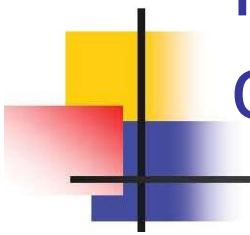

Modeling and Simulating STP vs RSTP on Ring and Mesh Network Topologies

ENSC 835: Communication Networks
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Final Project Presentation

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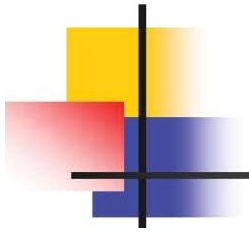
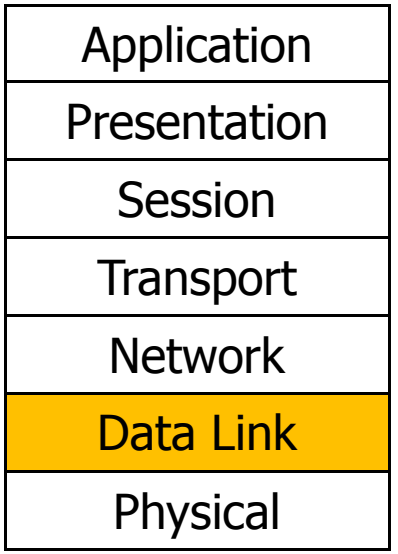


Roadmap

- Introduction
- Motivation and Objective
- Overview of related work
- Formation of Spanning Tree
- Bridge Protocol Data Unit
- Simulation and Results in OPNET14.0
- Summary and Conclusions
- Organization and Timelines
- Future Work
- References

Introduction

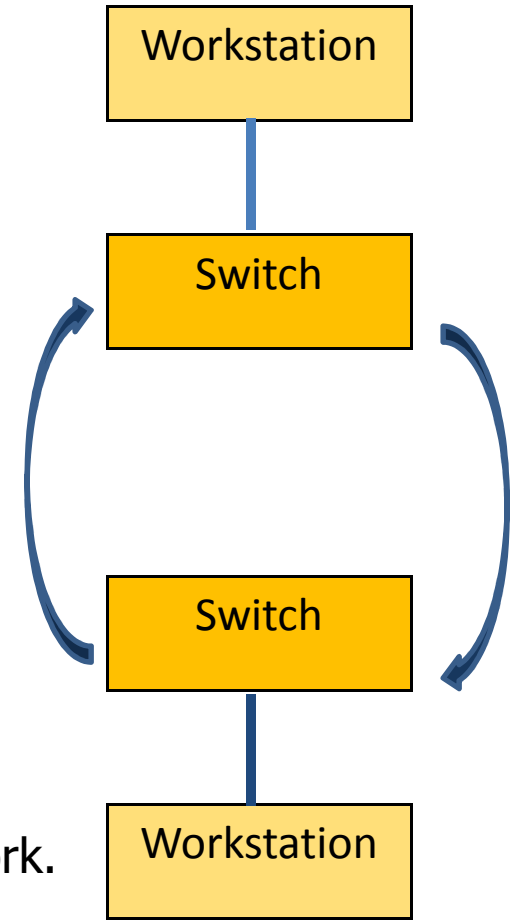
- Spanning Tree Protocol (STP) is a Data Link Layer protocol
- STP is standardized as IEEE 802.1D
- Rapid Spanning Tree Protocol (RSTP) is the refinement of STP
- RSTP is standardized as IEEE 802.1W
- Both, STP and RSTP, ensure a loop-free topology for a bridged Ethernet Local Area Network



OSI Model

Motivation and Objective

- When two endpoints have more than one Layer-2 path, a switching loop is formed
- Switching loop creates broadcast radiation, i.e. repeatedly rebroadcasting the broadcasted messages
- Objectives:
  - create a switching-loop free network using spanning tree protocols
  - analyze STP vs RSTP performance with a failure and recovery of network link
  - compare tree convergence behaviors by increasing the links and nodes in the network.

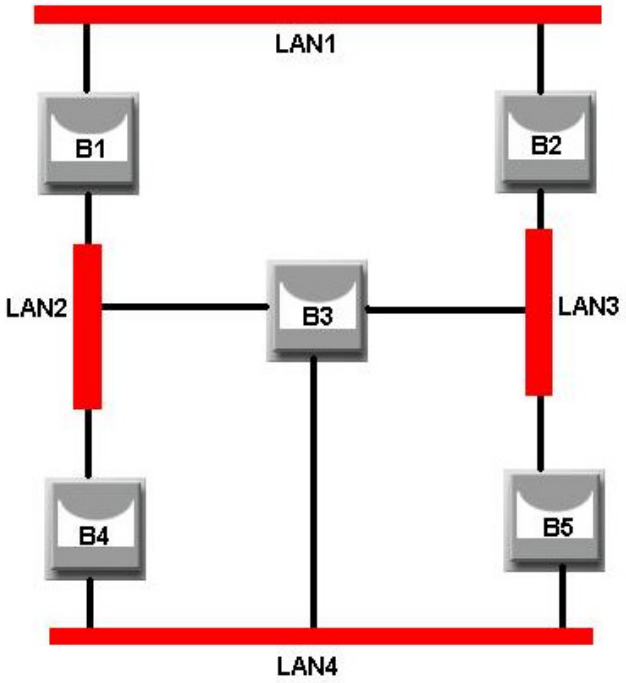


Overview of related work

- Raniwala and T. Chiueh, "Architecture and Algorithms for an IEEE 802.11-Based Multi-Channel Wireless Mesh Network," *Proc. of IEEE Infocom 2005*, vol. 3, 13-17, pp. 2223-2234, March 2005
  - used traffic load to dynamically assign STP forwarding path
- H. S. Chiu, B. Wu, K. L. Yeung, and K.-S. Lui, "Widest Spanning Tree for Multi-Channel Multi-Interface Wireless Mesh Networks," *Proc. Of IEEE WCNC,* pp. 2194-2199, April 2008
  - solved wide STP problem using mathematical formulation
- K. Lui, W.C. Lee and K. Nahrstedt, "STAR: A transparent spanning tree bridge protocol with alternate routing," *ACM SIGCOMM Computer Communications* ,Review 32, July 2002
  - presented shortest forwarding path to improve QoS

