

### **APPLICATION NOTE**

# Concurrent Connection and Connection Per Second Testing

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

Rev 3

WWW.XENANETWORKS.COM



#### Contents

Applic	ation Note	3
Basic (	Concepts	4
ТСР	Connection	4
Loa	d Profile	4
Con	nection Update	5
TCP C	C and CPS Testing	5
1.	Create Test Scenario	6
2.	Configure Load Profile	7
3.	Configure Connection Update	7
4.	Set TCP Segment Size	
HTTP	CC and CPS Testing	9
1.	Create Test Scenario	10
2.	Configure Load Profile	10
3.	Configure Connection Update	11
4.	Set TCP Segment Size	12
5.	Set HTTP Request and Response	13



## **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.



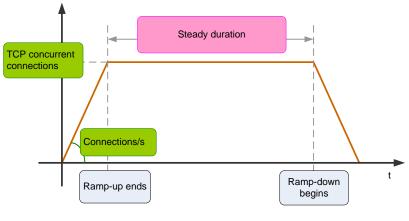


Figure 1. Concept of Load Profile

#### **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.

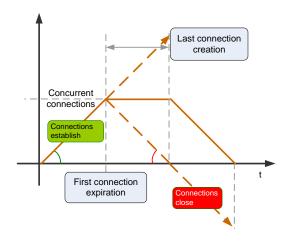


Figure 2. Concept of Connection Update

#### **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.

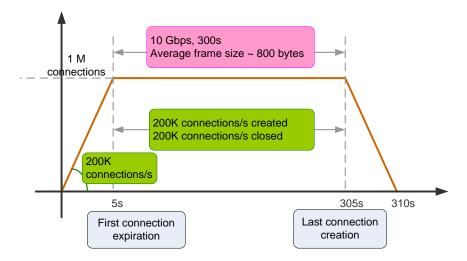


Figure 3. Target Test Scenario

#### **1.** CREATE TEST SCENARIO

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

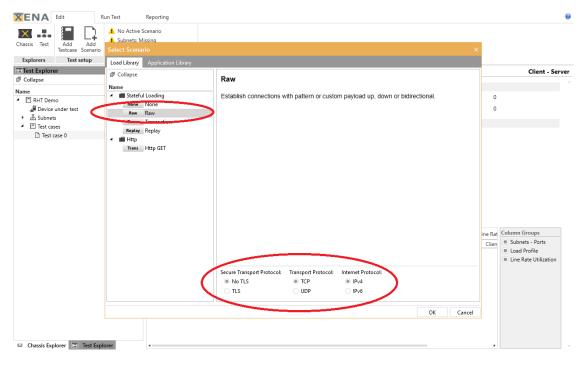


Figure 4. Create RAW Test Scenario



#### 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.

<b>XENA</b>	Edit R	un Test	Reporting					۲
Chassis Test	Add Add Testcase Scenario	<ul> <li>Scenario</li> <li>Network</li> <li>Ports assign</li> </ul>	nments missing					
Explorers	Test setup	Test Cont	figuration State					
Test Explor	er	Ą	Scenario 0					Connection Establishment
Collapse			Subnet Selection					*
Name		Use			Subnet size:	Used IP addresses:	Used IP Range:	
<ul> <li>RHT Den</li> <li>Device</li> </ul>	no e under test		Client Subnet:	Client IPv4 *	16,777,213	100,000	10.0.0.2 - 10.1.134.161	
▶ 品 Subner	ts		Server Subnet:	Server IPv4 *	16,777,213	1	11.0.0.2	
<ul> <li>Inest ca</li> <li>Test</li> </ul>			User Connections Setu					
	Scenario 0		Number of Source Port			Number of Des	stination IP Addresses:	1
00	Connection Establishme	ent	Use Ephemeral Source			Number of De		1
	ayer 4 - TCP			-				
	ayer 3 - IPv4		Source Port Minimum:	49152		Destination Po	rt Minimum:	80
€ [	Downstream		Connections per User:	10				
			Connection Establishn	ent Profile		Connection Up	odates	
		/	Total Users:	100,000		Connection Rel	birth: No rebirth	
			Total Connections:	1,000,000	)	Repetitions:	1	
						Concurrent Us	ers	
			Users Offset	Up Steady Down	Time Scale Segment	s 100.0 k		
			100,000 0	5 300 5	Seconds + Add Remo			
					- nem	50.0 k-		
						0	2 4	6 8
් Chassis Exp	plorer 📃 Test Expl	orer					Time [Min	utes]

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.



