Spirent SD-WAN Functional Test Suite Specification

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Overview

Software-defined networking (SDN) technology is an approach to cloud computing that facilitates network management and enables programmatically efficient network configuration in order to improve network performance and monitoring. SDN is meant to address the fact that the static architecture of traditional networks is decentralized and complex while current networks require more flexibility and easy troubleshooting. SDN attempts to centralize network intelligence in one network component by disassociating the forwarding process of network packets (data plane) from the routing process (control plane). The control plane consists of one or more controllers which are considered as the brain of SDN network where the whole intelligence is incorporated. However, the intelligence centralization has its own drawbacks when it comes to security, scalability and elasticity and this is the main issue of SDN.

An SD-WAN is a Wide Area Network (WAN) managed using the principles of software-defined networking. The main driver of SD-WAN is to lower WAN costs using more affordable and commercially available leased lines, as an alternative or partial replacement of more expensive MPLS lines. Control and management are administered separately from the hardware with central controllers allowing for easier configuration and administration.

Test Pack Specification

Testing and evaluate SD-WAN device and SD-WAN service is challenge for many SD-WAN subscribers. Many SD-WAN subscribers don't have too much experience on network testing, they need a packaged SD-WAN test suite, the test suite which should be:

- Easy to deploy
- Easy to use
- With clear result output

Based on powerful test instrument and rich test experience, Spirent SD-WAN Test Pack provides a series of test cases for users to evaluate functionality and performance of their SD-WAN device and SD-WAN service.

Attribute	Description
Test Pack Name	SD-WAN
Test Areas	• Path Selection • Resiliency -- Link Blackout • Resiliency -- Link Brownout
Test Case Count	9 cases
DUT/SUT	SD-WAN router, virtual appliance and SDN controller
Test Instrument	Spirent Test Center (STC), Spirent Network Emulator (SNE)

Test Configuration

STC Configuration

Device configuration #1

Port	Device Block	Device Count	IPv4 address	IPv4 prefix length	Gateway	Link
Local	Local_Head	1	150.0.0.1	24	150.0.0.2	
	Local_Device1	100	101.0.0.1 to 101.0.0.100	24		L3 forwarding link to Local_Head
	Local_Device2	100	102.0.0.1 to 102.0.0.100	24		L3 forwarding link to Local_Head
Remote	Remote_Head	1	150.0.1.1	24	150.0.1.2	
	Remote_Device1	200	200.0.0.1 to 200.0.0.200	24		L3 forwarding link to Remote_Head

Device configuration #2

Port	Device Block	Device Count	IPv4 address	IPv4 prefix length	Gateway	Link
Local	Local_Head	1	150.0.0.1	24	150.0.0.2	
	Local_Device1	10	101.0.0.1 to 101.0.0.10	24		L3 forwarding link to Local_Head
Remote	Remote_Head	1	150.0.1.1	24	150.0.1.2	
	Remote_Device1	20	200.0.0.1 to 200.0.0.20	24		L3 forwarding link to Remote_Head

Stream configuration #1

Stream	Source endpoint	Destination endpoint	Packet length	Protocol	port number (Dport if not specified)	Packet pattern	Traffic rate	Duration
1	Local_Device1	Remote Device1	1024	TCP	80	Constant (0000)	1Mbps	60sec
2	Local_Device2	Remote Device1	1024	TCP	80	Constant (0000)	1Mbps	60sec
3	Local_Device1	Remote Device1	1024	UDP	5060	Constant (0000)	1Mbps	60sec
4	Local_Device2	Remote Device1	1024	UDP	5060	Constant (0000)	1Mbps	60sec
5	Local_Device1	Remote Device1	1024	UDP	50050 to 50098, even	Constant (0000)	1Mbps	60sec
6	Local_Device2	Remote Device1	1024	UDP	50050 to 50098, even	Constant (0000)	1Mbps	60sec
7	Local_Device1	Remote Device1	1024	UDP	50050 to 50100, odd	Constant (0000)	1Mbps	60sec
8	Local_Device2	Remote Device1	1024	UDP	50050 to 50100, odd	Constant (0000)	1Mbps	60sec

Stream configuration #2

Stream	Source endpoint	Destination endpoint	Packet length	Protocol	port number (Dport if not specified)	Packet pattern	Traffic rate	Duration
1	Local_Device1	Remote Device1	1024	TCP	80	Constant (0000)	1Mbps	continuous
2	Local_Device2	Remote Device1	1024	TCP	80	Constant (0000)	1Mbps	continuous
3	Local_Device1	Remote Device1	1024	UDP	50050 to 50098, even	Constant (0000)	1Mbps	continuous
4	Local_Device2	Remote Device1	1024	UDP	50050 to 50098, even	Constant (0000)	1Mbps	continuous

ALP load profile #1

Load Type	Random Seed	Max Connections Attempted	Max. Open Connections	Max. Transactions Attempt
Connection Per Time Unit	123456	1500	20	4294967295

Phase	Load Pattern	Duration Unit	Repetitions	Height	Ramp Time	Steady Time	Period
Delay (1)	Flat	Seconds	NA	0	0	5	NA
Ramp Up (2)	Stair	Seconds	1	10	10	0	NA
Stair Step (3)	Stair	Seconds	5	4	5	5	NA
Steady Step (4)	Stair	Seconds	1	0	0	30	NA
Ramp Down (5)	Flat	Seconds	NA	0	0	20	NA

ALP load profile #2

Lode Type	Random Seed	Max Connections Attempted	Max. Open Connections	Max. Transactions Attempt
Connection Per Time Unit	123456	200	10	4294967295

Phase	Load Pattern	Duration Unit	Repetitions	Height	Ramp Time	Steady Time	Period
1	Flat	Seconds	NA	4	180	0	NA

SUT Configuration

SD-WAN edge device configuration #1

SD-WAN edge 1

Port	IPv4 address	IPv4 subnet mask
To STC port ‘Local’	150.0.0.2	255.255.255.0
To MPLS	Real or simulated WAN link	
To Internet	Real of simulated WAN link	