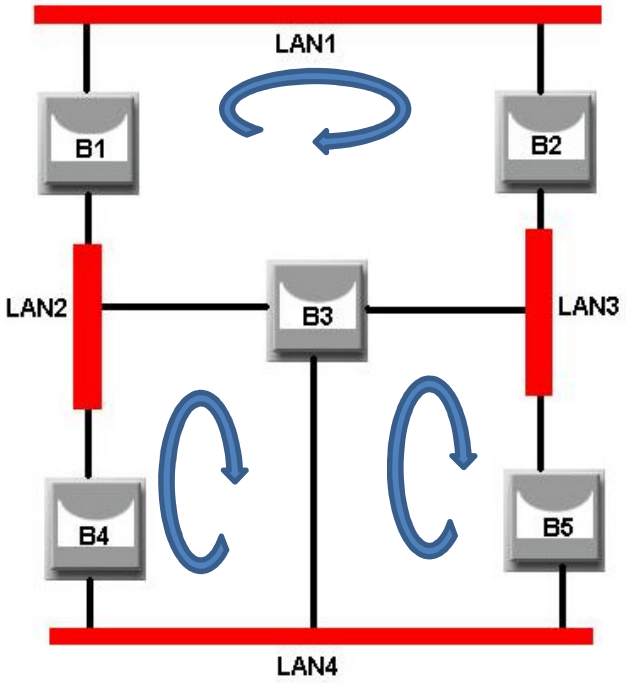
Formation of Spanning Tree

- Five bridges
  - B1, B2, B3, B4 and B5
- Four LANs
  - LAN1, LAN2, LAN3 and LAN4
- LANs connected to each other through Bridges

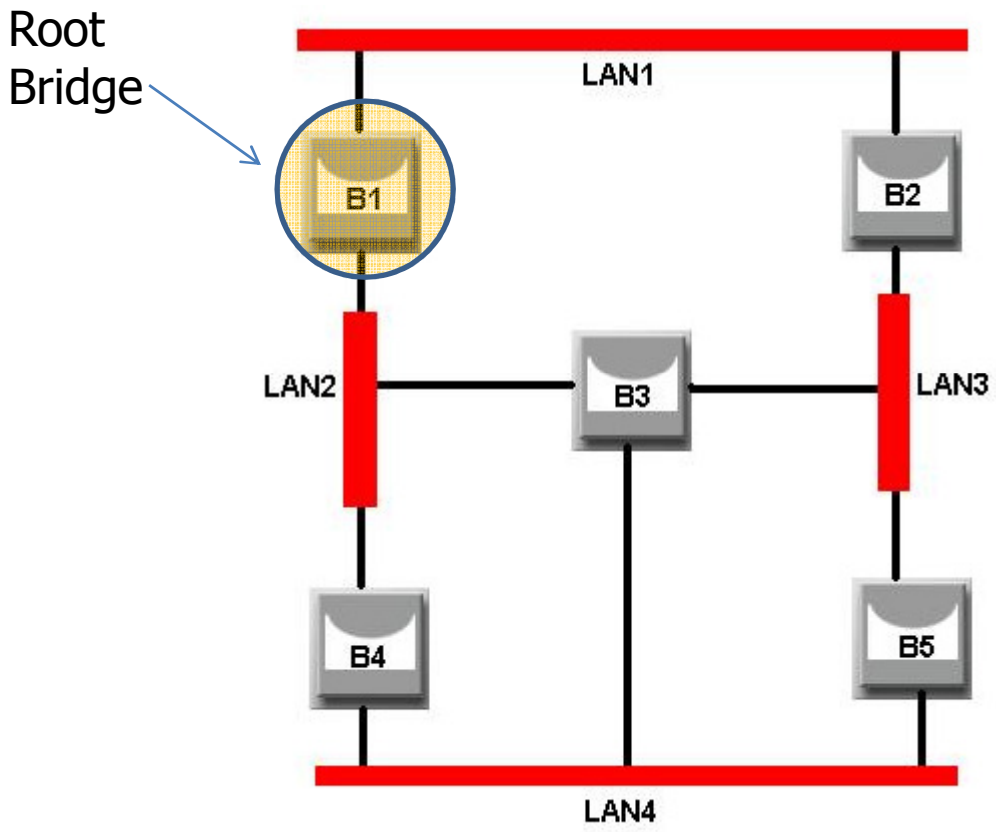


Formation of Spanning Tree

- Five bridges
  - B1, B2, B3, B4 and B5
- Four LANs
  - LAN1, LAN2, LAN3 and LAN4
- LANs connected to each other through Bridges
- Loops are created due to physical connections

