RIT

Meshed Trees for Resilient Switched Networks

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Research Motivation

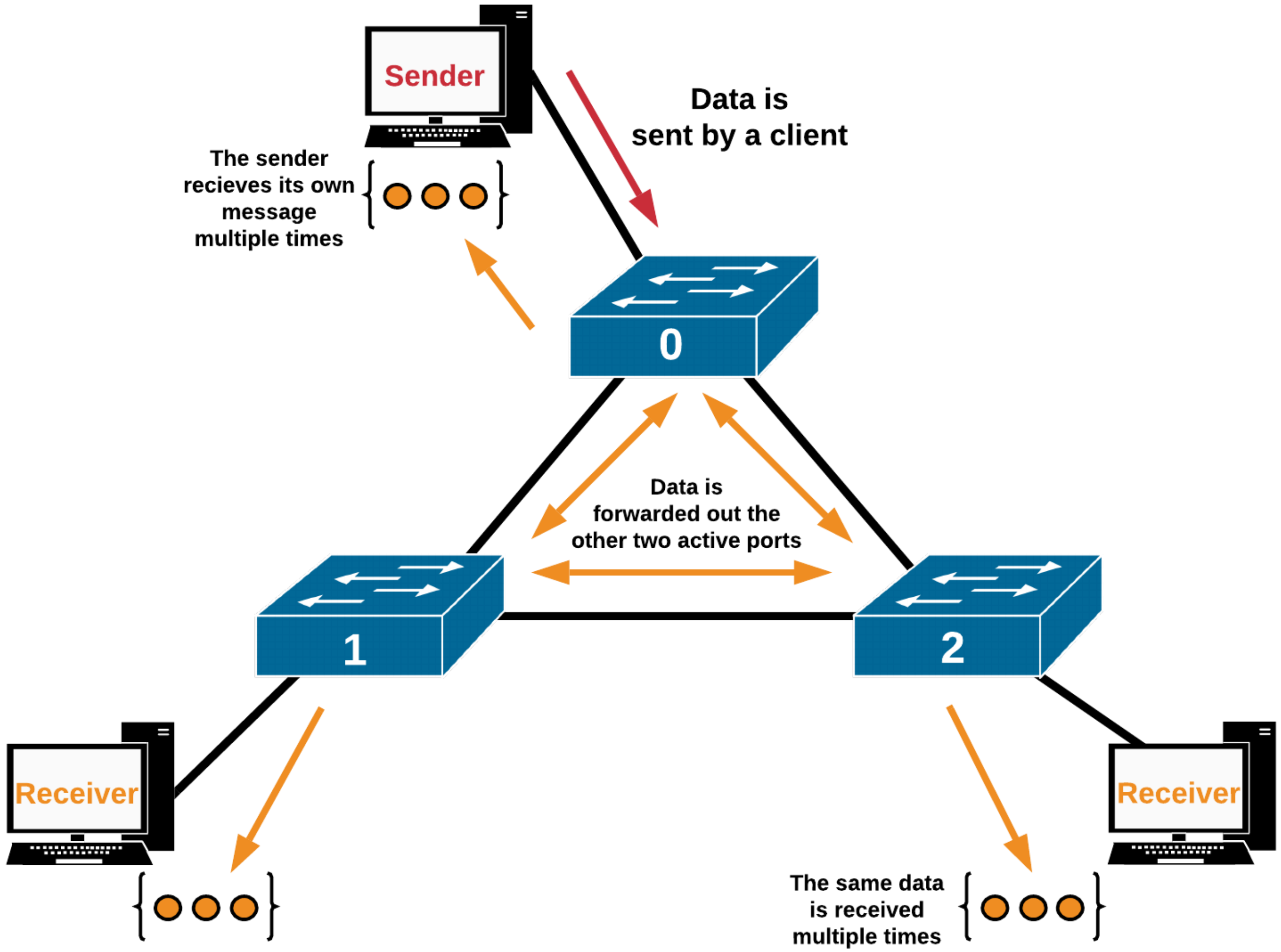
- Correctly forwarding data so that participating nodes can freely exchange information is the core goal of a computer network.

- Network functionality is more crucial than ever, especially during the current SARS-CoV-2 pandemic.
  - Failures of even a couple seconds can cause issues.

- **Loop avoidance protocols** are critical for the valid transmission of data in switched networks and as such serves as the focus of this research.