SD-WAN edge 2

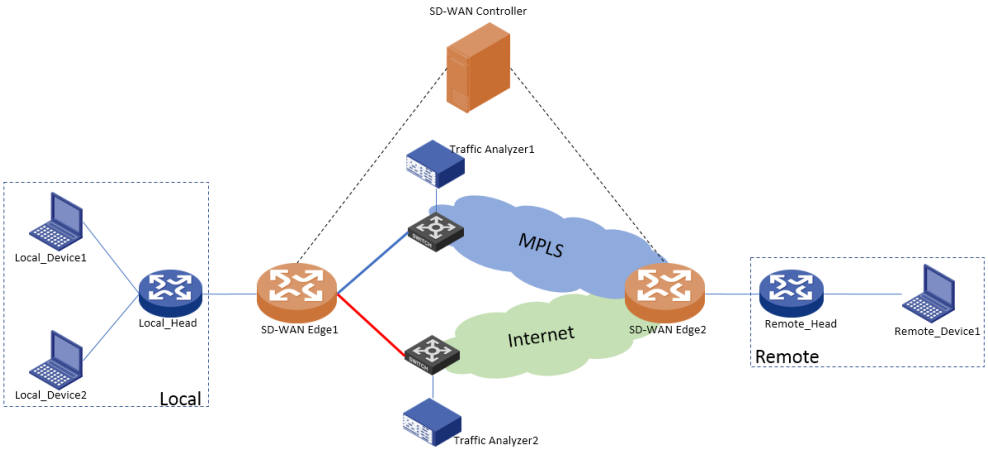
Port	IPv4 address	IPv4 subnet mask
To STC port ‘Remote’	150.0.1.2	255.255.255.0
To MPLS	Real or simulated WAN link	
To Internet	Real of simulated WAN link	

Test Case Specification

Path Selection

SD-WAN Path Selection L2 To L4 Steering

Test Case Name	SD-WAN Path Selection L2 To L4 Steering
Test Case ID	sd-wan.path_selection.001
Test Area	Path Selection
Test Objective	Validate DUT is able to steer traffic among WAN links by using traditional L2/L3/L4 traffic classification method.

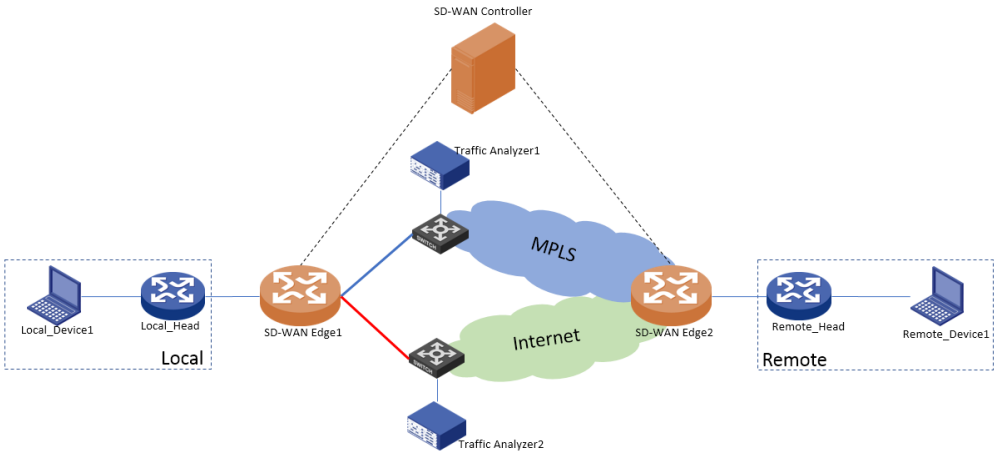
Test Type	Functional
Topology Name	4stc_2dut_type01
Topology	
Test Instrument	Spirent Test Center
Prerequisites	Connect STC, Switches and DUT as per test topology.
Pre-Configuration	**<STC Configuration>** Device: Device configuration #1 Stream: Stream configuration #1 **<SUT Configuration>** SD-WAN edge: SD-WAN edge device configuration #1 SD-WAN Controller: Proper policies must be applied to SD-WAN edges to steer stream 1, 4, 5, 7 towards Internet link and steer stream 2, 3, 6 ,8 towards MPLS link. **<Peripheral Devices Configuration>** Switches: Mirror bidirectional packets forwarded on MPLS WAN link to Traffic Analyzer 1 Mirror bidirectional packets forwarded on Internet WAN link to Traffic Analyzer 2
Customizable Test Parameters	**STC:** IPv4 address and gateway of Local_Device1 IPv4 address and gateway of Local_Device2 IPv4 address and gateway of Local_Head IPv4 address and gateway of Remote_Device1 IPv4 address and gateway of Remote_Head

Test Sequence	Step	Type	Description	Expected Result
	1	Action	Perform ARP on all STC devices and all stream blocks	All ARPs are resolved successfully
	2	Action	Start stream 1, 4, 5 and 7	All generators are started successfully
	3	Action	Wait for traffic to stop	All generators are stopped successfully

	4	Check	Check stream forwarding status	Stream 1, 4, 5 and 7 are received on remote STC port without packet loss or duplication Packets of stream 1, 4, 5 and 7 should be received on Traffic Analyzer 2 Packets of stream 1, 4, 5 and 7 should not be received on Traffic Analyzer 1
	5	Action	Start stream 2, 3, 6 and 8	All generators are started successfully
	6	Action	Wait for traffic to stop	All generators are stopped successfully
	7	Check	Check stream forwarding status	Stream 2, 3, 6 and 8 are received on remote STC port without packet loss or duplication Packets of stream 2, 3, 6 and 8 should be received on Traffic Analyzer 1 Packets of stream 2, 3, 6 and 8 should not be received on Traffic Analyzer 2
Results and Outputs	1. STC Configuration; 2. Script output; 3. STC detailed results (get it by using “Save Results” command), result view “Stream Block Results”, “Stream Block Results” and “Port Traffic Results” must be included; 4. STC logs (BLL/IL/Chassis); 5. DUT logs if possible.			
PASS/FAIL Criteria	PASS criteria: 1. All stream blocks are received at remote STC port without packet loss or duplication; 2. All stream blocks are steered towards expected link.			