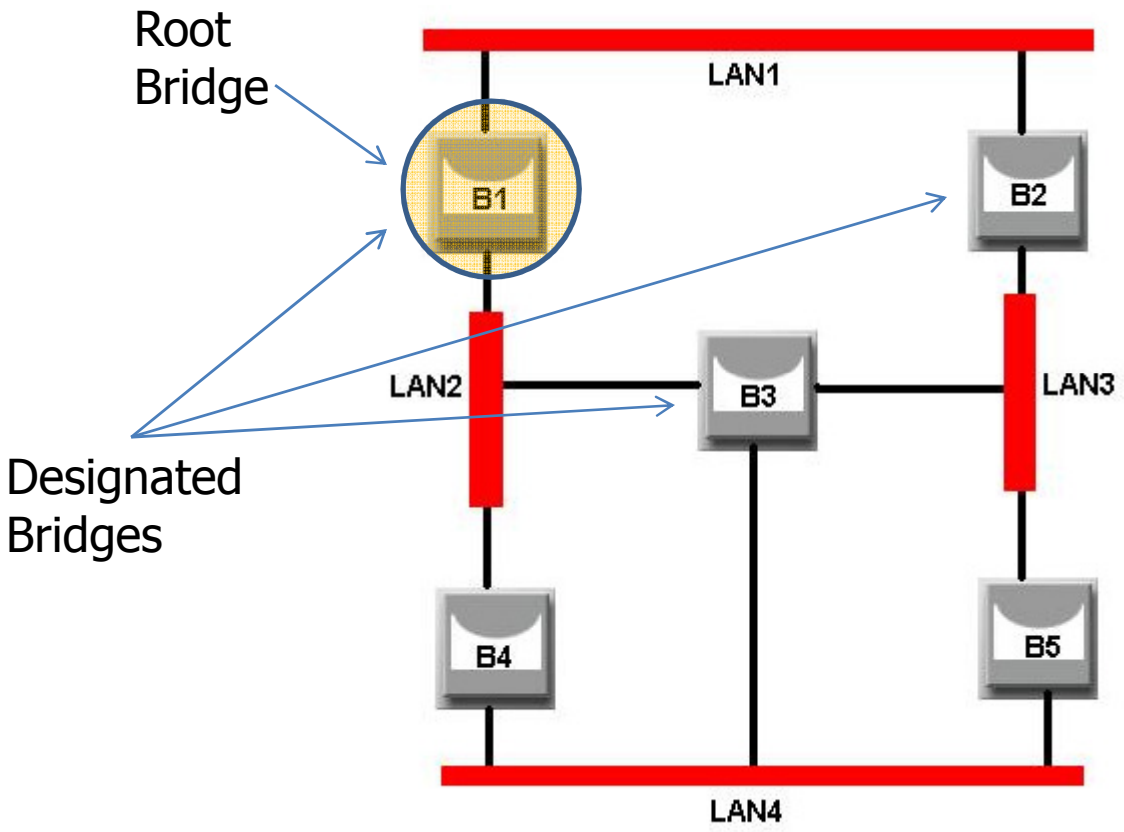


Formation of Spanning Tree



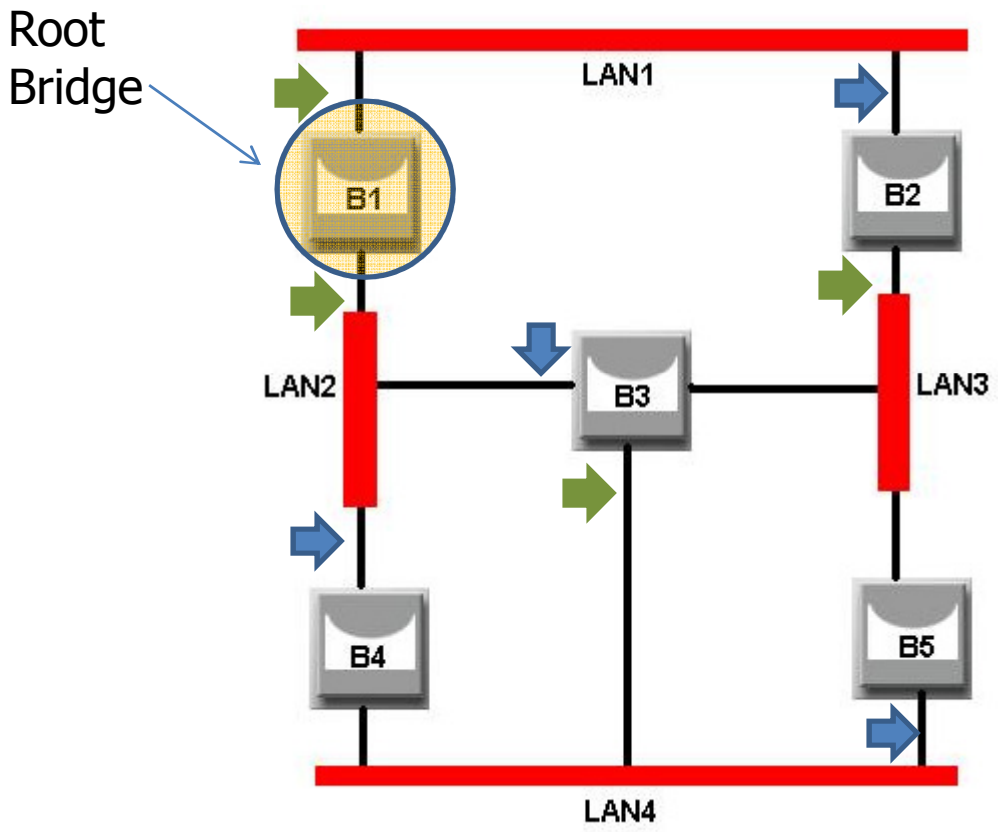
The bridge with the smallest ID is the root bridge

Formation of Spanning Tree



On each LAN, the bridge with the least cost path to the root bridge is the designated bridge