Loop-Avoidance Protocols Overview

- Network users require the data-forwarding capabilities provided by IEEE 802.3 Ethernet [1] and IEEE 802.1D[2] networks.
- Loop-avoidance protocols allow traffic to broadcast on a computer network without duplicating and infinitely forwarding data between nodes.



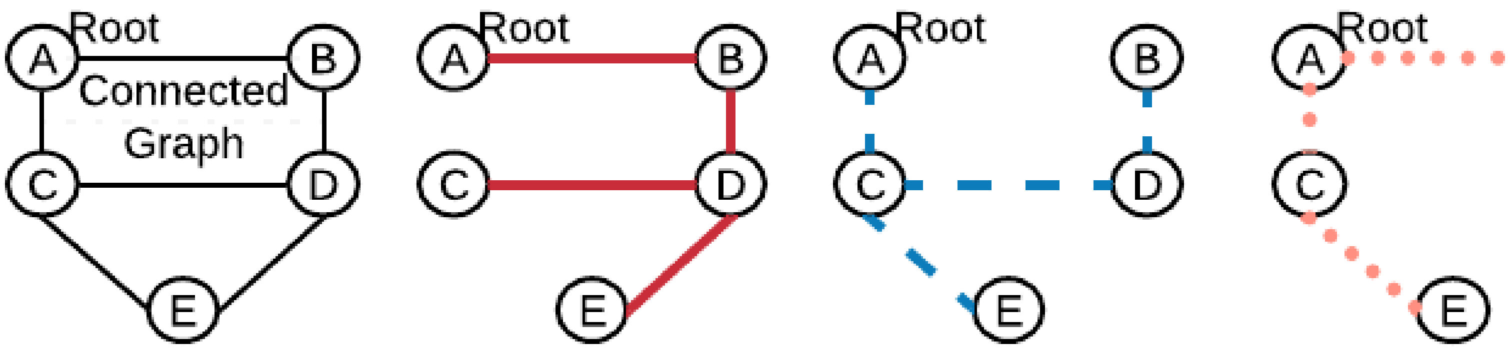
[1] "IEEE Standard for Ethernet," IEEE Std 802.3-2018 (Revision of IEEE Std 802.3-2015), 2018.
[2] "IEEE Standard for Local and metropolitan area networks: Media Access Control (MAC) Bridges," IEEE Std 802.1D-2004 (Revision of IEEE Std 802.1D-1998), 2004.

The Research Contribution

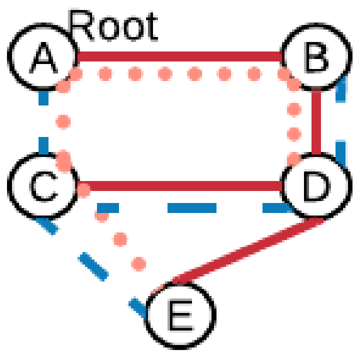
- The Meshed Tree Protocol (MTP), a proposed standard for use in switched networks, is our novel contribution to the loop-avoidance space.

- MTP does not block or disable links when creating forwarding paths for broadcast traffic.
  - Non-broadcast traffic has access to the entire network.

Meshed Trees for Resiliency and Fast Recovery



Dijkstra and Spanning Tree algorithm construct and mainatin one of these trees from the Root - either Red, Blue or Orange based on Link weights. Computing the tree requires global knowlegde of connectivity at each node.



Meshed Trees maintain multiple trees red, blue and orange in readiness. On failure of one link- fallback paths are readily available. Construction of the three trees is based on local decision made at each node.

Meshed Trees - This picture shows the three co-existing trees distinctly. Notice that each node is on all three trees.

