IEEE 802.1D Spanning Tree Protocol Conformance and Interoperability Testing

Network Benchmarking Lab

Outline

- Purposes
- Introduction to Spanning Tree Protocol
- Experiment Equipment
- STP Conformance Testing
- STP Interoperability Testing

Purposes

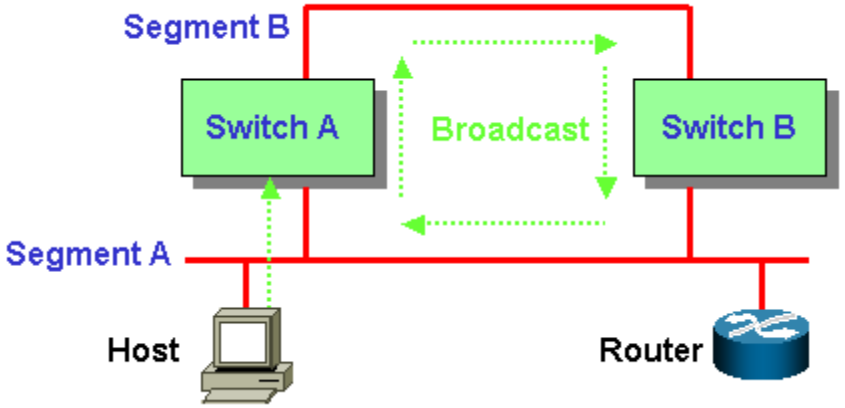
- Knowing Spanning Tree Protocol (STP)
- Learning STP configuration on a bridge or a switch
- Performing Ixia IxANVL for STP conformance testing
- Performing UNH-IOL test suite for STP interoperability testing
- Analyzing and explaining test results

What is Spanning Tree Protocol

- STP is a Layer 2 protocol designed to run on bridges and switches
- STP is defined in IEEE 802.1D standard
- STP provides backup links between bridges and switches
- STP detects and disables network loops
- STP ensures only one path exists between any two stations

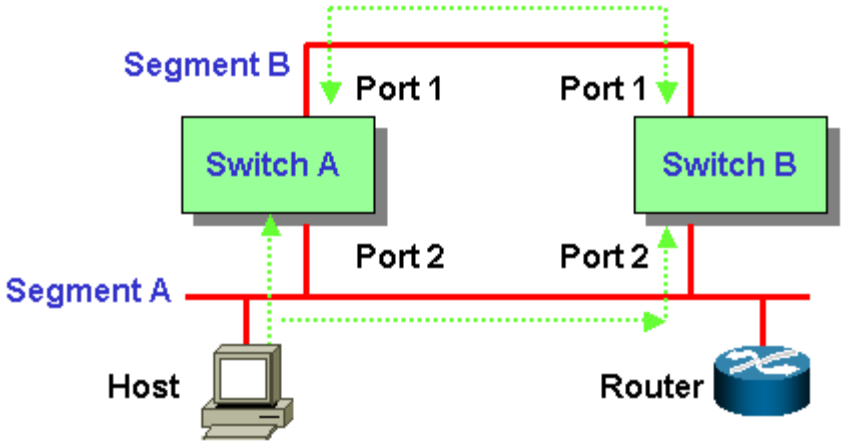
Broadcast Storm

1. When Host sends a broadcast frame, like an ARP request to Router, the frame will be received by Switch A.
2. Switch A identify the destination MAC address field (broadcast FF:FF:FF:FF:FF:FF) in the frame and determine to flood it onto Segment B.
3. When the broadcast frame arrives at Switch B, Switch will repeat above process, flood it to Segment A.
4. The broadcast frame will endlessly travel around the loop network even Router has already received this frame.



Filtering Database Instability

1. Host sends an unicast frame to Router (source MAC address is Host's MAC, destination MAC address is Router's MAC). Both Switch A and Switch B will receive this frame and learn MAC address of Host on Port 2.
2. Switch A has not yet learned the MAC address of Router. So Switch A will flood a copy of the received frame to Segment B.
3. When the copy of the frame from Switch A arrive at Switch B, Switch B will remove the first entry (Host MAC address on Port 2) in Filtering Database and add a new mapping of Host MAC address on Port 1. Switch B incorrectly learn Host MAC address on Port 1. Switch B can't forward frames properly because the instability of mapping MAC address to Port.