Formation of Spanning Tree

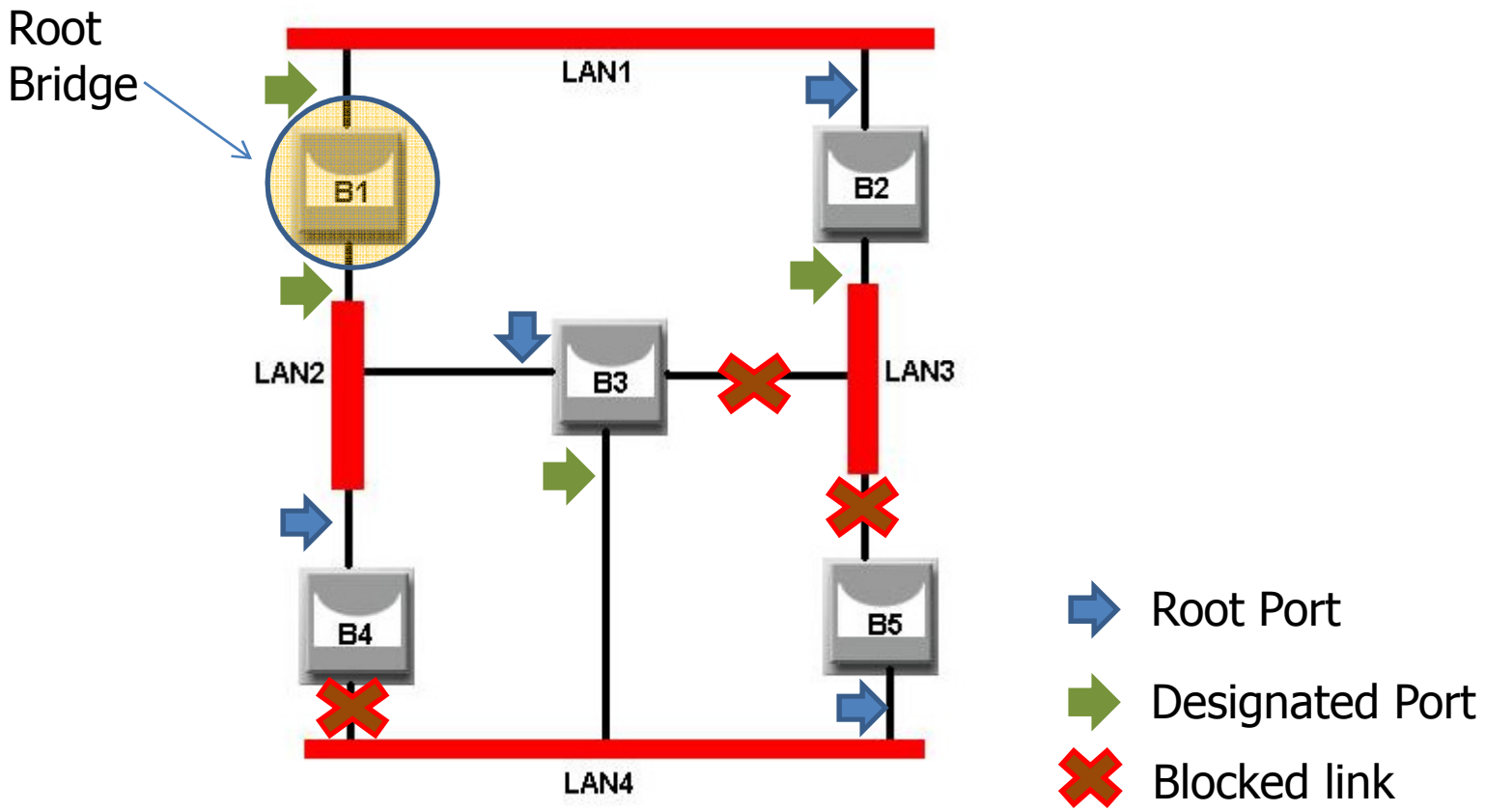


On each bridge, the port with the least cost path to the root bridge is the root port

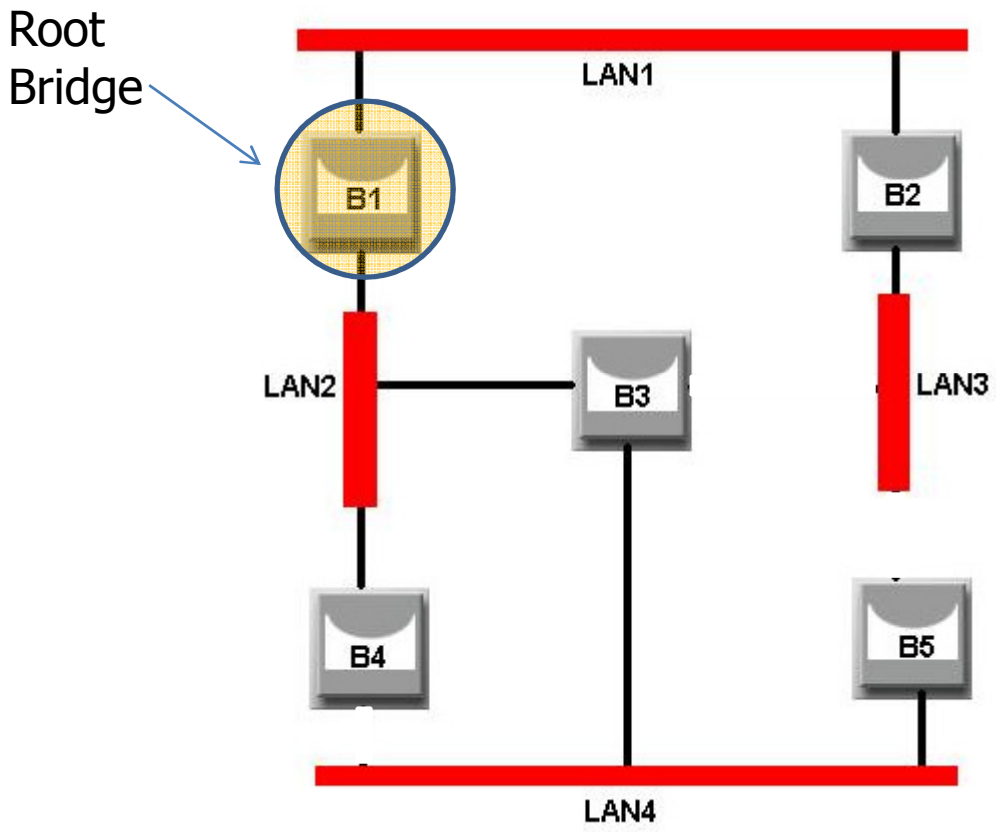
Root Port

Designated Port

Formation of Spanning Tree



Formation of Spanning Tree



Bridge Protocol Data Unit (BPDU)