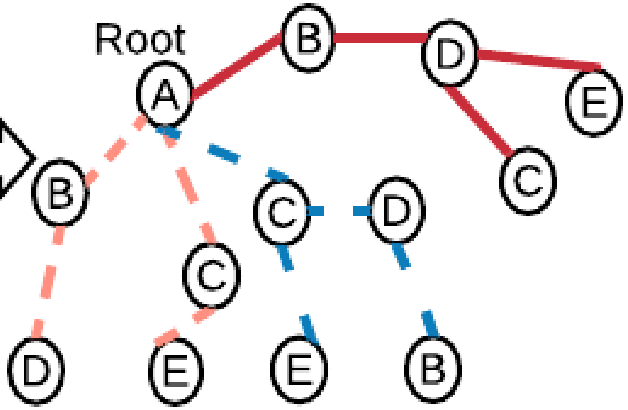
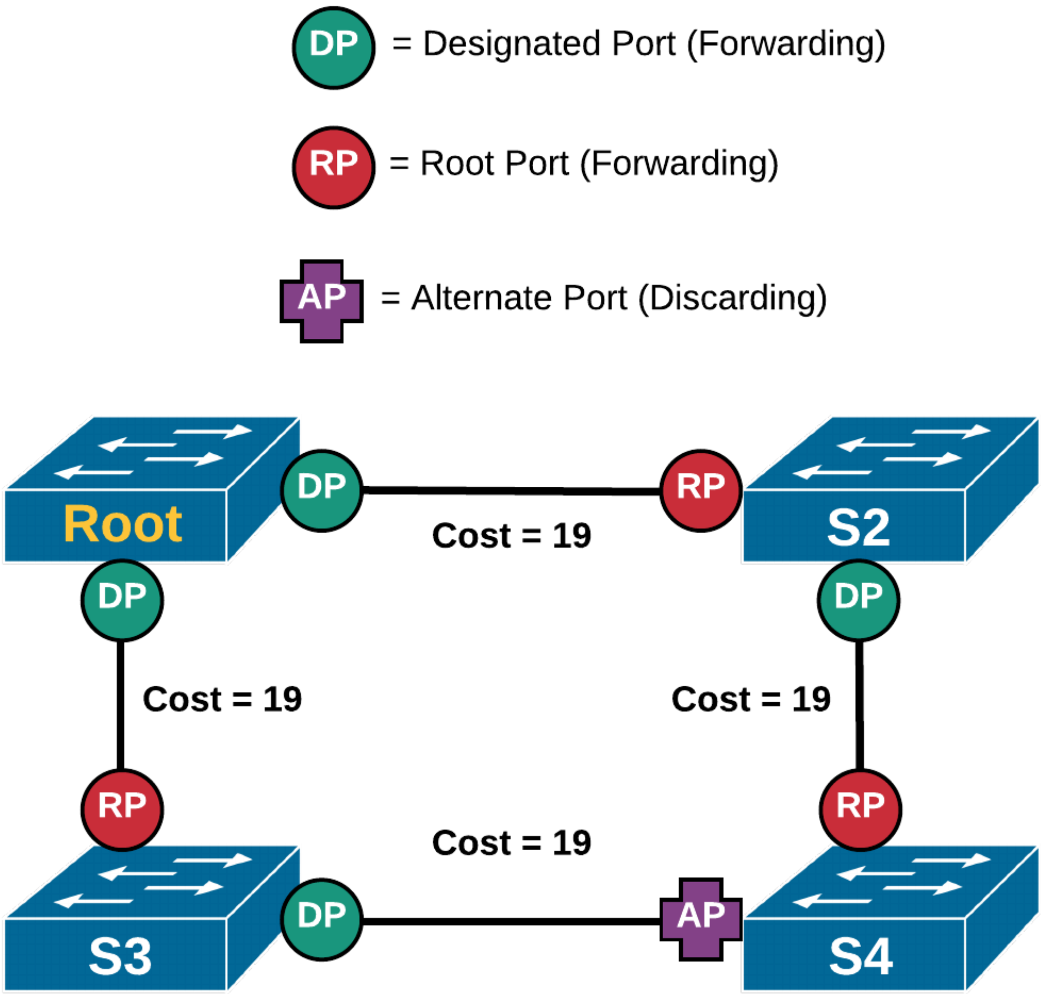