<b>XENA</b>	Edit	Run Test	Reporting								0
Chassis Test	Add Add Add Testcase Scenari		-								
Explorers	Test setup	Test Conf	iguration State								
Test Explore	er	Ą	Scenario 0							Conr	ection Establishment
Collapse			Subnet Selection								
Name		Use				Subnet size	: L	Jsed IP addresses:	Used IP Range:		
🖌 🗐 RHT Den			Client Subnet:	Clie	nt IPv4 ▼	16,77	7,213	100,000	10.0.0.2 - 10.1.134.161		
Jevice 사용 Subnet 네 Test ca			Server Subnet:	Serv	erlPv4 ▼	16,77	7,213	1	11.0.0.2		
▲ ☐ Test of		=	User Connections Setu	р							
A Raw	Scenario 0		Number of Source Port	5:	10			Number of De	stination IP Addresses:	1	
	Connection Establis	nment	Use Ephemeral Source					Number of De		1	
	ayer 4 - TCP.		Source Port Minimum:	Fort hange.							
	ayer 3 - IPv4				49152			Destination Po	rt Minimum:	80	
€0	Downstream		Connections per User:		10						
			Connection Establishm	nent Profile				Connection Up			
			Total Users:		100,000			Connection Re	birth: With same Src IP	· )	
			Total Connections:		1,000,000			Repetitions:			
								Concurrent Us	ers		
			Users Offset	Up Steady	Down	Time Scale 5	eqments	100.0 k			
			100.000 0	5 300	1		+ Add	_			
				-	-		× Remove				
								20			
								툴 50.0 k			
								0			
									2	4	6 8
් Chassis Exp	plorer \Xi Test E	kplorer							Time	[Minutes]	÷

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).



<b>XENA</b>	Edit Ru	in Test	Reporting					0
Chassis Test		<ul> <li>Scenario</li> <li>Network</li> <li>Ports</li> </ul>						
Explorers	Test setup	Test Conf	iguration State					
Test Explore	er	Ą	Scenario 0					Layer 4 - TCP
In Collapse			TCP (Client)			TCP (Server)		*
A RHT Dem	-	Use	TCP Congestion Mode:	New Reno 🔻		TCP Congestion Mode:	New Reno *	
Revice			Window Size:	65535	bytes	Window Size:	65535	bytes
▶ 品 Subnet	s		Enable Window Scaling:			Enable Window Scaling:		-
<ul> <li>Test cas</li> </ul>			Window Scaling Factor:		2^factor	Window Scaling Factor:		2^factor
A D Test of A Raw	ase 0 Scenario 0		Mammum TCP Segment			Maximum TCP Segment		
	onnection Establishme	nt 🖉	Modifier Type:	Fixed *		Modifier Type:	Fixed *	
<> La	ayer 4 - TCP		Value:	746	bytes	Value:		bytes
	ayer 3 - IPv4	(	Minimum Value:		bytes	Minimum Value:		bytes
€D	lownstream		Maximum Value:	1460	butes	Maximum Value:		bytes
			Retransmission (Client)	1400			1400	bytes
			Retransmission (Client) Duplicate ACK Threshold:	3		Retransmission (Server) Duplicate ACK Threshold:	3	
							32	
			Retries:	32		Retries:		
			Back Off:	3		Back Off:	3	
			Timeout Type:	Dynamic *		Timeout Type:	Dynamic *	
			Timeout:		milliseconds	Timeout:		milliseconds
			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.



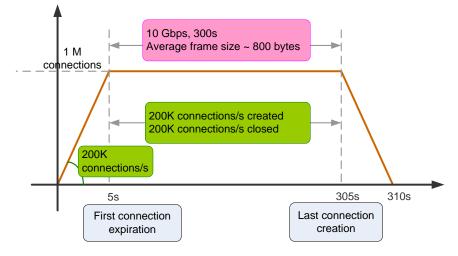


Figure 8. Target Test Scenario

#### **1.** CREATE TEST SCENARIO

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

<b>XENA</b>	Edit	Run	Test Reporting				
X		4	No Active Scenario				
Chassis Test	Add Add Testcase Scenari	io A	Select Scenario	1	×		
Explorers	Test setup		Load Library Application Librar				
Test Explore	er		d Collapse		Http GET		Client
d <sup>□</sup> Collapse			Name		http de l		
Name			🔺 💼 Stateful Loading		Establish connections with a Http GET request, response payload pattern.		
	teful Load Testing		None None			0	
🚚 Device			Raw Raw			0	
▶ 品 Subnet			Trans Transaction				
🖌 🔳 Test cas			Replay Replay				
🗋 Test c	ase 0	-	и 📓 пар	-			
		C	Trans Http GET				
						LTR	Column Groups
						TX	Subnets - Ports
							Load Profile
							Line Rate Utilization
					Secure Transport Protocol: Internet Protocol:		
				1	No TLS     IPv4		
					⊖ TLS O IPv6		
					OK Cancel		
					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.