SD-WAN Path Selection Application Aware Steering

Test Case Name	SD-WAN Path Selection Application Aware Steering
Test Case ID	sd-wan.path_selection.002
Test Area	Path Selection
Test Objective	Validate DUT can steer traffic among WAN links by using application aware traffic classification method.
Test Type	Functional
Topology Type	4stc_2dut_type01

Topology	
Test Instrument	Spirent Test Center
Prerequisites	Connect STC, Switches and DUT as per test topology.
Pre-Configuration	**<STC Configuration>** Device: Device configuration #2 HTTP client on Local_Device1: Connected Server: Remote_Device1 Client HTTP Profile: default profile Client Load Profile: ALP load profile #1 HTTP Server on Remote_Device1 Max Requests per Client: 10 Max Simultaneous Clients: 4294967295 Server HTTP Profile: default profile SIP Caller on Local_Device1 Callee Side: Remote_Device1 SIP UA Client Profile: default profile SIP Load Profile: ALP load profile #2 SIP Callee on Remote_Device1 SIP UA Client Profile: default profile UA number format on the two devices must be identical. **<SUT Configuration>** SD-WAN edge: SD-WAN edge device configuration #1 SD-WAN Controller: Proper application aware policies must be applied to SD-WAN edge to steer HTTP traffic towards Internet link and steer SIP/RTP/RTCP traffic towards MPLS link. **<Peripheral Devices Configuration>** Switches: Mirror bidirectional packets forwarded on MPLS WAN link to Traffic Analyzer 1 Mirror bidirectional packets forwarded on Internet WAN link to Traffic Analyzer 2
Customizable Test Parameters	**STC:** IPv4 address and gateway of Local_Device1 IPv4 address and gateway of Local_Head IPv4 address and gateway of Remote_Device1 IPv4 address and gateway of Remote_Head

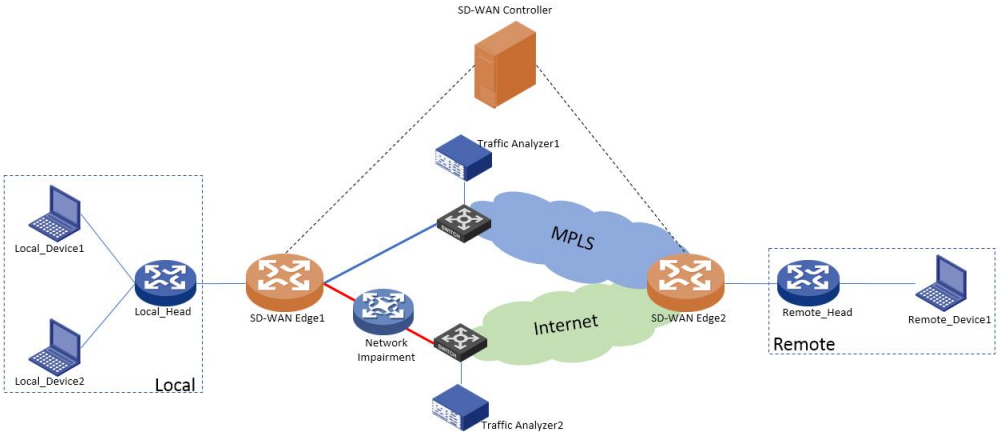
Test Sequence	Step	Type	Description	Expected Result
	1	Action	Perform ARP on all STC devices and all stream blocks	All ARPs are resolved successfully

	2	Action	Start HTTP server	HTTP server is started successfully
	3	Action	Start HTTP client	HTTP client is started successfully
	4	Action	Wait till all HTTP connections and transactions are done	HTTP connection count is 1500, HTTP transaction count is 15000
	5	Check	Check HTTP related results	All HTTP connections and transactions are finished without failure
	6	Check	Check received packets on Traffic Analyzers	HTTP packets from local to remote should be received on Traffic Analyzer 2
	7	Action	Start SIP caller	SIP client is started successfully
	8	Action	Wait till all SIP calls are done (Totally 200 calls)	200 calls are attempted
	9	Check	Check SIP related results	All SIP calls are finished without failure, Call Success Percentage should be 100%
	10	Check	Check received packets on Traffic Analyzers	SIP/RTP/RTCP packets from local to remote should be received on Traffic Analyzer 1
Results and Outputs	1. STC Configuration; 2. Script output; 3. STC detailed results (get it by using “Save Results” command), result view “HTTP Client Results”, “HTTP Server Results”, “SIP UA Results”, “Stream Block Results”, “Stream Block Results” and “Port Traffic Results” must be included; 4. STC logs (BLL/IL/Chassis); 5. DUT logs if possible.			
PASS/FAIL Criteria	PASS criteria: 1. All HTTP connections and transactions are finished without failure; 2. All SIP calls are finished without failure, Call Success Percentage should be 100%; 3. All HTTP traffic are steered towards Internet link without packet loss; 4. All SIP/RTP/RTCP traffic are steered towards MPLS link without packet loss.			

Link Resiliency

SD-WAN Resiliency Link Blackout Local No Congestion

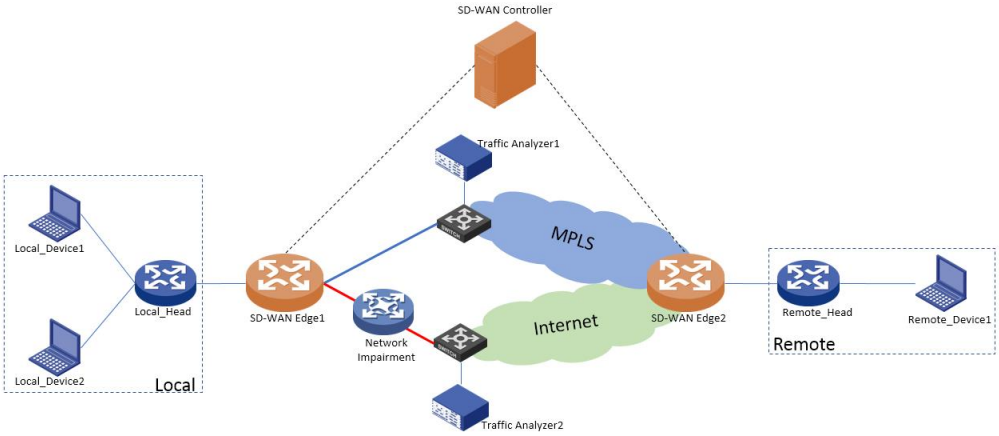
Test Case Name	SD-WAN Resiliency Link Blackout Local No Congestion
Test Case ID	sd-wan.resiliency_link.001
Test Area	Resiliency link blackout