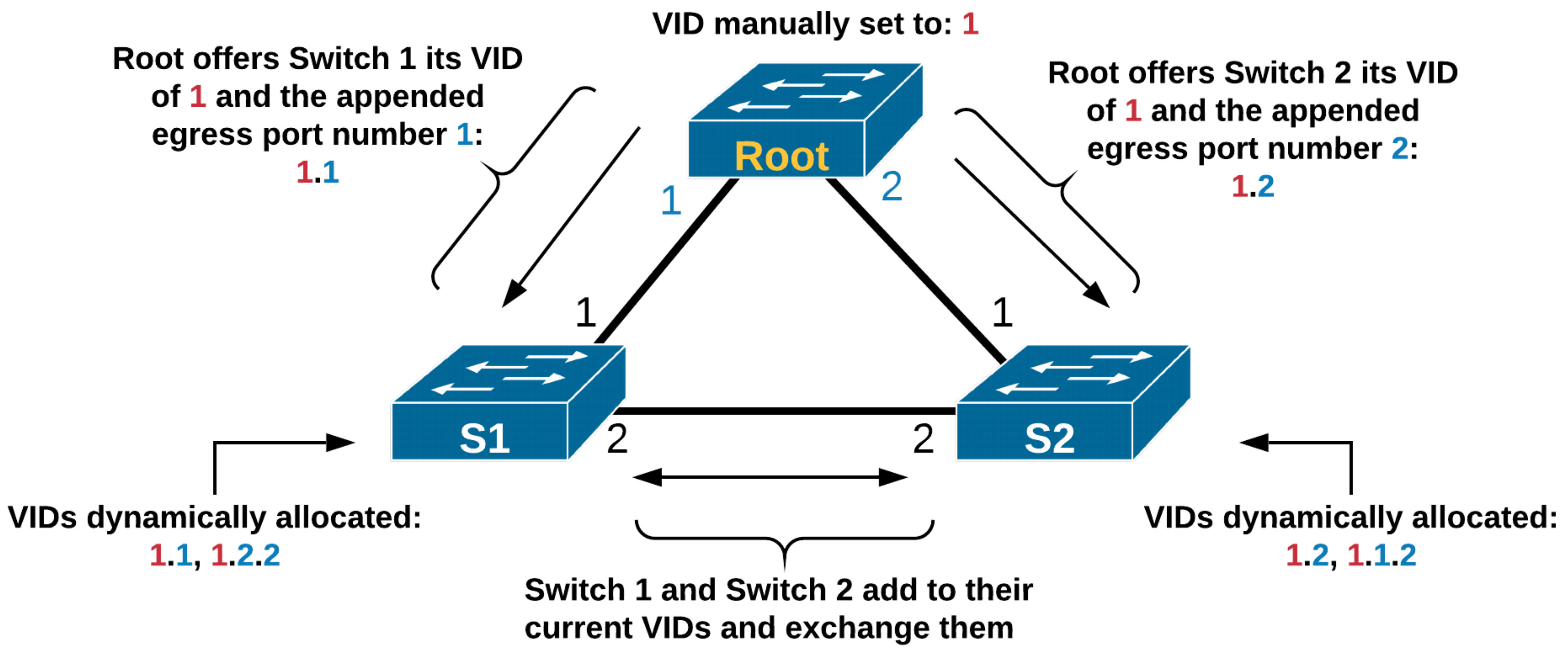