ENA Edit Ri	un Test	Reporting						
Chassis Test Add Add Testcase Scenario	<ul> <li>Scenario</li> <li>Network</li> <li>Ports assign</li> </ul>	-						
Explorers Test setup	Test Conf	figuration State						
Test Explorer	ą	Scenario 0						Connection Establishme
ම් Collapse		Subnet Selection						
Name	Use			Subnet size:	Used IP addresses:	Used IP Range:		
<ul> <li>Basic Stateful Load Testing</li> </ul>		Client Subnet:	Client IPv4 🔻	16,777,213	100,000	10.0.0.2 - 10.1.134.161		
Device under test								
▶ 🖧 Subnets		Server Subnet:	Server IPv4 *	16,777,213	1	11.0.0.2		
Test cases     Test case 0		User Connections Setu	-					
<ul> <li>Test case 0</li> <li>Trans Scenario 0</li> </ul>								
Connection Establishme	ant	Number of Source Ports	: 10	)	Number of Desti	nation IP Addresses:	1	
Layer 4 - TCP	Linc	Use Ephemeral Source F	Port Range: 🔳 🛛 💛		Number of Desti	nation Ports:	1	
<> Layer 3 - IPv4		Source Port Minimum:	49152		Destination Port	Minimum:	80	
→ Request		Connections per User:	10					
← Response		·			Connection Upd	ates		
		Connection establishm			Connection Rebi		*	
	- C	Total Users:	100,000			No rebirtir		
		Total Connections:	1,000,000		Repetitions:			
					Concurrent User	\$		
		Users Offset	Up Steady Down	ime Scale Segments	100.0 k			
	( (	100,000 0	5 300 5	Seconds + Add				
				× Remov	/e			
					2			
					išj 50.0 k-			
					0			
					0	2	4	6 8
🛍 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.



XENA	Edit	Run Test	Reporting						
Chassis Test	Add Add Testcase Scena	io 🛕 Ports assign	nments missing						
Explorers	Test setup	Test Con	figuration State						
Test Explore	er	Ф	Scenario 0						Connection Establ
d Collapse			Subnet Selection						
Name		Use			Subnet	size:	Used IP addresses:	Used IP Range:	
<ul> <li>Basic Stat</li> <li>Bevice</li> </ul>	teful Load Testing under test		Client Subnet:	Client IP	v4 * 1	6,777,213	100,000	10.0.0.2 - 10.1.134.161	
▶ 品 Subnets ▲ 王 Test cas			Server Subnet:	Server IP	v4 * 1	6,777,213	1	11.0.0.2	
🖌 🗋 Test c			User Connections Setu	qu					
Trans	Scenario 0		Number of Source Port	e.	10		Number of De	stination IP Addresses:	1
<> C	onnection Establis	hment	Use Ephemeral Source	Dant Danasa 🗐			Number of De	stination Ports:	1
	ayer 4 - TCP			-					
	ayer 3 - IPv4		Source Port Minimum:	4	9152		Destination Po	rt Minimum:	80
	equest		Connections per User:		10				
€ Re	esponse		Connection Establishm	nent Profile			Connection Up	odates	
			Total Users:	100	,000		Connection Re	birth: With same Src IP	•
			Total Connections:	1,000	,000		Repetitions:		
							Concurrent Us	ers	
			Users Offset	Up Steady E	Down Time Scale	Segments	100.0 k		
			100,000 0	5 300	5 Seconds	+ Add			
						× Remove			
							2		
							So.0 k		
							0	2	4 6 8
台 Chassis Exp	olorer 🔳 Test B	xplorer						Time	[Minutes]

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).