Test Objective	Validate DUT can steer traffic from Internet link to MPLS link if link blackout was detected on local side of Internet link and vice versa.
Test Type	Functional
Topology Type	4stc_1sne_2dut_type01
Topology	
Test Instrument	Spirent Test Center, Spirent Network Emulator
Prerequisites	Connect STC, SNE, Switches and DUT as per test topology.
Pre-Configuration	**<STC Configuration>** Device: Device configuration #1 Stream: Stream 1 to 4 in Stream configuration #2 **<SUT Configuration>** SD-WAN edge: SD-WAN edge device configuration #1 SD-WAN Controller: Proper policies must be applied to SD-WAN edge to: • Steer stream 1 and 3 towards Internet link and steer stream 2 and 4 towards MPLS link. • If Internet link down is detected by SD-WAN edge, SD-WAN edge should steer stream 1 and 3 to MPLS link • After Internet link resume, stream 1 and 3 should be steered back to Internet link **<SNE configuration>** Set SNE attribute 'Idle traffic flow setting' (in Settings – General Settings…) to "Actively route traffic whilst unit is idle". **<Peripheral Devices Configuration>** Switches: Mirror bidirectional packets forwarded on MPLS WAN link to Traffic Analyzer 1 Mirror bidirectional packets forwarded on Internet WAN link to Traffic Analyzer 2
Customizable Test Parameters	**STC:** IPv4 address and gateway of Local_Device1 IPv4 address and gateway of Local_Device2 IPv4 address and gateway of Local_Head IPv4 address and gateway of Remote_Device1 IPv4 address and gateway of Remote_Head **Timers:** Wait time (seconds) after link blackout (30 seconds by default) Wait time (seconds) after link recovery (30 seconds by default)

Test Sequence	Step	Type	Description	Expected Result
	1	Action	Perform ARP on all STC devices and all stream blocks	All ARPs are resolved successfully
	2	Action	Start traffic on all STC ports	All generators are started successfully
	3	Action	Impairment tool: Emulate SD-WAN Edge 1 facing port down (physically down)	DUT is able to detect the link failure and steer stream 1 and 3 to MPLS link; Stream 2 and 4 should not be impacted; Verify DUT behavior by checking packets received at Traffic Analyzer 1 and 2.
	4	Action	Stop traffic	All generators are stopped successfully
	5	Check	Record out of service time	
	6	Action	Start traffic on all STC ports	All generators are started successfully
	7	Action	Stop impairment	DUT is able to detect the link is resumed and steer stream 1 and 3 back to Internet link; Stream 2 and 4 should not be impacted; Verify DUT behavior by checking packets received at Traffic Analyzer 1 and 2.
	8	Check	Record recovery time	
Results and Outputs	1. STC Configuration; 2. Script output with out of service time and recovery time; 3. STC detailed results (get it by using “Save Results” command), result view “Stream Block Results”, “Stream Block Results” and “Port Traffic Results” must be included; 4. Out of service time and recovery time; 5. STC logs (BLL/IL/Chassis); 6. DUT logs if possible.			
PASS/FAIL Criteria	PASS criteria: 1. DUT can correctly detect link blackout and resume; 2. Stream 1 and 3 are correctly steered in link blackout and resume; 3. Forwarding of stream 2 and 4 are not impacted by link blackout and resume.			

SD-WAN Resiliency Link Blackout Remote No Congestion

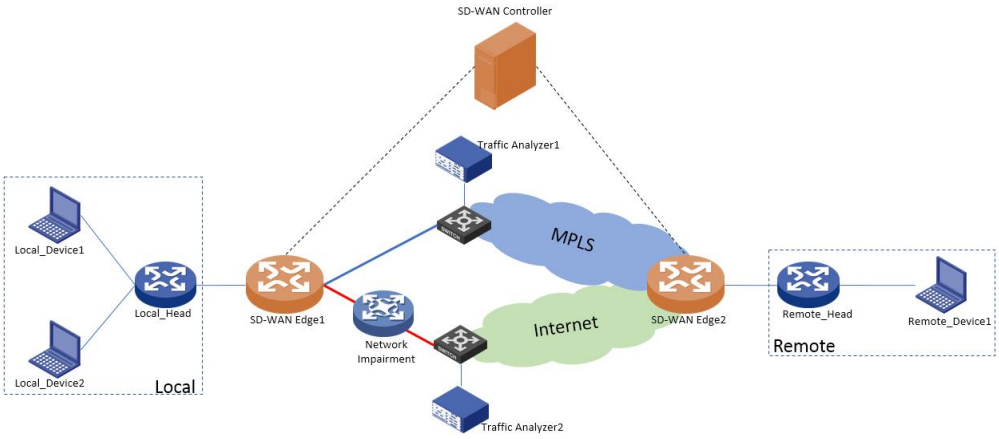
Test Case Name	SD-WAN Resiliency Link Blackout Remote No Congestion
Test Case ID	sd-wan.resiliency_link.002

Test Area	Resiliency link blackout
Test Objective	Validate DUT can steer traffic from Internet link to MPLS link if link blackout was detected on remote side of Internet link and vice versa.
Test Type	Functional
Topology Type	4stc_1sne_2dut_type01
Topology	
Test Instrument	Spirent Test Center, Spirent Network Emulator
Prerequisites	Connect STC, SNE, Switches and DUT as per test topology.
Pre-Configuration	**<STC Configuration>** Device: Device configuration #1 Stream: Stream 1 to 4 in Stream configuration #2 **<SUT Configuration>** SD-WAN edge: SD-WAN edge device configuration #1 Link status detection method (such as BFD) should be configured between SD-WAN edge 1 and SD-WAN edge 2 to detect link failure. SD-WAN Controller: Proper policies must be applied to SD-WAN edge 1 to: • Steer stream 1 and 3 towards Internet link and steer stream 2 and 4 towards MPLS link. • If Internet link down is detected by SD-WAN edge 1, steer stream 1 and 3 to MPLS link. • After Internet link resume, steer stream 1 and 3 back to Internet link. **<SNE configuration>** Set SNE attribute 'Idle traffic flow setting' (in Settings – General Settings…) to "Actively route traffic whilst unit is idle". **<Peripheral Devices Configuration>** Switches: Mirror bidirectional packets forwarded on MPLS WAN link to Traffic Analyzer 1 Mirror bidirectional packets forwarded on Internet WAN link to Traffic Analyzer 2
Customizable Test Parameters	**STC:** IPv4 address and gateway of Local_Device1 IPv4 address and gateway of Local_Device2 IPv4 address and gateway of Local_Head IPv4 address and gateway of Remote_Device1 IPv4 address and gateway of Remote_Head **Timers:**