Figure 1 Concept of Meshed Trees

Rapid Spanning Tree Protocol (RSTP) Tree Construction

- A spanning tree is logically constructed on the network.
- Uses a series of tie breakers to determine the role and state of each interface.
- A “Hello time” of 2 seconds is used as a heartbeat.





MTP Overview

- Uses virtual identifiers (VIDs) to describe a node’s place in the meshed tree.
- A Root offers its VID to its neighbors.
- Nodes that have acquired VIDs offer VIDs to their neighbors.

Prototype Evaluation

- Comparing the performance of an MTP implementation against an RSTP implementation.
  - Custom C implementation of MTP
  - OvS has an implementation of RSTP
- 3 Topologies were created for testing
  - 5, 8, and 17 nodes
- Tests were conducted on topologies created on the Global Environment for Network Innovations (GENI) Testbed [3]

[3] M. Berman, J. S. Chase, L. Landweber, A. Nakao, M. Ott, D. Raychaudhuri, R. Ricci, and I. Seskar, "Geni: A federated testbed for innovative network experiments," Computer Networks, vol. 61, pp. 5 – 23, 2014. Special issue on Future Internet Testbeds – Part I.

5 Node Topology Results

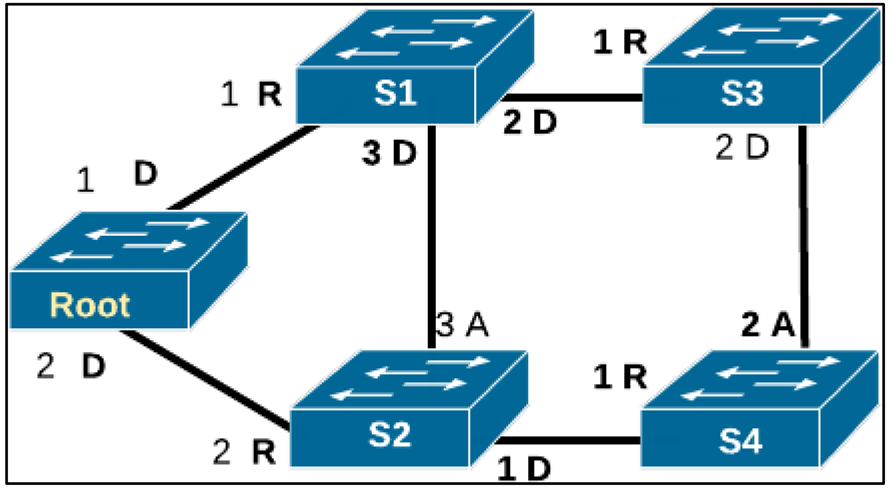
Case	Port	FDT	PRT	CT	PRS	TCNs
Root(2)	D	5.115s by S2	3.519s	8.634s	9	24
S1(1)	R	S1 Initiates	3.523s	3.523s	13	20
S1(3)	D	4.030s by S2	2.999s	7.029s	3	16
S1(2)	D	4.810s by S3	03.018s	7.828s	8	25
S3(1)	R	S3 Initiates	18ms	18 ms	5	26
S3(2)	D	4.733s by S4	3.164s	7.897s	3	18
S4(1)	R	S4 Initiates	9ms	9 ms	5	none

Table 1: RSTP Convergence Results (5 Node Topology)

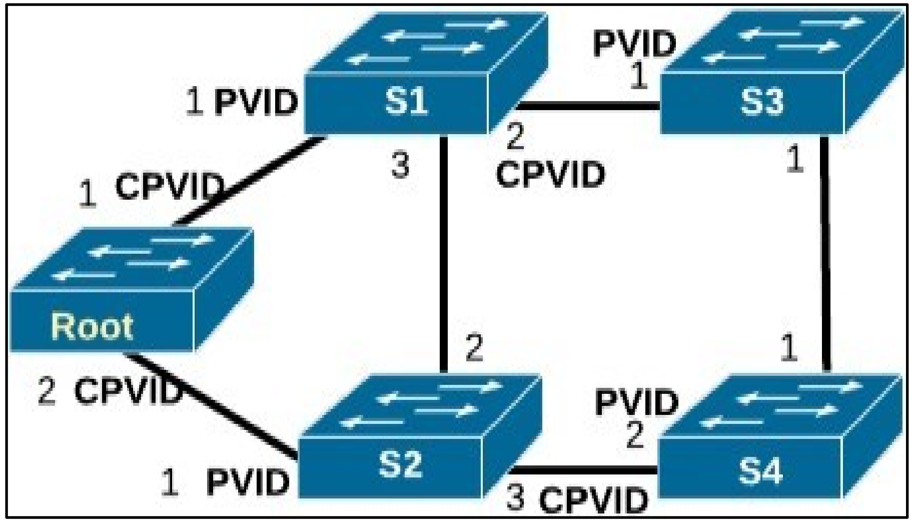
Case	Port	FDT	PRT	CT	Messages
Root(1)	CPVID	1.15s	1.5 ms	1.15s	2
S1(1)	PVID	2.71s	0.14 ms	2.71s	3
S1(3)	No Impact				
S1(2)	CPVID		1.8 ms	1.8 ms	4
S3(1)	No Impact				
S3(2)	PVID		1.77 ms	1.77 ms	2
S4(1)	PVID		0.7 ms	0.7 ms	2

Table 2: MTP Convergence Results (5 Node Topology)