How STP Works

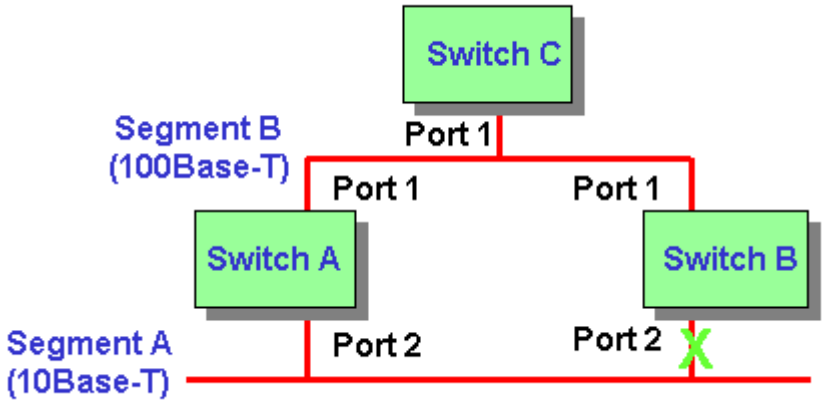
1. Select a root bridge
   - Only one switch/ bridge can be selected as the root bridge in a given network.
   - The root bridge is the "root" of the constructed "tree".
2. Select a root port for the non-root bridge
   - For the non-root switch/ bridge, there will be one root port.
   - The root port is the port through which this non-root switch/ bridge communicates with the root bridge (the "leaf" side of the "tree").
3. Select a designated port on each segment
   - For each LAN segment (collision domain), there is a designated port.
   - The designated port has the lowest cost to the root bridge.
   - Designated ports are normally in the forwarding state to forward and receive traffic to the segment.
   - If more than one port in the segment have the same path cost, the port on which bridge has lowest bridge ID is selected as a designated port
4. Run spanning tree algorithm
   - STP enables all root ports and designated ports, and disables all other ports.
   - Network packets are therefore only forwarded between root ports and designated ports, eliminating any possible network loops.
   - STP-aware devices exchange Bridge Protocol Data Units (BPDUs) periodically.
   - When the bridged LAN topology changes, a new spanning tree is constructed.

Path Cost Defined in IEEE 802.1D

Link Speed	Recommended Cost	Recommended Cost Range
4Mbps	250	100 to 1000
10Mbps	100	50 to 600
16Mbps	62	40 to 400
100Mbps	19	10 to 60
1Gbps	4	3 to 10
10Gbps	2	1 to 5

STP Example

Switch A: MAC = 00A0C5111111 Priority = 32768			Switch B: MAC = 00A0C5222222 Priority = 32768			Switch C: MAC = 00A0C5333333 Priority = 1	
	Port 1	Port 2		Port 1	Port 2		Port 1
Cost	19	100	Cost	19	100	Cost	19
Priority	128	128	Priority	128	128	Priority	128



- Switch:
  - C: Root bridge
  - A: Non-root bridge
  - B: Non-root bridge
- Switch C:
  - Port 1: Designated port (Forwarding)
- Switch A:
  - Port 1: Root port (Cost=19, Forwarding)
  - Port 2: Designated port of Segment A (Cost=119, Forwarding)
- Switch B:
  - Port 1: Root port (Cost=19, Forwarding)
  - Port 2: (Cost=119, Blocking)

STP Conformance and Interoperability Testing

- STP conformance testing:
  - Validate whether a bridge or a switch is conform to “IEEE 802.1D - MAC Bridge” standard
- STP interoperability testing:
  - Validate whether a bridge or a switch is interoperable with other STP-aware devices

Experiment Equipment

- Hardware:

Name	Qty	Comment
Personal Computer	1	
Network Interface Card	4	
Bridge or Switch	4	STP supported
Agilent Router Tester 900	1	
Network Cable	> 10	
Repeater	1	
Console Cable	4	

- Software:

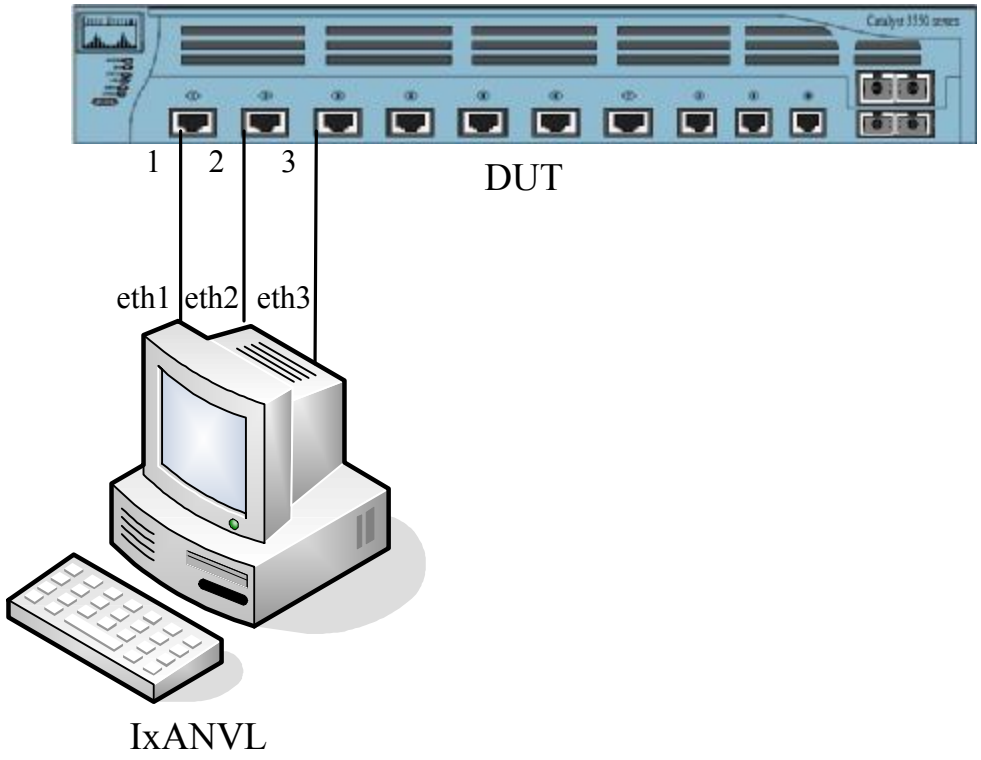
Name	Qty	Comment
RedHat Linux	1	X-Window supported
Windows 2000 or up	1	
IxANVL STP Test Suite	1	
Agilent Router Tester 900 Software	1	

STP Conformance Testing

- Testbed setup
- STP configuration on device under test (DUT)
- Configuration and parameters setting on IxANVL
- Test cases execution (total 53 test cases)
- Test result analysis and explanation

Testbed Setup

- Connect eth1, eth2 and eth3 of the PC to port1, port 2 , and port 3 of the DUT respectively



DUT Configuration (For SMC ES-3626G)

- Enable STP:

  Console#conf
  Console(config)#spanning-tree mode stp
  Console(config)#exit
  Console#

- Show STP status:

  Console#show spanning tree

- Change Aging Time of filtering database:

  Console#conf
  Console(config)#mac-address-table aging-time 300

IxANVL Setting

- General Configuration:

Field	Value
DUT Hostname	SMC_ES-3626G
802.1d Bridge Address	02:22:18:24:1a:0b
802.1d Bridge ID	0:0:0:0:0:0:0:0
802.1d Bridge Priority	0x8000
802.1d Bridged Data Protocol	0xFFFF
802.1d Virtual Net BPDU Interval	1000
802.1d Virtual Net Test Duration	120
STP Bridge Forward Delay	15
STP Bridge Hello Time	2
STP Bridge Max Age	20
802.1d Packet Rate	50

- Network Interface Configuration:

Field	Value
Selection	Ethernet
Ethernet Interface	eth1
DUT MAC Address	02:22:18:24:1a:0c
802.1d Port Number	1
802.1d Port Priority	0x80
802.1d Bridged Data Encapsulation	SNAP