	Wait time (seconds) after link blackout (30 seconds by default) Wait time (seconds) after link recovery (30 seconds by default)			
Test Sequence	Step	Type	Description	Expected Result
	1	Action	Perform ARP on all STC devices and all stream blocks	All ARPs are resolved successfully
	2	Action	Start traffic on all STC ports	All generators are started successfully
	3	Action	Impairment tool: Emulate packet sinkhole (drop all packets)	DUT is able to detect the link failure and steer stream 1 and 3 to MPLS link; Stream 2 and 4 should not be impacted; Verify DUT behavior by checking packets received at Traffic Analyzer 1 and 2.
	4	Action	Stop traffic	All generators are stopped successfully
	5	Check	Record out of service time	
	6	Action	Start traffic on all STC ports	All generators are started successfully
	7	Action	Stop impairment	DUT is able to detect the link is recovered and steer stream 1 and 3 back to Internet link; Stream 2 and 4 should not be impacted; Verify DUT behavior by checking packets received at Traffic Analyzer 1 and 2.
	8	Check	Record recovery time	
Results and Outputs	1. STC Configuration; 2. Script output with out of service time and recovery time; 3. STC detailed results (get it by using “Save Results” command), result view “Stream Block Results”, “Stream Block Results” and “Port Traffic Results” must be included; 4. Out of service time and recovery time; 5. STC logs (BLL/IL/Chassis); 6. DUT logs if possible.			
PASS/FAIL Criteria	PASS criteria: 1. DUT can correctly detect link blackout and resume; 2. Stream 1 and 3 are correctly steered in link blackout and resume; 3. Forwarding of stream 2 and 4 are not impacted by link blackout and resume.			

SD-WAN Resiliency Link Brownout Packet Loss

Test Case Name	SD-WAN Resiliency Link Brownout Packet Loss

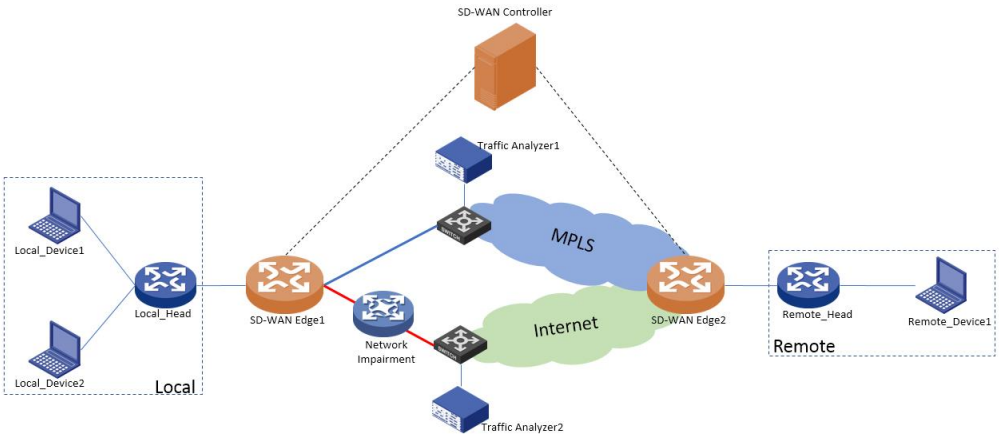
Test Case ID	sd-wan.resiliency_link.003
Test Area	Resiliency link brownout
Test Objective	Validate DUT can steer traffic from Internet link to MPLS link if packet loss ratio on Internet link exceeds threshold and vice versa.
Test Type	Functional
Topology Type	4stc_1sne_2dut_type01
Topology	
Test Instrument	Spirent Test Center, Spirent Network Emulator
Prerequisites	Connect STC, SNE, Switches and DUT as per test topology.
Pre-Configuration	**<STC Configuration>** Device: Device configuration #1 Stream: Stream 1 to 4 in Stream configuration #2 **<SUT Configuration>** SD-WAN edge: SD-WAN edge device configuration #1 Link status detection method should be configured between SD-WAN edge 1 and SD-WAN edge 2 to detect packet loss. SD-WAN Controller: Proper policies must be applied to SD-WAN edge 1 to: • Steer stream 1 and 3 towards Internet link and steer stream 2 and 4 towards MPLS link. • If packet loss ratio of Internet link is > Packet loss threshold, steer stream 1 and 3 to MPLS link. • After Internet link packet loss ratio reduced to < Packet loss threshold, steer stream 1 and 3 back to Internet link. **<SNE configuration>** Set SNE attribute 'Idle traffic flow setting' (in Settings – General Settings…) to "Actively route traffic whilst unit is idle". **<Peripheral Devices Configuration>** Switches: Mirror bidirectional packets forwarded on MPLS WAN link to Traffic Analyzer 1 Mirror bidirectional packets forwarded on Internet WAN link to Traffic Analyzer 2
Customizable Test Parameters	**STC:** IPv4 address and gateway of Local_Device1 IPv4 address and gateway of Local_Device2 IPv4 address and gateway of Local_Head

	IPv4 address and gateway of Remote_Device1 IPv4 address and gateway of Remote_Head **SNE:** Packet loss ratio (5% by default) **Thresholds:** Packet loss threshold (2% by default) **Timers:** Wait time (seconds) after link brownout (30 seconds by default) Wait time (seconds) after link recovery (30 seconds by default)

Test Sequence	Step	Type	Description	Expected Result
	1	Action	Perform ARP on all STC devices and all stream blocks	All ARPs are resolved successfully
	2	Action	Start traffic on all STC ports	All generators are started successfully
	3	Action	Impairment tool: Drop Packet loss ratio packets	DUT is able to detect packet loss ratio of Internet link is over threshold and steer stream 1 and 3 to MPLS link; Stream 2 and 4 should not be impacted; Verify DUT behavior by checking packets received at Traffic Analyzer 1 and 2.
	4	Action	Wait for traffic to stop	All generators are stopped successfully
	5	Check	Record out of service time	
	6	Action	Start traffic on all STC ports	All generators are started successfully
	7	Action	Stop impairment	DUT is able to detect the packet loss ratio of Internet link is below threshold and steer stream 1 and 3 back to Internet link; Stream 2 and 4 should not be impacted; Verify DUT behavior by checking packets received at Traffic Analyzer 1 and 2.
	8	Check	Record recovery time	

Results and Outputs	1. STC Configuration; 2. Script output with out of service time and recovery time; 3. STC detailed results (get it by using “Save Results” command), result view “Stream Block Results”, “Stream Block Results” and “Port Traffic Results” must be included; 4. Out of service time and recovery time; 5. STC logs (BLL/IL/Chassis); 6. DUT logs if possible.
PASS/FAIL Criteria	PASS criteria: 1. DUT can correctly detect link brownout caused by packet loss ratio over threshold and resume; 2. Stream 1 and 3 are correctly steered in link brownout and resume; 3. Forwarding of stream 2 and 4 are not impacted by link brownout and resume.