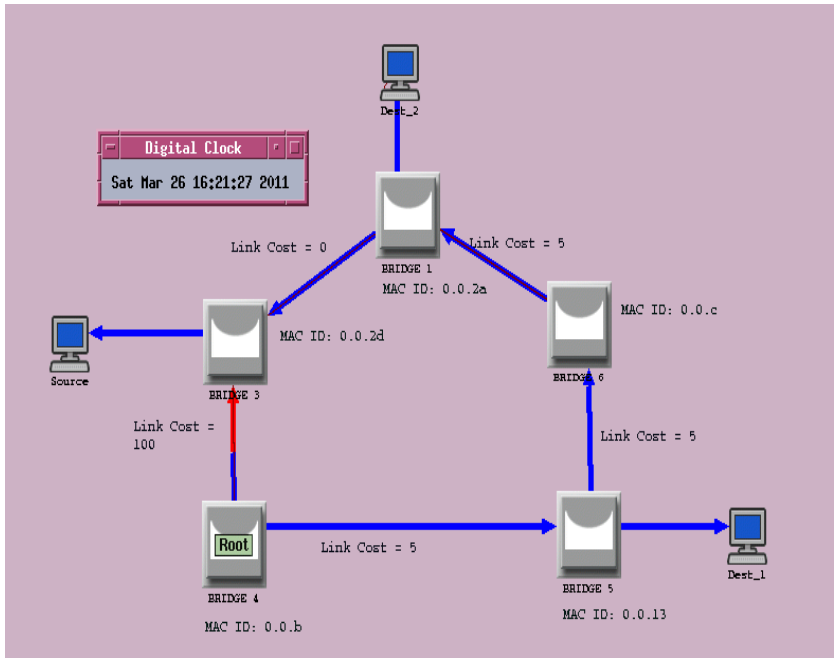
2	1	1	1	8	4	8	2	2	2	2	2
Proto ID	**Ver**	**BPDU Type**	**Flags**	**Root ID**	**Root Path Cost**	**Bridge ID**	**Port ID**	**Msg Age**	**Max Age**	**Hello Time**	**Forward Delay**

- BPDU is a 802.1 data frame used to communicate between bridges
- Contains timing parameters, MAC Address and priority of the root bridge and designated bridge

Timing Parameter	Description	Simulation Value
Hello Time	How often bridge broadcasts BPDU frame to the network	2 seconds
Maximum Age	Time before the received BPDU expires in the bridge	20 seconds
Forwarding Delay	Time the bridge takes to converge from blocking state to forwarding state	15 seconds

Simulation – OPNET14.0

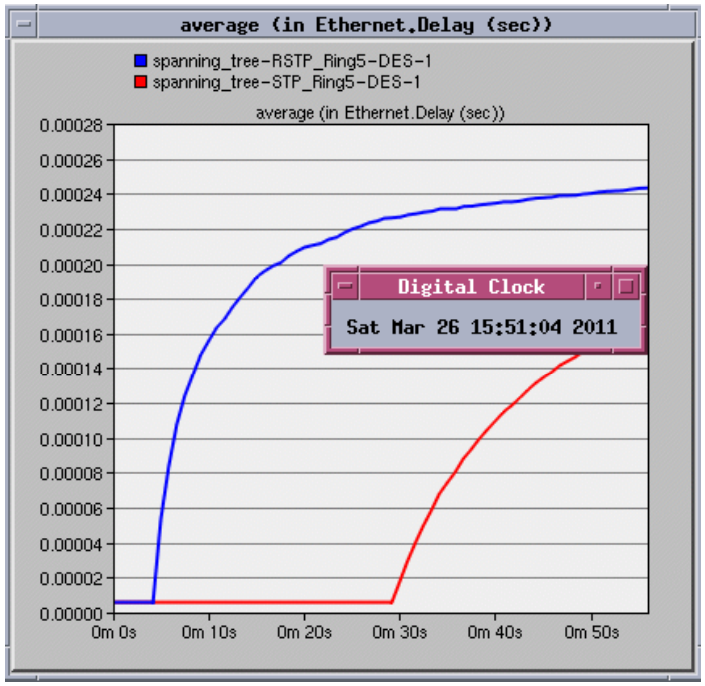
- Ring Topology with 5 bridges
- Server connected to Bridge 3
- Workstation connected to Bridge 5
- Bridge 3-4 link virtually blocked by STP formation