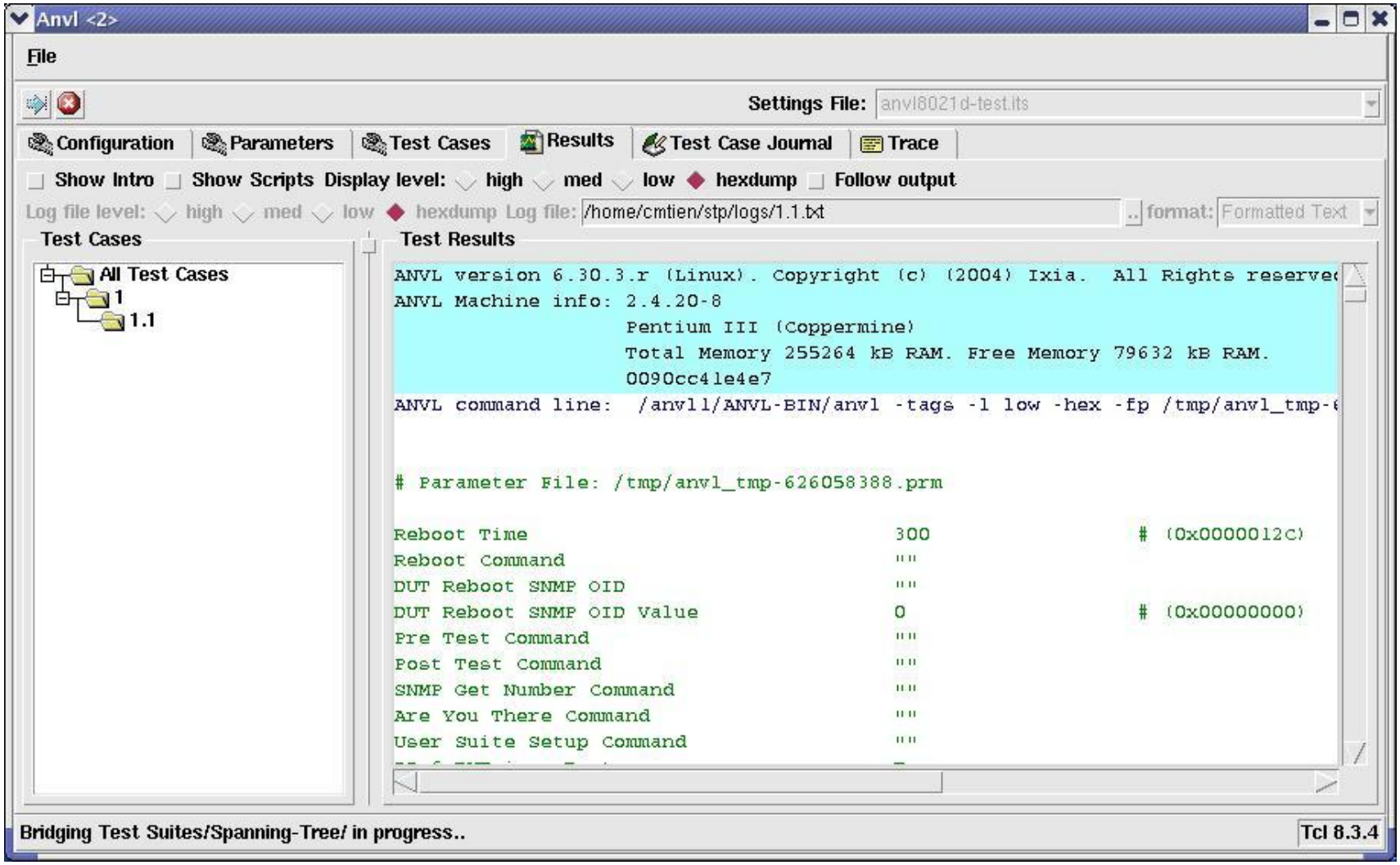
- Parameters Setting:

Field	Value
Reboot Time	60
802.1d Filter Table Aging Time	300
802.1d Filter Table Size	8000
802.1d Stress Number Addresses	1000

IxANVL Execution

- Check cases to be tested:
  - Execute one test case at a time
- Inspect testing process:
  - Display level: high, med, low, hexdump
  - Log level: high, med, low, hexdump
- Configure DUT if needed
- Record test results
  - Passed test cases
  - Failed tests cases and failure reasons

IxANVL Screenshot



Experiment Records

1. DUT configuration file
2. IxANVL configuration file
3. IxANVL parameters file
4. IxANVL log files (one file for each case)
5. Result table of STP conformance testing

STP Interoperability Testing

- Read UNH-IOL Spanning Tree Protocol – Multi-System Interoperability Test Suite (total 5 test cases)
- Test setup
- STP configuration on device under test (DUT)
- Frame capture and generation using Agilent Router Tester 900
- Test procedure
- Test result observation

UNH-IOL STP Interoperability Test Suite

- Test D.1.1 – Link Failure:
  - To ensure that the device under test (DUT) can properly reconfigure the Spanning Tree in the event of link failure on one of its Ports.
- Test D.1.2 – Repeated Network:
  - To ensure that the device under test (DUT) can interoperate with another Spanning Tree Capable Bridge when the active topology contains a Repeater.
- Test D.1.3 – Maximum Hello Time:
  - To ensure that the device under test (DUT) can properly reconfigure Spanning Tree when the Root Bridge uses the maximum allowed value for Bridge Hello Time.
- Test D.1.4 – Network Initialization:
  - To ensure the device under test (DUT) can properly execute the Spanning Tree Algorithm when the network is (re)initialized.
- Test D.1.5 – Topology Change:
  - To ensure that the device under test (DUT) can properly reconfigure Spanning Tree in the event of a Topology Change.

