LUMINOUS NETWORKS

Topology Discovery and Protection Switching

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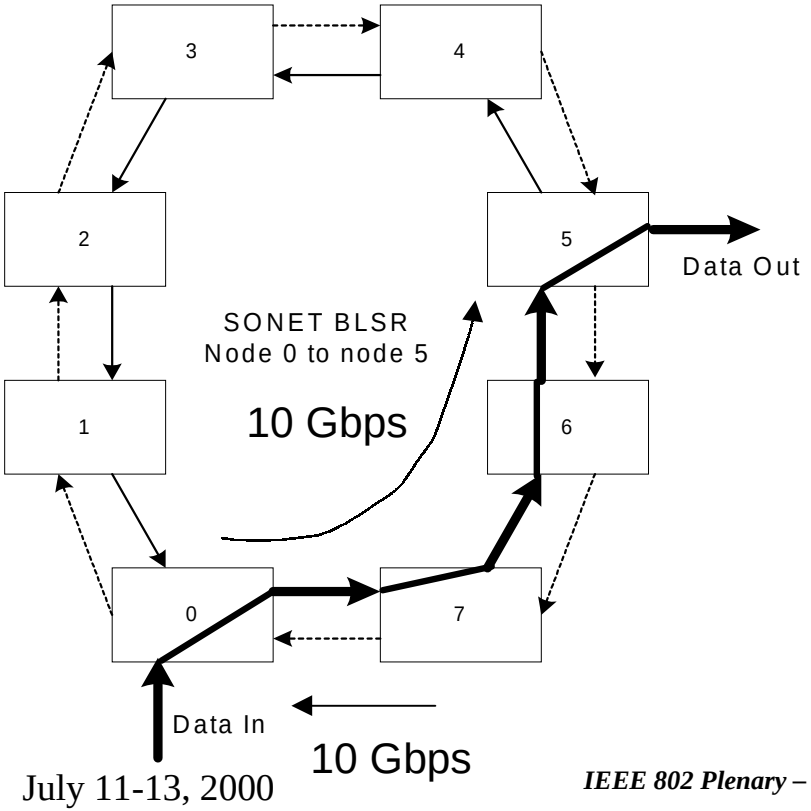
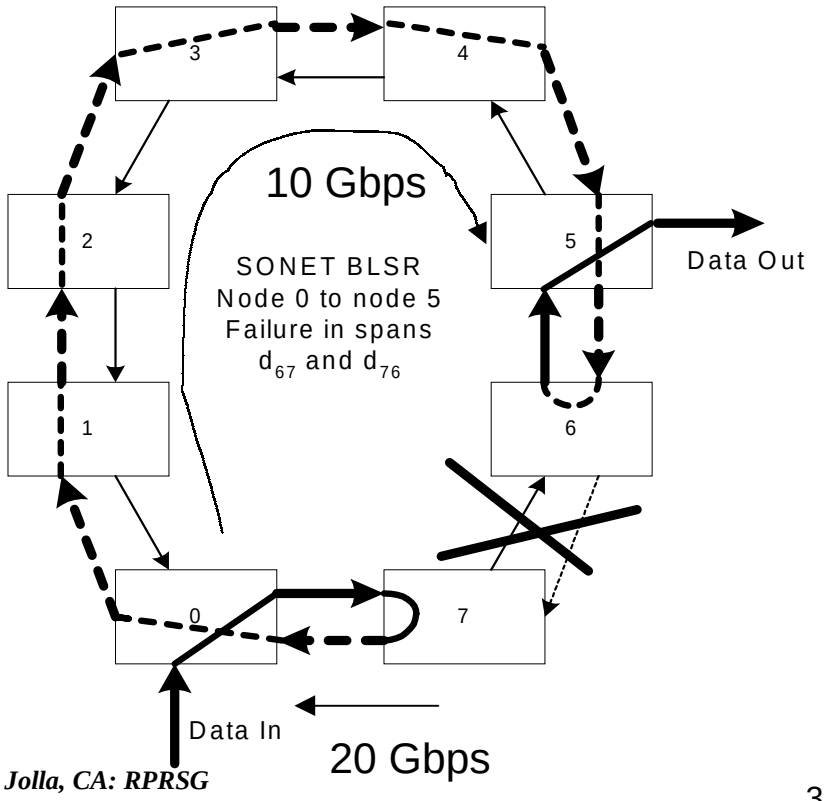
Problems to be Solved

- Limitations of spanning-tree-based layer 2 protocols
  - Do not enable full utilization of ring topologies (loops not allowed)
  - Re-convergence in the event of span failure significantly slower than 50 ms - important for voice applications

More Problems to be Solved

- Allocation of protection bandwidth in conventional BLSR
- Span usage inefficiency of BLSR protection
  - Can cause unnecessary oversubscription of spans