RSTP



MTP



8 Node Topology Results

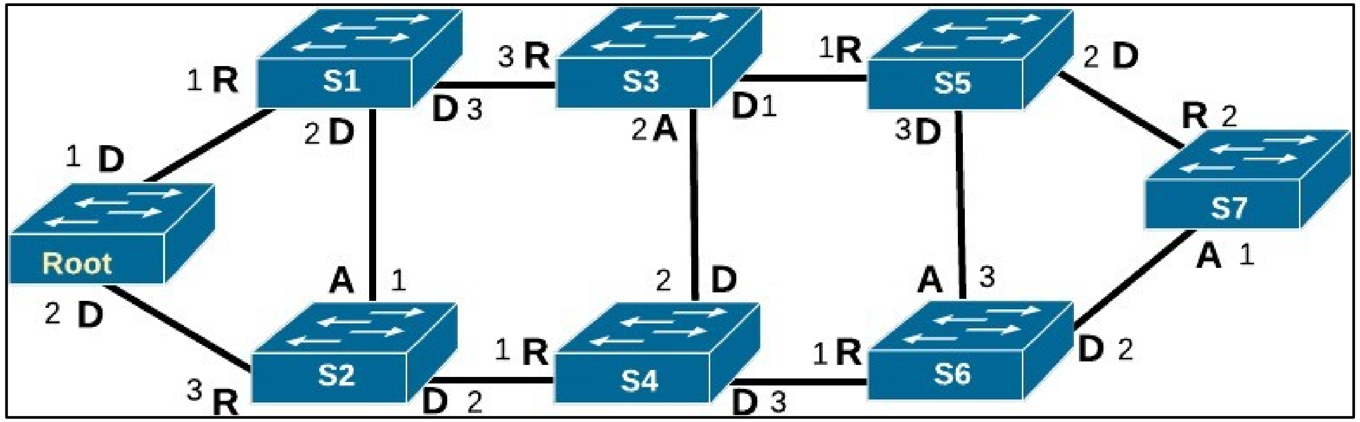
Case	Port	FDT	PRT	CT	PRS	TCN
Root(1)	D	5.037s by S1	3.021s	8.058s	22	75
S1(1)	R	S1 initiates	3.032s	3.032s	19	68
S1(2)	D	4.023s by S2	3.005s	7.028s	3	37
S1(3)	D	5.206s by S3	3.027s	8.233s	13	59
S4(1)	R	S4 initiates	2.528s	2.528s	15	72
S4(2)	D	5.017s by S4	3.004s	8.021s	3	37
S4(3)	D	5.526s by S6	3.014s	8.540s	6	30
S5(1)	R	S5 initiates	3.525s	3.525s	15	40
S5(2)	D	4.199s by S7	3.012s	7.211s	6	35
S5(3)	D	5.018s by S6	3.005s	8.023s	3	39
S7(2)	R	S7 initiates	12 ms	12 ms	3	36

Table 3: RSTP Convergence Results (8 Node Topology)

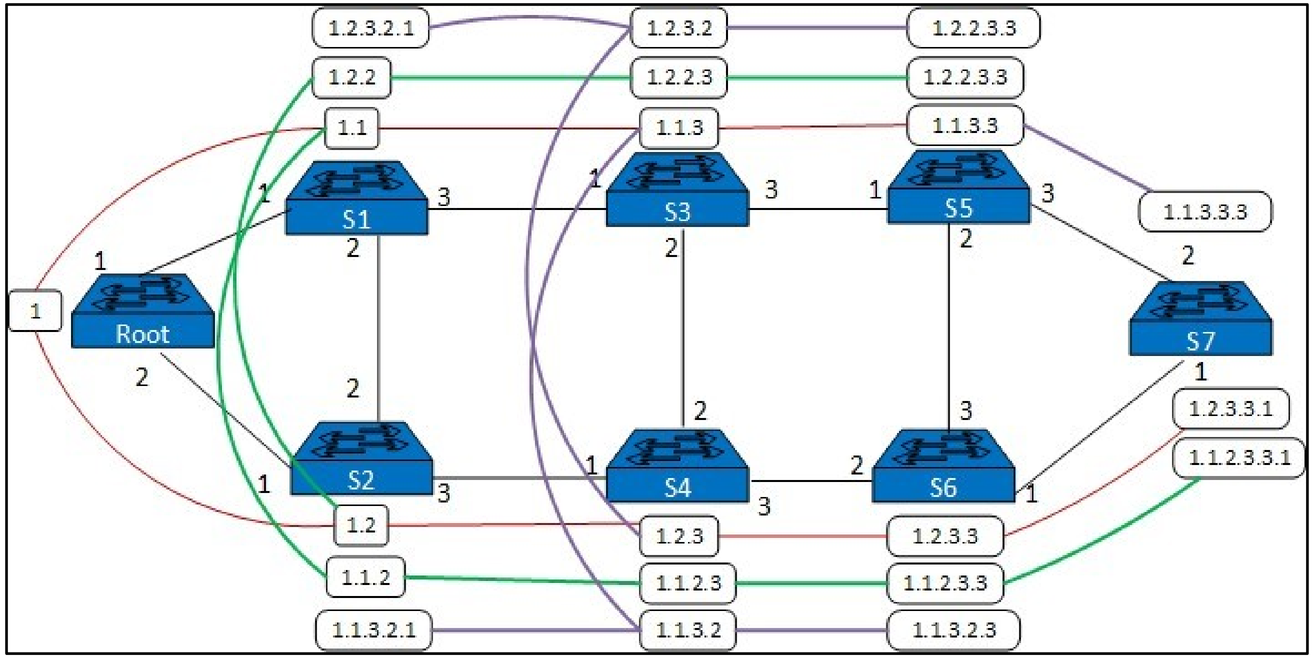
Case	Port	FDT	PRT	CT	Messages
Root(1)	CPVID	1.740s	14.6ms	1.74	6
S1(1)	PVID		17ms	17ms	4
S1(3)	CPVID	1.024s	15ms	1.024	5
S4(1)	PVID		6ms	0.006	4
S4(3)	CPVID	2.407s	7ms	2.407	4
S5(1)	PVID	2.290s	< 1ms	2.29	4
S5(3)	CPVID	1.046s	5ms	1.046	3
S7(2)	PVID	2.756s	< 1ms	2.756	0