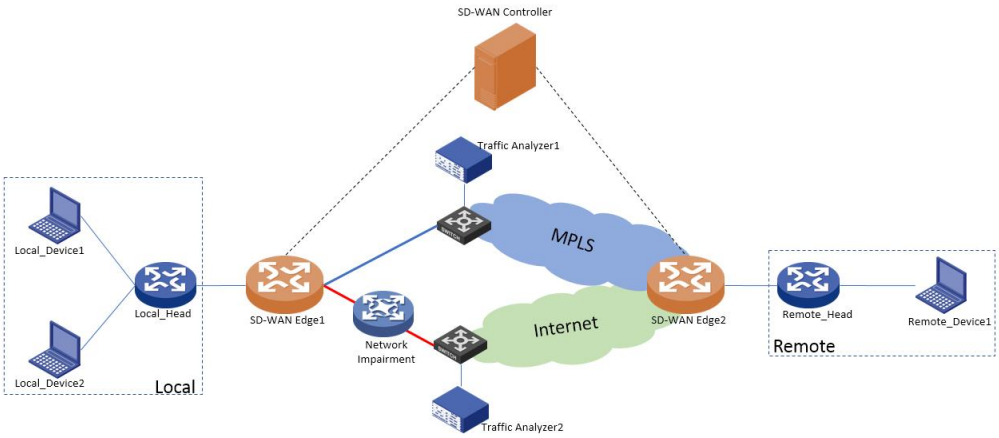
SD-WAN Resiliency Link Brownout Packet Delay

Test Case Name	SD-WAN Resiliency Link Brownout Packet Delay
Test Case ID	sd-wan.resiliency_link.004
Test Area	Resiliency link brownout
Test Objective	Validate DUT can steer traffic from Internet link to MPLS link if two-way delay (from DUT1 to DUT2) on Internet link exceeds threshold and vice versa.
Test Type	Functional
Topology Type	4stc_1sne_2dut_type01
Topology	
Test Instrument	Spirent Test Center, Spirent Network Emulator
Prerequisites	Connect STC, SNE, Switches and DUT as per test topology.
Pre-Configuration	**<STC Configuration>** Device: Device configuration #1 Stream: Stream 1 to 4 in Stream configuration #2 **<SUT Configuration>** SD-WAN edge: SD-WAN edge device configuration #1 Link status detection method should be configured between SD-WAN edge 1 and SD-WAN edge 2 to detect two-way delay. SD-WAN controller: Proper policies must be applied to SD-WAN edge 1 to: • Steer stream 1 and 3 towards Internet link and steer stream 2 and 4 towards MPLS link. • If one-way delay of Internet link is > Packet delay threshold, steer stream 1 and 3 to MPLS link. • After Internet link one-way delay reduced to < Packet delay threshold, steer stream 1 and 3 back to Internet link. **<SNE configuration>** Set SNE attribute 'Idle traffic flow setting' (in Settings – General Settings…) to "Actively route traffic whilst unit is idle". **<Peripheral Devices Configuration>** Switches: Mirror bidirectional packets forwarded on MPLS WAN link to Traffic Analyzer 1

	Mirror bidirectional packets forwarded on Internet WAN link to Traffic Analyzer 2			
Customizable Test Parameters	**STC:** IPv4 address and gateway of Local_Device1 IPv4 address and gateway of Local_Device2 IPv4 address and gateway of Local_Head IPv4 address and gateway of Remote_Device1 IPv4 address and gateway of Remote_Head **SNE:** Packet delay value (200ms by default) **Thresholds:** Packet delay threshold (150ms by default) **Timers:** Wait time (seconds) after link brownout (30 seconds by default) Wait time (seconds) after link recovery (30 seconds by default)			
Test Sequence	Step	Type	Description	Expected Result
	1	Action	Perform ARP on all STC devices and all stream blocks	All ARPs are resolved successfully
	2	Action	Start traffic on all STC ports	All generators are started successfully
	3	Action	Impairment tool: Increase latency to Packer delay value	DUT is able to detect packet delay value of Internet link is over threshold and steer stream 1 and 3 to MPLS link; Stream 2 and 4 should not be impacted; Verify DUT behavior by checking packets received at Traffic Analyzer 1 and 2.
	4	Action	Stop traffic	All generators are stopped successfully
	5	Check	Record out of service time	
	6	Action	Start traffic on all STC ports	All generators are started successfully
	7	Action	Stop impairment	DUT is able to detect packet delay value of Internet link is below threshold and steer stream 1 and 3 back to Internet link; Stream 2 and 4 should not be impacted; Verify DUT behavior by checking packets received at Traffic Analyzer 1 and 2.
	8	Check	Record recovery time	
Results and Outputs	1. STC Configuration; 2. Script output with out of service time and recovery time; 3. STC detailed results (get it by using “Save Results” command), result view “Stream Block Results”, “Stream Block Results” and “Port Traffic Results” must be included; 4. Out of service time and recovery time;			

	5. STC logs (BLL/IL/Chassis); 6. DUT logs if possible.
PASS/FAIL Criteria	PASS criteria: 1. DUT can correctly detect link brownout caused by packet delay over threshold and resume; 2. Stream 1 and 3 are correctly steered in link brownout and resume; 3. Forwarding of stream 2 and 4 are not impacted by link brownout and resume.

SD-WAN Resiliency Link Brownout Jitter

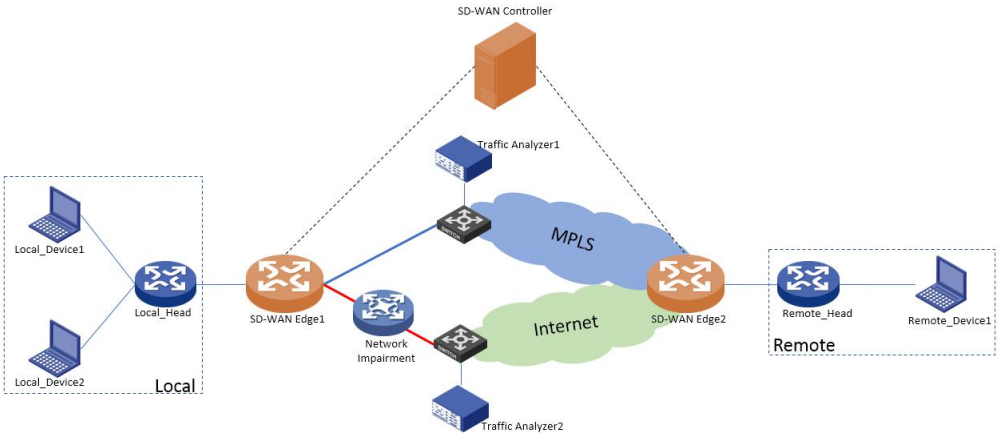
Test Case Name	SD-WAN Resiliency Link Brownout Jitter
Test Case ID	sd-wan.resiliency_link.005
Test Area	Resiliency link brownout
Test Objective	Validate DUT can steer traffic from Internet link to MPLS link if jitter on Internet link exceeds threshold and vice versa.
Test Type	Functional
Topology Type	4stc_1sne_2dut_type01
Topology	
Test Instrument	Spirent Test Center, Spirent Network Emulator
Prerequisites	Connect STC, SNE, Switches and DUT as per test topology.
Pre-Configuration	**<STC Configuration>** Device: Device configuration #1 Stream: Stream 1 to 4 in Stream configuration #2 **<SUT Configuration>** SD-WAN edge: SD-WAN edge device configuration #1 Link status detection method should be configured between SD-WAN edge 1 and SD-WAN edge 2 to detect jitter. SD-WAN controller: Proper policies must be applied to SD-WAN edge 1 to: • Steer stream 1 and 3 towards Internet link and steer stream 2 and 4 towards MPLS link.