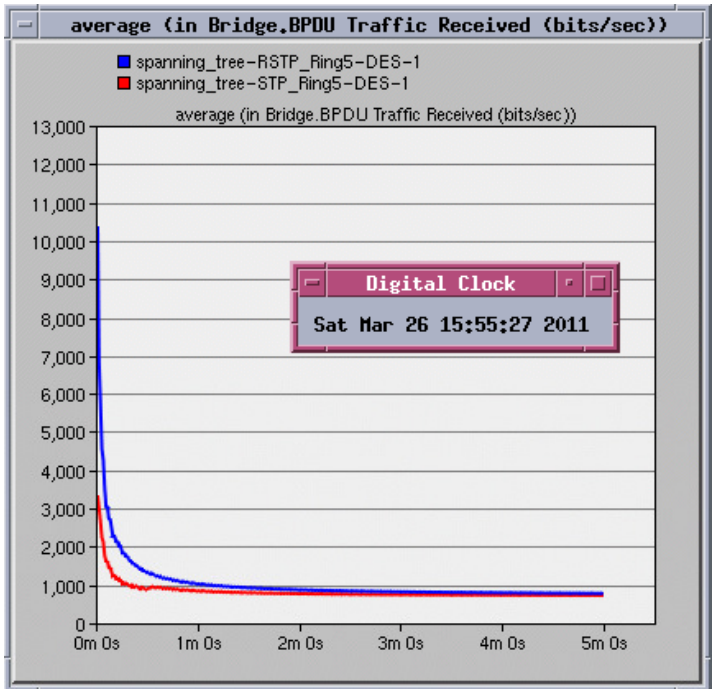


Spanning Tree

Blocked Link

STP vs RSTP in Ring Topology



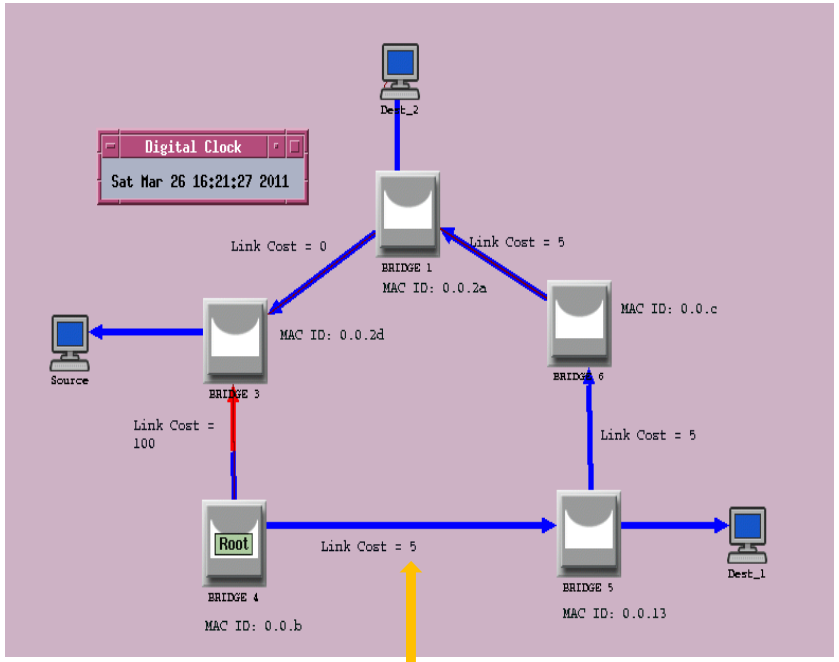


- STP formation delay ~ 30s
- RSTP formation delay ~ 6s

- BPDU traffic in RSTP > STP
- Results in quick formation of spanning tree in RSTP

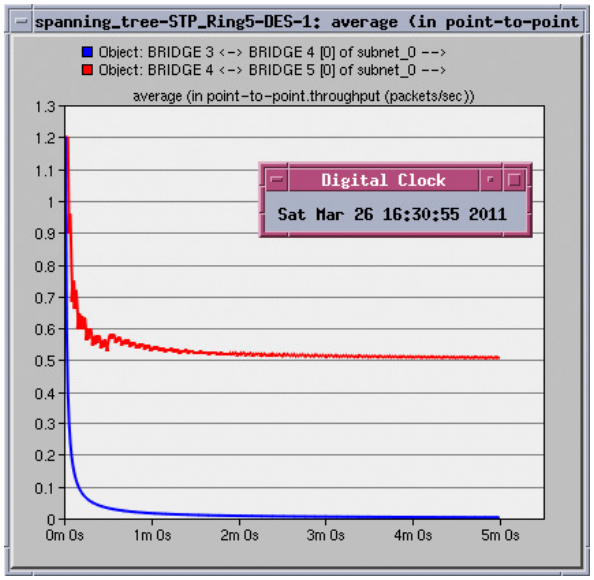
Failure/Recovery Analysis in STP

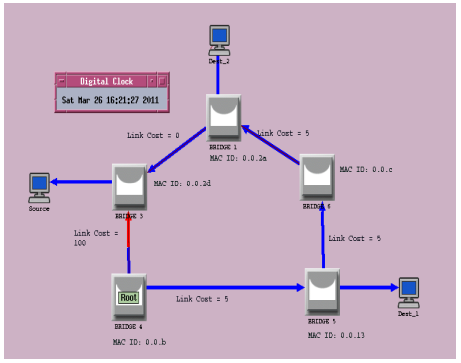
- At 2 minutes, link between Bridge 4 and Bridge 5 fails
- Blocked link between Bridge 3 and Bridge 4 reactivates
- At 3 minutes, link between Bridge 4 and Bridge 5 recovers
- Link between Bridge 3 and Bridge 4 gets blocked

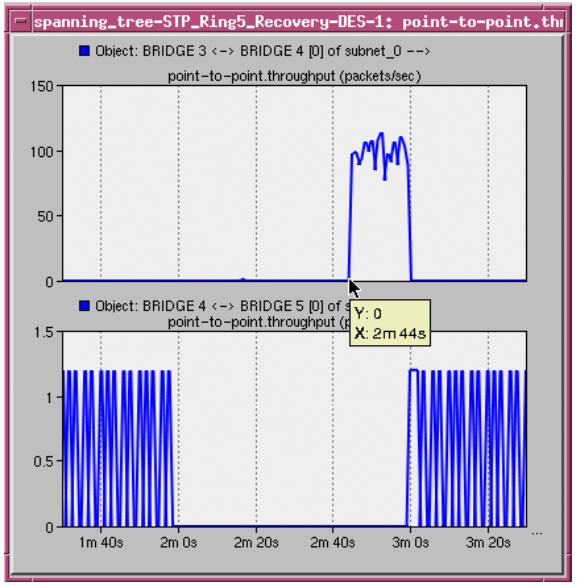


Link fails at 2 min.
Link recovers at 3 min.