Organization of Test Cases

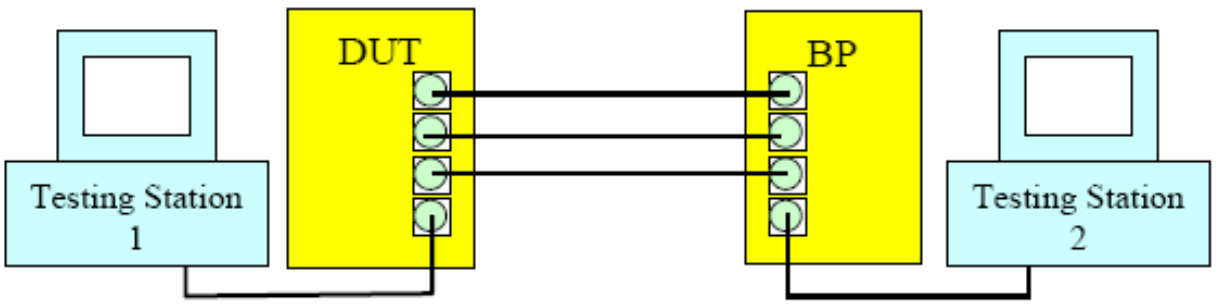
- Test Number
- Purpose
- References
- Resource Requirement
- Last Modification
- Discussion
- Test Setup
- Procedure
- Observable Results
- Possible Problems

Example Test Case: D.1.1 Link Failure

- Purpose:
  - To ensure that the device under test (DUT) can properly reconfigure the Spanning Tree in the event of link failure on one of its Ports.
- References:
  - IEEE 802.1D-1998: sub-clauses 8.1, 8.3.1, 8.6.11
- Resource Requirement:
  - Testing Stations capable of transmitting and receiving arbitrary MAC frames.
- Discussion:
  - This test verifies that the DUT can properly reconfigure the Spanning Tree when a link between the DUT and a Spanning Tree capable Bridge is broken. This tests both a Port in the Forwarding State and Ports in the Blocking State on the DUT, as well as Basic Spanning Tree Interoperability. Disconnecting the Blocking Ports should have no effect on network traffic. Disconnecting the Forwarding Port should eventually put a Blocking Port into the Forwarding State.

Test Case D.1.1: Test Setup

- DUT: Device Under Test
- BP: Bridge Partner
- Test Stations: Ports of Agilent Router Tester 900



DUT Configuration (For SMC ES-3626G)

- Set Bridge Priority:
  Console(config)#spanning-tree priority 4096
- Set Bridge Hello Time:
  Console(config)#spanning-tree hello-time 2
- Set Bridge Max Age:
  Console(config)#spanning-tree max-age 20
- Set Bridge Forward Delay:
  Console(config)#spanning-tree forward-time 15

Frame Capture and Generation

- Tool:
  - Agilent Router Tester 900 (or SmartBits or Ixia)
- Frame Generation:
  - Unicast:
    - Source MAC Address: 01:01:01:01:01:01
    - Destination MAC Address: 02:02:02:02:02:02
  - Multicast:
    - Source MAC Address: 01:01:01:01:01:01
    - Destination MAC Address: 01:00:5E:01:01:01 (Multicast prefix is 01:00:5E)
  - Broadcast:
    - Source MAC Address: 01:01:01:01:01:01
    - Destination MAC Address: FF:FF:FF:FF:FF:FF

Test Case D.1.1: Procedure

- Part a: Disconnect the Blocking Port:
  1. Ensure the DUT is not the Root Bridge.
  2. Allow time for configuration of the Spanning Tree.
  3. Set the Testing Stations to capture arbitrary MAC frames.
  4. Pass unicast, multicast, and broadcast frames between the Testing Stations.
  5. While passing frames, disconnect a Blocking Port on the DUT.
  6. Repeat Steps 3-5, disconnecting the remaining Blocking Port on the DUT.
  7. Return the test setup to its original configuration.

Test Case D.1.1: Procedure (cont.)

- Part b: Disconnect the Forwarding Port:
  8. Ensure the DUT is not the Root Bridge.
  9. Allow time for configuration of the Spanning Tree.
  10. Set the Testing Stations to capture arbitrary MAC frames.
  11. Pass unicast, multicast, and broadcast frames between the Testing Stations.
  12. While passing frames, disconnect the Forwarding Port on the DUT.
  13. Record frames received by the Testing Stations for a period greater than twice the Bridge Forward Delay value of the Bridge Partner.

Test Case D.1.1: Observable Results

- Part a: Disconnect the Blocking Port:
  - There should be no interruption in network traffic (none of the frames should be lost). None of the frames should be duplicated or misordered.
- Part b: Disconnect the Forwarding Port
  - Once the Spanning Tree reconfigures, frames should be exchanged between Testing Stations (no additional frames should be observed). None of the frames should be duplicated or misordered.