scenario to build is shown as in Figure 3. Maximum concurrent TCP connections is 1M. Connections establishment rate is 200K connections/s. Ramp-up duration is 5 seconds. After the ramp-up phase, connections will be created and closed at 200K connections/s, so that the number of concurrent connections does not change during the steady phase. Traffic direction is from servers to clients. In the



ramp-down phase, no more connections are created, and all are closed at 200K connections/s. Packet size is 800 bytes.

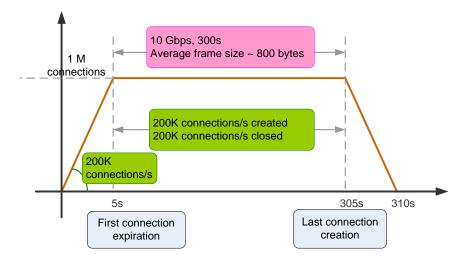


Figure 3. Target Test Scenario

1. CREATE TEST SCENARIO

Create a RAW test scenario. Select No TLS, TCP, and IPv4 as shown below.

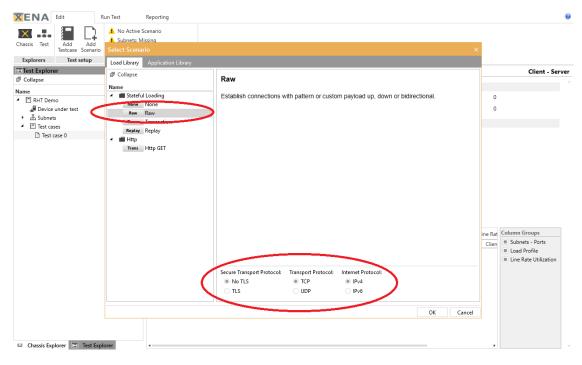


Figure 4. Create RAW Test Scenario



2. CONFIGURE LOAD PROFILE

Expand the test tree in *Test Explorer*, and click *Connection Establishment*.

As shown in Figure 4, change *Number of Source Ports* to 10, and you will see *Total Users: 100,000*, and *Total Connections: 1,000,000*.

Change *Steady* duration to 300 seconds.

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▶ 品 Subner	ts		Server Subnet:	Server IPv4 *	16,777,213	1	11.0.0.2	
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Figure 5. Configure Load Profile

3. CONFIGURE CONNECTION UPDATE

In *Connection Updates* section, change *Connection Rebirth* from *No rebirth* to *With same Src IP*. Delete the value in *Repetitions* or set it to 0 so that the connection opening and closing will continue until the ramp-down phase.

The reason for choosing *With same Src IP* is to avoid IP address depletion during the test. You can also choose *With new Src IP*. If you do so, as soon as a TCP connection is closed, a new connection with a new source IP address will be created. The new source IP address is from the client subnet.



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Figure 6. Configure Connection Updates

4. SET TCP SEGMENT SIZE

In *Test Explorer*, click *Layer 4 – TCP*. In *Maximum TCP Segment Size (Client)*, change value to 746 bytes. By doing this, the clients will advertise this value in their TCP SYN packets and the server will adjust the outgoing TCP segment size accordingly.

To generate traffic of 800-byte frame size, the TCP segment size should be 746 bytes, i.e. 800 bytes (frame size) - 14 bytes (Ethernet header) - 20 bytes (IP header) - 20 bytes of (TCP header).



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 Test cas 			Window Scaling Factor:		2^factor	Window Scaling Factor:		2^factor
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							32	
			Retries:	32		Retries:		
			Back Off:	3		Back Off:	3	
			Timeout Type:	Dynamic *		Timeout Type:	Dynamic *	
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			Timeout Minimum:	200	milliseconds	Timeout Minimum:		milliseconds
			Timeout Maximum:	120000	milliseconds	Timeout Maximum:	120000	milliseconds
			SYN Retransmission (Clie	nt)		SYN Retransmission (Clie	ent)	
			Timeout:	200	milliseconds	Timeout:	200	milliseconds
			Retries:	32		Retries:	32	
			Back Off:	3		Back Off:	3	
🖾 Chassis Exp	olorer 🔳 Test Explo	rer						Ψ.