Failure/Recovery Analysis in STP



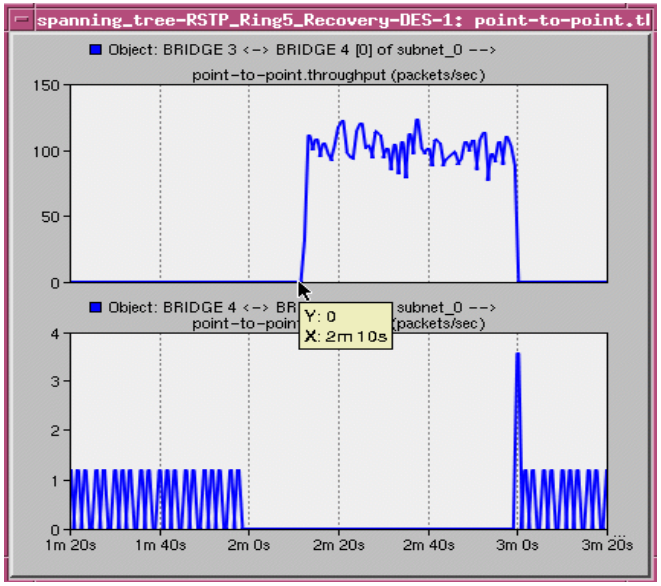


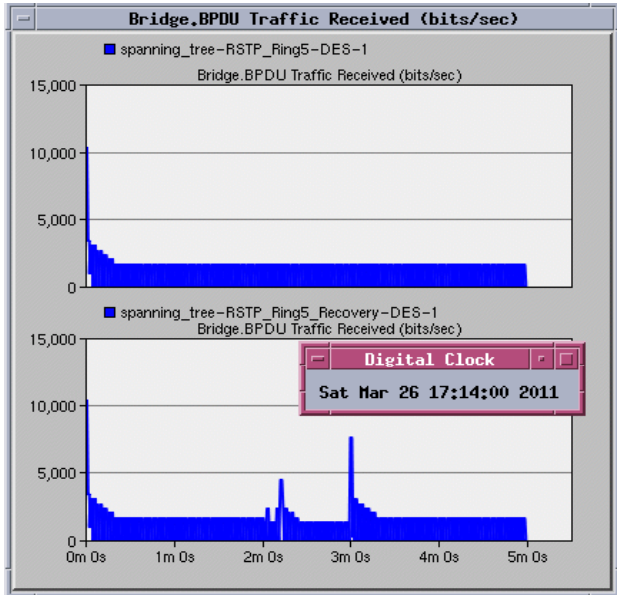


- Without failure/recovery
- Bridge4<->Bridge5 has continuous throughput
- Bridge3<->Bridge4 has zero throughput

- With failure/recovery
- Bridge4<->Bridge5 fails from 2 minutes up to 3 minutes
- Bridge3<->Bridge4 activates after 2 minutes + STP formation time

Failure/Recovery Analysis in RSTP



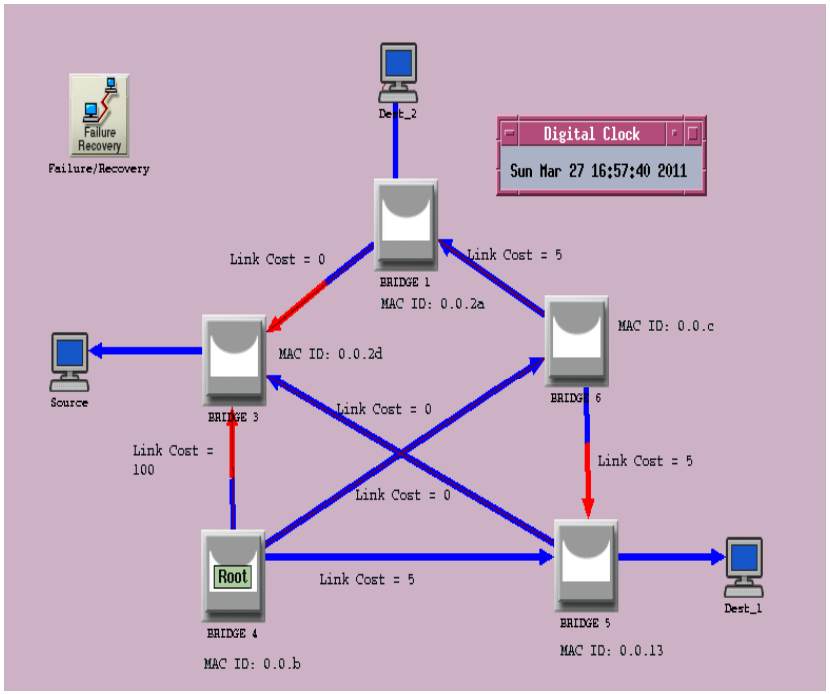


- Bridge4<->Bridge5 fails from 2 minutes up to 3 minutes
- Bridge3<->Bridge4 activates after 2 minutes + RSTP formation time

- BPDU Traffic increases at 2 minutes and 3 minutes

Simulation – OPNET14.0

- Mesh Topology with 5 bridges
- Server connected to Bridge 3
- Workstation connected to Bridge 5
- Bridge3<->Bridge4, Bridge1<->Bridge3 and Bridge5<->Bridge6 blocked by STP formation