	• If jitter of Internet link is > Packet jitter threshold, steer stream 1 and 3 to MPLS link. • After Internet link jitter reduced to < Packet jitter threshold, steer stream 1 and 3 back to Internet link. **<SNE configuration>** Set SNE attribute 'Idle traffic flow setting' (in Settings – General Settings…) to "Actively route traffic whilst unit is idle". **<Peripheral Devices Configuration>** Switches: Mirror bidirectional packets forwarded on MPLS WAN link to Traffic Analyzer 1 Mirror bidirectional packets forwarded on Internet WAN link to Traffic Analyzer 2
Customizable Test Parameters	**STC:** IPv4 address and gateway of Local_Device1 IPv4 address and gateway of Local_Device2 IPv4 address and gateway of Local_Head IPv4 address and gateway of Remote_Device1 IPv4 address and gateway of Remote_Head **SNE:** Packet jitter value (50ms by default) **Thresholds:** Packet jitter threshold (30ms by default) **Timers:** Wait time (seconds) after link brownout (30 seconds by default) Wait time (seconds) after link recovery (30 seconds by default)

Test Sequence	Step	Type	Description	Expected Result
	1	Action	Perform ARP on all STC devices and all stream blocks	All ARPs are resolved successfully
	2	Action	Start traffic on all STC ports	All generators are started successfully
	3	Action	Impairment tool: Increase jitter to Packet jitter value	DUT is able to detect jitter value of Internet link is over threshold and steer stream 1 and 3 to MPLS link; Stream 2 and 4 should not be impacted; Verify DUT behavior by checking packets received at Traffic Analyzer 1 and 2.
	4	Action	Stop traffic	All generators are stopped successfully
	5	Check	Record out of service time	
	6	Action	Start traffic on all STC ports	All generators are started successfully
	7	Action	Stop impairment	DUT is able to detect jitter value of Internet link is below threshold and steer stream 1 and 3 back to Internet link; Stream 2 and 4 should not be impacted; Verify DUT behavior by checking packets received at Traffic Analyzer 1 and 2.

	8	Check	Record recovery time	
Results and Outputs	1. STC Configuration; 2. Script output with out of service time and recovery time; 3. STC detailed results (get it by using “Save Results” command), result view “Stream Block Results”, “Stream Block Results” and “Port Traffic Results” must be included; 4. Out of service time and recovery time; 5. STC logs (BLL/IL/Chassis); 6. DUT logs if possible.			
PASS/FAIL Criteria	PASS criteria: 1. DUT can correctly detect link brownout caused by packet jitter over threshold and resume; 2. Stream 1 and 3 are correctly steered in link brownout and resume; 3. Forwarding of stream 2 and 4 are not impacted by link brownout and resume.			

SD-WAN Resiliency Link Brownout Packet Out of Order

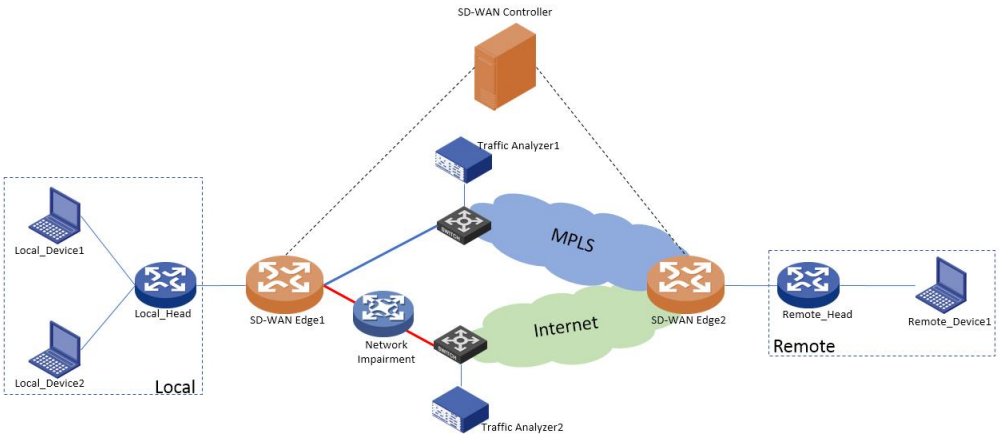
Test Case Name	SD-WAN Resiliency Link Brownout Packet Out of Order
Test Case ID	sd-wan.resiliency_link.006
Test Area	Resiliency link brownout
Test Objective	Validate DUT can steer traffic from Internet link to MPLS link if packet out-of-order ratio on Internet link exceeds threshold and vice versa.
Test Type	Functional
Topology Type	4stc_1sne_2dut_type01
Topology	
Test Instrument	Spirent Test Center, Spirent Network Emulator
Prerequisites	Connect STC, SNE, Switches and DUT as per test topology.
Pre-Configuration	**<STC Configuration>** Device: Device configuration #1 Stream: Stream 1 to 4 in Stream configuration #2 **<SUT Configuration>**