Automatic Topology Discovery

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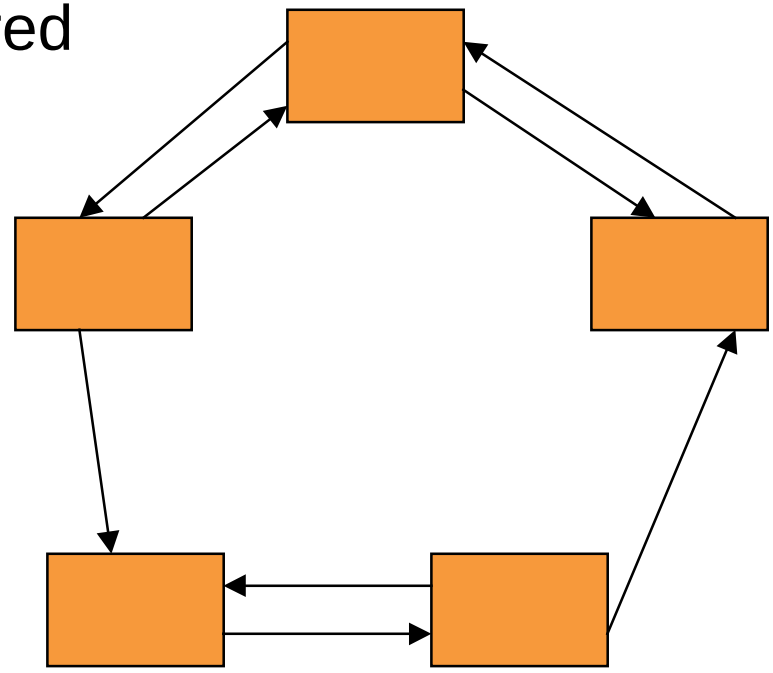
- Motivation
  - Enables sub-50 ms zero-bandwidth (source-routed) protection switching mechanism on layer 2
  - Enables complete discovery and use of all available fiber links
  - Enables seamless addition and deletion of nodes
    - No service disruption for existing protected traffic
  - Handles different topologies (bi-directional ring, linear, extensible to mesh)

Features

- Distributed algorithm
  - Each node performs topology discovery independently
- All available fiber links discovered
- Discovery occurs only when triggered, not periodically
- Topology validation eliminates need for acknowledgements
- No wrap-arounds

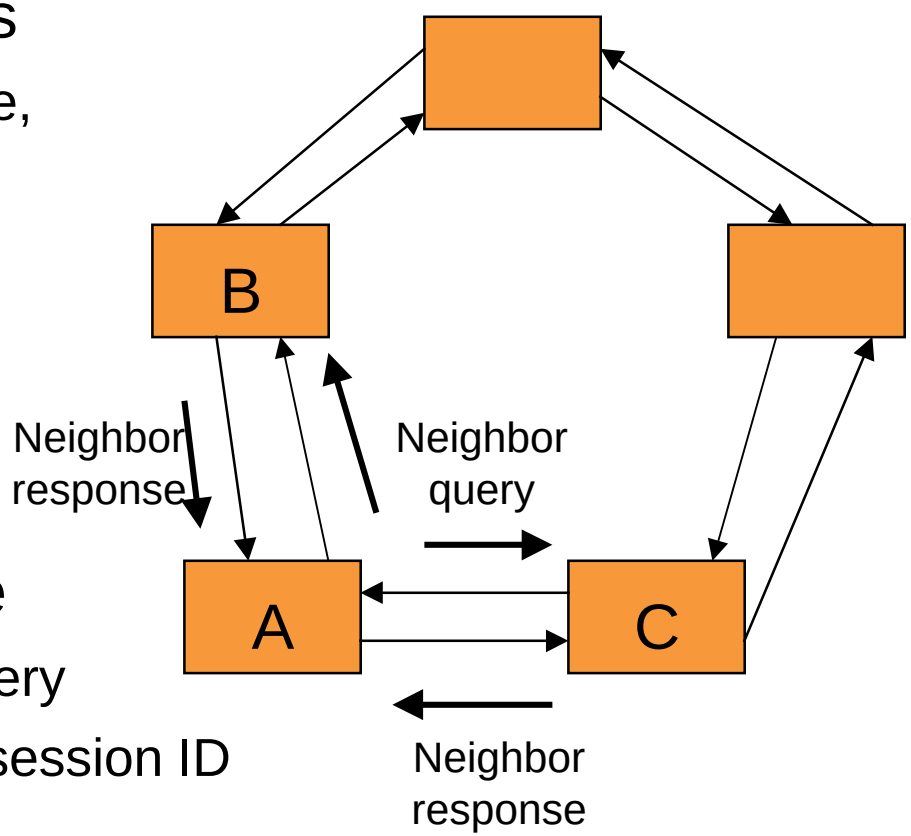


Topology Discovery Triggers

- Automatic:
  - Neighbor change at any node
    - Addition or deletion of neighbor
    - Fiber cut
  - Detection of a higher session number on an incoming message at a node
  - Invalid topology discovered at a node
- Operator:
  - Discover topology command