<b>XENA</b>	Edit	Run Test	Reporting						۲
Chassis Test	Add Add Scenar	rio 🥼 Ports assig	nments missing						
Explorers	Test setup	Test Cor	figuration State						
Test Explore	er	¢.	Scenario 0					La	ayer 4 - TCI
Collapse			TCP (Client)			TCP (Server)			
Name	teful Load Testing	Use	TCP Congestion Mode:	New Reno 🔻		TCP Congestion Mode:	New Reno *		
	under test		Window Size:	65535	bytes	Window Size:	65535	bytes	
► 🖧 Subnet			Enable Window Scaling:		-,	Enable Window Scaling:		] -,	
🖌 🛅 Test ca			Window Scaling Factor:		2^factor	Window Scaling Factor:		2^factor	
<ul> <li>Test of</li> <li>Trans</li> </ul>			-		2 Inctor	-			
	<ul> <li>Scenario 0</li> <li>Connection Establis</li> </ul>	hmant	Maximum TCP Segment Modifier Type:	Fixed T		Maximum TCP Segment Modifier Type:	Fixed *		
	ayer 4 - TCP	in the second seco							
<> L	ayer 3 - IPv4		Value:	/40	byte	Value:		bytes	
	lequest		Minimum Value:		bytes	Minimum Value:		bytes	
€ R	lesponse		Maximum Value:	1460	bytes	Maximum Value:	1460	bytes	
			Retransmission (Client)			Retransmission (Server)			
			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)		
			Timeout:	200	milliseconds	Timeout:	200	milliseconds	
			Retries:	32		Retries:	32		
			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.



XENA	Edit	R	un Test	Reporting								
Chassis Test	Add Testcase	Add Scenario	<ul> <li>Scenario</li> <li>Network</li> <li>Ports assign</li> </ul>	ments missing								
Explorers	Test s	etup	Test Conf	iguration State								
Test Explore	er		ф.	→ Request								Reques
Collapse												
Name			Use	Payload Configuration				Transmit Setup				
🖌 🔳 Basic Stat	teful Load T	esting		Pattern total length:	42 bytes			Transmit During Ramp Up:	-			
	under test							Transmit Start Offset:		ms		
▶ 品 Subnet								Transmit During Ramp Down:				
<ul> <li>Test case</li> </ul>								Transmit Stop Offset:		ms		
Test of Trans									10	11.5		
	Scenario							Traffic Burst				
	ayer 4 - TCF		ent					Enable Bursty Traffic:				
	ayer 3 - IPv4							Traffic Busy Period:		ms		
	lequest							Traffic Inactive Period:		ms		
€ R	lesponse			Payload Editor								
				-							Segments	i i i
				Segment/Field Name	e Value		Named Val	ues			+ Import	
				r I≣ nequest							× Remove	
											- nemore	-
				00000000 47 45 5	54 20 2F 20 48 54 54 50 2F	31 2E 31 0D 0A	GET / HTTP/	1.1			^ Navigate	i
				00000010 48 6F 7	73 74 3A 20 77 77 77 2E 79		Host: www.y				<ul> <li>Previous</li> </ul>	
				00000020 73 74 2	2E 63 6F 6D 0D 0A 0D 0A		st.com				▼ Next	
											*	

Scenario	
Chassis Test Add Add Add Testcare Scenario A Ports assignments missing	
Explorers Test setup Test Configuration State	
Test Explorer	Response
ම් Collapse	
Name Use Payload Configuration Transmit Setup	
<ul> <li>Basic Stateful Load Testing</li> <li>Pattern total length: 67 bytes</li> <li>Transmit During Ramp Up:</li> </ul>	
Je Device under test Transmit Start Offset: 10 ms	
▶ 聶 Subnets Transmit During Ramp Down: ■	
Test cases     Transmit Stop Offset: 10 ms	
Trans Scenario 0     Traffic Burst     Connection Establishment     Eachle Purch Traffic	
Connection Establishment Enable Bursty Traffic: Layer 4 - TCP	
→ Request Traffic Inactive Period: 10 ms	
Response Payload Editor	
Segment/Field Name Value Named Values	Segments
▶ III Response	+ Import
	× Remove
00000000 48 54 54 50 27 31 22 31 20 33 03 20 47 48 50 HTTP/1.1 200 0K. 00000010 0A 43 56 FE 74 56 5C 74 2D 4C 56 5E 57 46 53 A. COLLENT-LEARTH:	^ Navigate
0000000 20310 D0 A 43 6F 6E 74 55 6E 74 2D 54 79 70 65 1Content-Type	<ul> <li>Previous</li> </ul>
00000030 3A 20 74 65 78 74 2F 70 6C 61 69 6E 0D 0A 0D 0A : text/plain	▼ Next
00000040 41 0D 0A A.	·

Figure 13. Set HTTP Request and Response