Figure 7. Set TCP Segment Size

HTTP CC AND CPS TESTING

The scenario to build is shown as in Figure 8. Maximum concurrent HTTP connections is 1M. Connections establishment rate is 200K connections/s. Ramp-up duration is 5 seconds. After the ramp-up phase, connections will be created and closed at 200K connections/s, so that the number of concurrent connections does not change during the steady phase. In the ramp-down phase, no more connections are created, and all are closed at 200K connections/s. Packet size is 800 bytes.



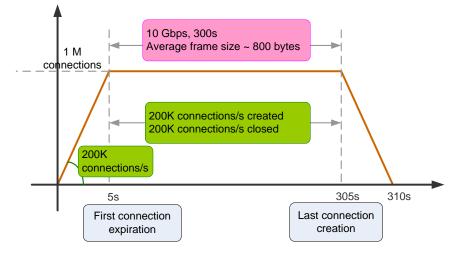


Figure 8. Target Test Scenario

1. CREATE TEST SCENARIO

Create a HTTP GET test scenario. Select No TLS, TCP, and IPv4 as shown below.

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d [□] Collapse			Name		http de l		
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		C	Trans Http GET				
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					OK Cancel		
ta Chassis Exp	lorer \Xi Test E	kplore	r 4			•	

Figure 9. Create HTTP GET Test Scenario

2. CONFIGURE LOAD PROFILE

Expand the test tree in *Test Explorer*, and click *Connection Establishment*.

As shown in Figure 10, change *Number of Source Ports* to 10, and you will see *Total Users: 100,000*, and *Total Connections: 1,000,000*.



Change *Steady* duration to 300 seconds.

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← Response		·			Connection Upd	ates		
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🛍 Chassis Explorer 🔳 Test Explo	orer					Time	[Minutes]	

Figure 10. Configure Load Profile

3. CONFIGURE CONNECTION UPDATE

In *Connection Updates* section, change *Connection Rebirth* from *No rebirth* to *With same Src IP*. Delete the value in *Repetitions* or set it to 0 so that the connection opening and closing will continue until the ramp-down phase.

The reason for choosing *With same Src IP* is to avoid IP address depletion during the test. You can also choose *With new Src IP*. If you do so, as soon as a TCP connection is closed, a new connection with a new source IP address will be created. The new source IP address is from the client subnet.



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Figure 11. Configure Connection Updates

4. SET TCP SEGMENT SIZE

In *Test Explorer*, click *Layer 4 – TCP*. In *Maximum TCP Segment Size (Client)*, change value to 746 bytes. By doing this, the clients will advertise this value in their TCP SYN packets and the server will adjust the outgoing TCP segment size accordingly.

To generate traffic of 800-byte frame size, the TCP segment size should be 746 bytes, i.e. 800 bytes (frame size) - 14 bytes (Ethernet header) - 20 bytes (IP header) - 20 bytes of (TCP header).



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€ R	lesponse		Maximum Value:	1460	bytes	Maximum Value:	1460	bytes	
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			Duplicate ACK Threshold:	3		Duplicate ACK Threshold:	3		
			Retries:	32		Retries:	32		
			Back Off:	3		Back Off:	3		
			Timeout Type:	Dynamic •		Timeout Type:	Dynamic *		
			Timeout:	200	milliseconds	Timeout:	200	milliseconds	
			Timeout Minimum:	200	milliseconds	Timeout Minimum:	200	milliseconds	
			Timeout Maximum:	120000	milliseconds	Timeout Maximum:	120000	milliseconds	
			SYN Retransmission (Cli	ent)		SYN Retransmission (Clie	ent)		
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			Back Off:	3		Back Off:	3		
4 Chassis Exp	olorer 🗉 Test E	xplorer	1						

Figure 12. Set TCP Segment Size

5. SET HTTP REQUEST AND RESPONSE

In *Test Explorer*, click *Request* or *Response* to view/modify the HTTP Request or Response. To modify the payload, click Import on the right side to import any file. The total length of the payload should be less than 256 KB.



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▶ 聶 Subnets Transmit During Ramp Down: ■	
Test cases Transmit Stop Offset: 10 ms	
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Connection Establishment Enable Bursty Traffic: Layer 4 - TCP	
→ Request Traffic Inactive Period: 10 ms	
Response Payload Editor	
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00000040 41 0D 0A A.	·

Figure 13. Set HTTP Request and Response