Table 4: MTP Convergence Results (8 Node Topology)

RSTP



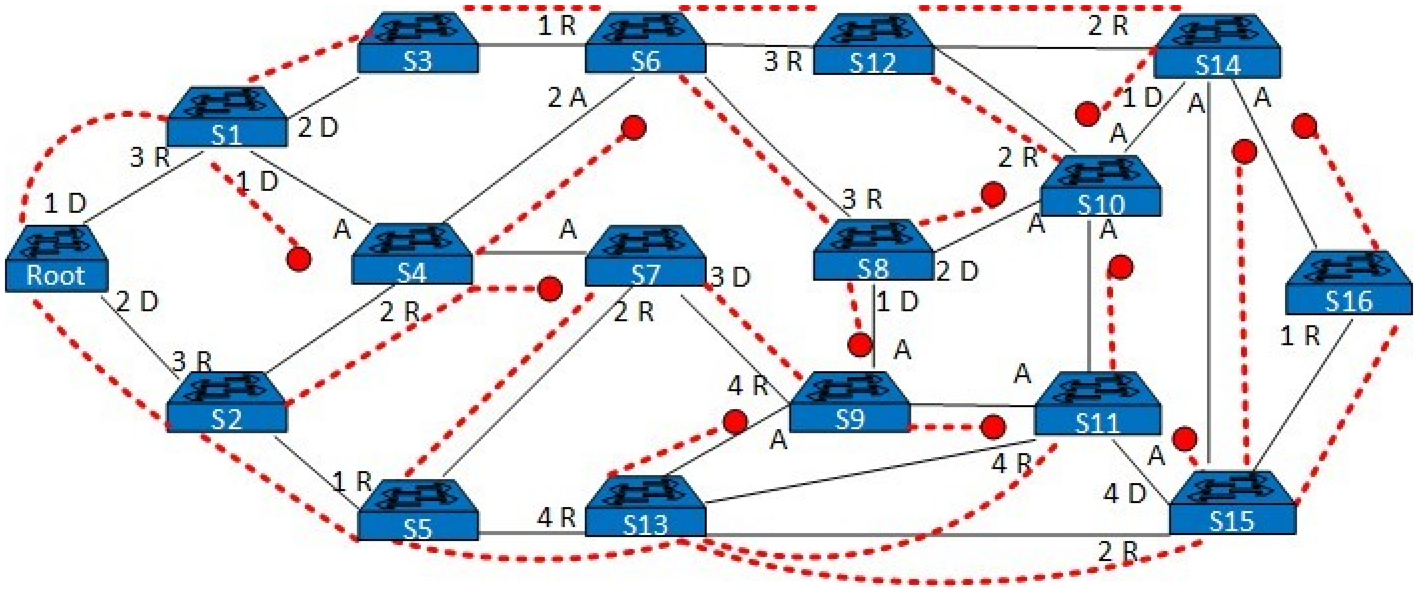
MTP



17 Node Topology Results - RSTP

Case	Port	FDT	PRT	CT	PRS	TCN
Root (1)	D	4.501s by S3	3.462s	7.963s	26	100
S1 (1)	D	5.024s by S4	3.010s	8.034s	3	80
S1 (2)	D	4.086s by S3	3.028s	7.112s	10	80
S1 (3)	R	S1 Initiates	40ms	40ms	20	110
S7 (2)	R	S7 Initiates	24ms	24ms	3	90
S7 (3)	D	4.680s by S9	3.019s	7.699s	6	85
S8 (1)	D	3.231s by S8	3.000s	6.231s	3	84
S8 (2)	D	3.998s by S10	3.001s	6.999s	3	84
S8 (3)	R	S8 Initiates	32ms	32ms	10	106
S14 (1)	D	4.466s by S10	3.007s	7.473s	3	93
S14 (2)	R	S14 Initiates	0.025	25ms	3	100
S15 (2)	R	S15 Initiates	3.054s	3.054s	30	153
S15 (4)	D	5.475s by S11	3.011s	8.486s	3	80
S16 (1)	R	S16 Initiates	15ms	15ms	5	88