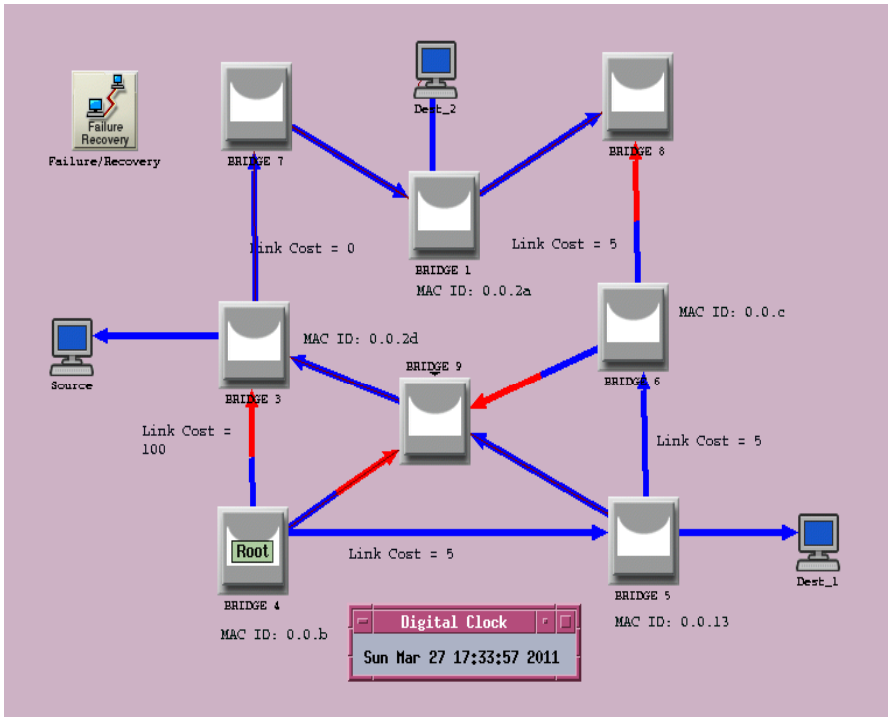


Spanning Tree

Blocked Link

Simulation – OPNET14.0

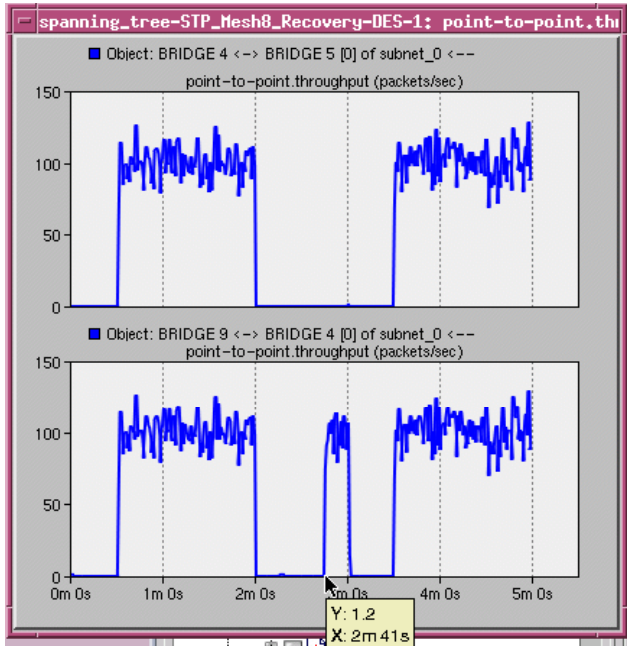
- Mesh Topology with 8 bridges
- Bridge3<->Bridge4, Bridge4<->Bridge9, Bridge9<->Bridge6 and Bridge9<->Bridge8 blocked by STP formation



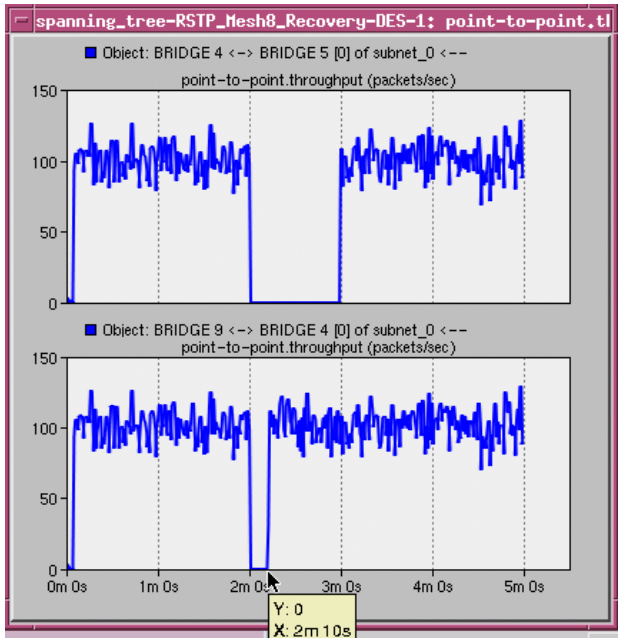
Spanning Tree

Blocked Link

STP vs RSTP with 8 bridges in Mesh



- STP takes 41 seconds to reform a tree



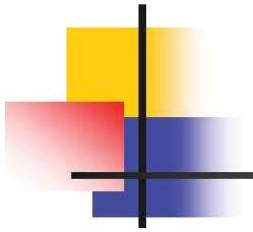
- RSTP takes 10 seconds to reform a tree

Conclusion

- STP and RSTP create virtual network and prevents switching loop
- Ring Topology
  - STP takes ~30s to form a spanning tree
  - RSTP takes ~6s to form a spanning tree
- Mesh Topology
  - Increasing links did not change the spanning tree formation time
  - Increasing nodes increased STP formation time by 11s and RSTP formation time by 4s
- RSTP uses more BPDU traffic than STP

Organization and Timelines

Task	Completed by	Completion Time
Understand Spanning Tree protocols	Simran and Manjur	4 weeks
Familiarize with OPNET14.0	Simran and Manjur	12 weeks
Create Ring Model	Simran and Manjur	4 weeks
Create Mesh Model with 5 bridges	Simran and Manjur	1 week
Create Mesh Model with 8 bridges	Simran and Manjur	1 week
Analyze results	Simran and Manjur	2 weeks



Future Work

- Determine the maximum number of nodes supported by a tree to ensure the BPDU travels to all the nodes before its maximum age expires
- Reduce Spanning tree re-formation time by storing pre-calculated spanning trees with every possible link failure

References

- J. Farkas and Z. Arato, "Performance Analysis of Shortest Path Bridging Control Protocols," *Global Telecommunications Conference*, Budapest, Hungary, pp.1-6, Nov./Dec. 2009.
- A. Azcorra and G. Ibanez, "Application of Rapid Spanning Tree Protocol for Automatic Hierarchical Address Assignment to Bridges," *Telecommunications Network Strategy and Planning Symposium,* Madrid, Spain, pp. 435-440, June 2004.
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- J. T. Yu, "Applying IEEE 802.1w (RSTP) to Improve Service Availability," *IEEE International Conference on Dependable Systems and Networks,* pp. B10-B11, June 2003.
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Questions