	SD-WAN edge: SD-WAN edge device configuration #1 Link status detection method should be configured between SD-WAN edge 1 and SD-WAN edge 2 to packet out-of-order. SD-WAN controller: Proper policies must be applied to SD-WAN edge 1 to: • Steer stream 1 and 3 towards Internet link and steer stream 2 and 4 towards MPLS link. • If packet out-of-order ratio of Internet link is > Packet out-of-order threshold, steer stream 1 and 3 to MPLS link. • After Internet packet out-of-order ratio reduced to < Packet out-of-order threshold, steer stream 1 and 3 back to Internet link. **<SNE configuration>** Set SNE attribute 'Idle traffic flow setting' (in Settings – General Settings…) to "Actively route traffic whilst unit is idle". **<Peripheral Devices Configuration>** Switches: Mirror bidirectional packets forwarded on MPLS WAN link to Traffic Analyzer 1 Mirror bidirectional packets forwarded on Internet WAN link to Traffic Analyzer 2
Customizable Test Parameters	**STC:** IPv4 address and gateway of Local_Device1 IPv4 address and gateway of Local_Device2 IPv4 address and gateway of Local_Head IPv4 address and gateway of Remote_Device1 IPv4 address and gateway of Remote_Head **SNE:** Packet out-of-order ratio (8% by default) **Thresholds:** Packet out-of-order threshold (5% by default) **Timers:** Wait time (seconds) after link brownout (30 seconds by default) Wait time (seconds) after link recovery (30 seconds by default)

Test Sequence	Step	Type	Description	Expected Result
	1	Action	Perform ARP on all STC devices and all stream blocks	All ARPs are resolved successfully
	2	Action	Start traffic on all STC ports	All generators are started successfully
	3	Action	Impairment tool: Introduce Packet out-of-order value packet reordering	DUT is able to detect packet out-of-order ratio of Internet link is over threshold and steer stream 1 and 3 to MPLS link Stream 2 and 4 should not be impacted; Verify DUT behavior by checking packets received at Traffic Analyzer 1 and 2.
	4	Action	Stop traffic	All generators are stopped successfully
	5	Check	Record out of service time	
	6	Action	Start traffic on all STC ports	All generators are started successfully

	7	Action	Stop impairment	DUT is able to detect packet out-of-order ratio of Internet link is below threshold and steer stream 1 and 3 back to Internet link; Stream 2 and 4 should not be impacted; Verify DUT behavior by checking packets received at Traffic Analyzer 1 and 2.
	8	Check	Record recovery time	
Results and Outputs	1. STC Configuration; 2. Script output with out of service time and recovery time; 3. STC detailed results (get it by using “Save Results” command), result view “Stream Block Results”, “Stream Block Results” and “Port Traffic Results” must be included; 4. Out of service time and recovery time; 5. STC logs (BLL/IL/Chassis); 6. DUT logs if possible.			
PASS/FAIL Criteria	PASS criteria: 1. DUT can correctly detect link brownout caused by packet out-of-order ratio over threshold and resume; 2. Stream 1 and 3 are correctly steered in link brownout and resume; 3. Forwarding of stream 2 and 4 are not impacted by link brownout and resume.			

SD-WAN Resiliency Link Brownout Packet Duplication

Test Case Name	SD-WAN Resiliency Link Brownout Packet Duplication
Test Case ID	sd-wan.resiliency_link.007
Test Area	Resiliency link brownout
Test Objective	Validate DUT can steer traffic from Internet link to MPLS link if packet duplication ratio on Internet link exceeds threshold and vice versa.
Test Type	Functional
Topology Type	4stc_1sne_2dut_type01
Topology	

Test Instrument	Spirent Test Center, Spirent Network Emulator
Prerequisites	Connect STC, SNE, Switches and DUT as per test topology.
Pre-Configuration	**<STC Configuration>** Device: Device configuration #1 Stream: Stream 1 to 4 in Stream configuration #2 **<SUT Configuration>** SD-WAN edge: SD-WAN edge device configuration #1 Link status detection method should be configured between SD-WAN edge 1 and SD-WAN edge 2 to detect packet duplication. SD-WAN controller: Proper policies must be applied to SD-WAN edge 1 to: • Steer stream 1 and 3 towards Internet link and steer stream 2 and 4 towards MPLS link. • If packet duplication ratio of Internet link is > Packet duplication threshold, steer stream 1 and 3 to MPLS link. • After Internet packet duplication ratio reduced to < Packet duplication threshold, steer stream 1 and 3 back to Internet link. **<SNE configuration>** Set SNE attribute 'Idle traffic flow setting' (in Settings – General Settings…) to "Actively route traffic whilst unit is idle". **<Peripheral Devices Configuration>** Switches: Mirror bidirectional packets forwarded on MPLS WAN link to Traffic Analyzer 1 Mirror bidirectional packets forwarded on Internet WAN link to Traffic Analyzer 2
Customizable Test Parameters	**STC:** IPv4 address and gateway of Local_Device1 IPv4 address and gateway of Local_Device2 IPv4 address and gateway of Local_Head IPv4 address and gateway of Remote_Device1 IPv4 address and gateway of Remote_Head **Thresholds:** Packet duplication threshold (5% by default) **Timers:** Wait time (seconds) after link brownout (30 seconds by default) Wait time (seconds) after link recovery (30 seconds by default)

Test Sequence	Step	Type	Description	Expected Result
	1	Action	Perform ARP on all STC devices and all stream blocks	All ARPs are resolved successfully
	2	Action	Start traffic on all STC ports	All generators are started successfully
	3	Action	Impairment tool: Introduce 100% packet duplication (Simple duplication mode in SNE)	DUT is able to detect packet duplication ratio of Internet link is over threshold and steer stream 1 and 3 to MPLS link; Stream 2 and 4 should not be impacted; Verify DUT behavior by checking packets received at Traffic Analyzer 1 and 2.
	4	Action	Stop traffic	All generators are stopped successfully

	5	Check	Record out of service time	
	6	Action	Start traffic on all STC ports	All generators are started successfully
	7	Action	Stop impairment	DUT is able to detect packet duplication ratio of Internet link is below threshold and steer stream 1 and 3 back to Internet link; Stream 2 and 4 should not be impacted; Verify DUT behavior by checking packets received at Traffic Analyzer 1 and 2.
	8	Check	Record recovery time	
Results and Outputs	1. STC Configuration; 2. Script output with out of service time and recovery time; 3. STC detailed results (get it by using “Save Results” command), result view “Stream Block Results”, “Stream Block Results” and “Port Traffic Results” must be included; 4. Out of service time and recovery time; 5. STC logs (BLL/IL/Chassis); 6. DUT logs if possible.			
PASS/FAIL Criteria	PASS criteria: 1. DUT can correctly detect link brownout caused by packet duplication ratio over threshold and resume; 2. Stream 1 and 3 are correctly steered in link brownout and resume; 3. Forwarding of stream 2 and 4 are not impacted by link brownout and resume.			