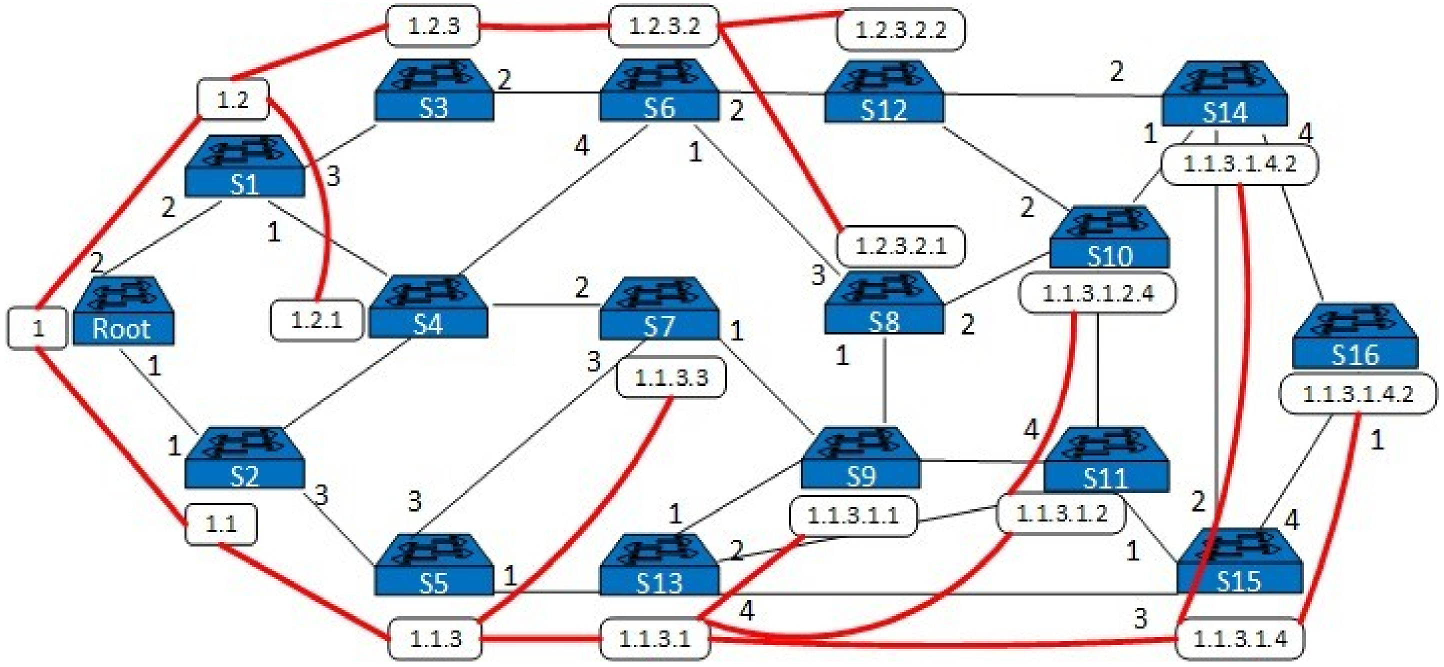
Table 5: RSTP Convergence Results (17 Node Topology)



17 Node Topology Results - MTP

Case	Port	FDT	PRT	CT	Messages
Root (1)	CPVID	2.763s –S2	36ms	2.763	9
S1 (1)	NO IMPACT				
S1 (3)	CPVID	2.726s -S3	5ms	2.726	2
S1 (2)	PVID	-	11ms	11ms	4
S7 (1)	NO IMPACT				
S7 (2)	NO IMPACT				
S7 (3)	PVID		5.4ms	5.4ms	2
S8 (2)	NO IMPACT				
S8 (3)	PVID	2.450-S6	7ms	2.45	3
S14 (2)	PVID	1.911 -S12	6ms	1.911	2
S14 (4)	NO IMPACT				
S15 (3)	PVID		12ms	12ms	5
S15 (4)	CPVID	2.453s -S16	3ms	2.453	2
S16 (1)	PVID	2.946s- S15	6ms	2.946	1

Table 6: MTP Convergence Results (17 Node Topology)



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Please reach out with questions