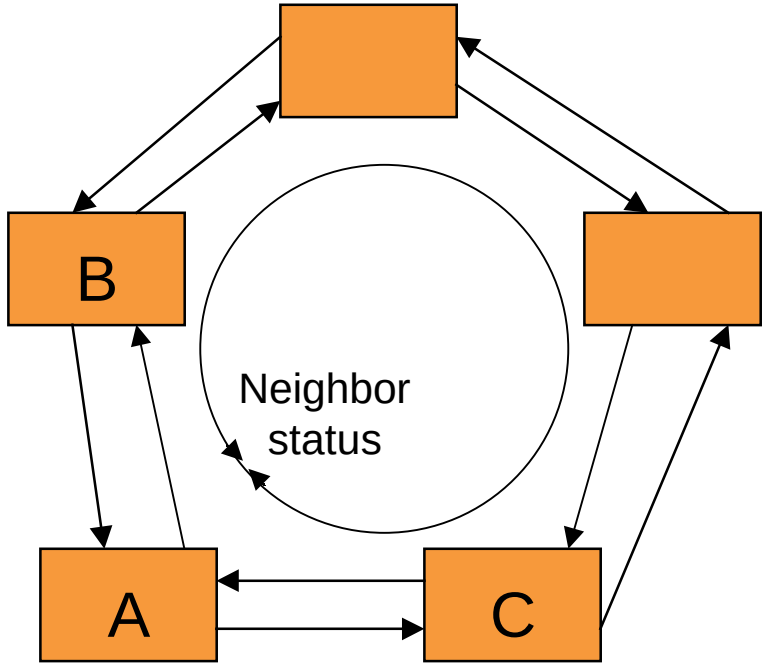
Control Messages

- All control messages contain control header, use 48-bit addresses
  - Contains priority, message type, checksum
- Neighbor query message
  - Immediate neighbor response
  - Contains node MAC address
  - Broadcast with TTL = 1
- Neighbor response message
  - Periodic and in response to query
  - Contains node MAC address, session ID
  - Broadcast with TTL = 1



More Control Messages

- Neighbor status message
  - Contains:
    - Node MAC address
    - Session ID
    - Neighbor MAC addresses
    - Measured BER on each ingress span
  - Broadcast with TTL = 255
    - Normally removed by source



Configurable Parameters

- Neighbor response message period
- Quiet time
  - No new neighbor status messages received
  - No neighbor changes detected
- Topology discovery time
  - Check if quiet time has been met
    - If not, continue with topology discovery for another topology discovery time
- Number of failed topology discovery attempts before event generated for management system

Execution Steps

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- Topology discovery trigger occurs
- If trigger is higher session ID on received neighbor status message
  - Collect all received neighbor status messages with that session ID
  - Send neighbor status message with equal session ID
- Else if trigger is anything else
  - Send out neighbor request message in both directions
  - Collect neighbor responses
  - Send out neighbor status message with incremented session ID
  - Collect all received neighbor status messages with that session ID

Execution Steps continued

- If topology discovery time expires and quiet time has been exceeded
  - Perform topology validation
    - Construct topology based on neighbor status messages
    - Check for inconsistencies
  - If valid:
    - Update topology and layer 2 directional information as needed
  - Else if invalid:
    - Attempt to perform topology discovery again
    - If number of retries is exceeded, then generate event to management system

Zero-Bandwidth Protection Switching

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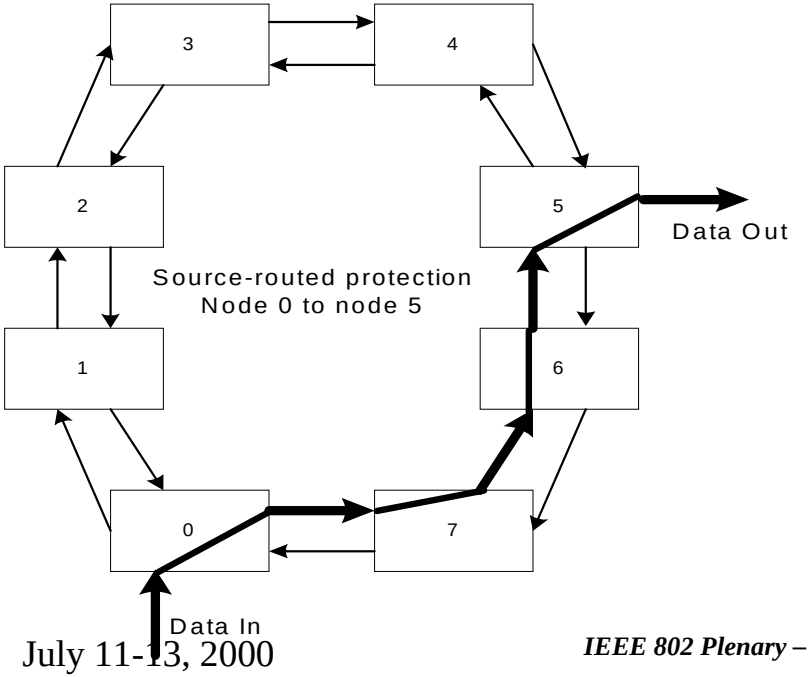
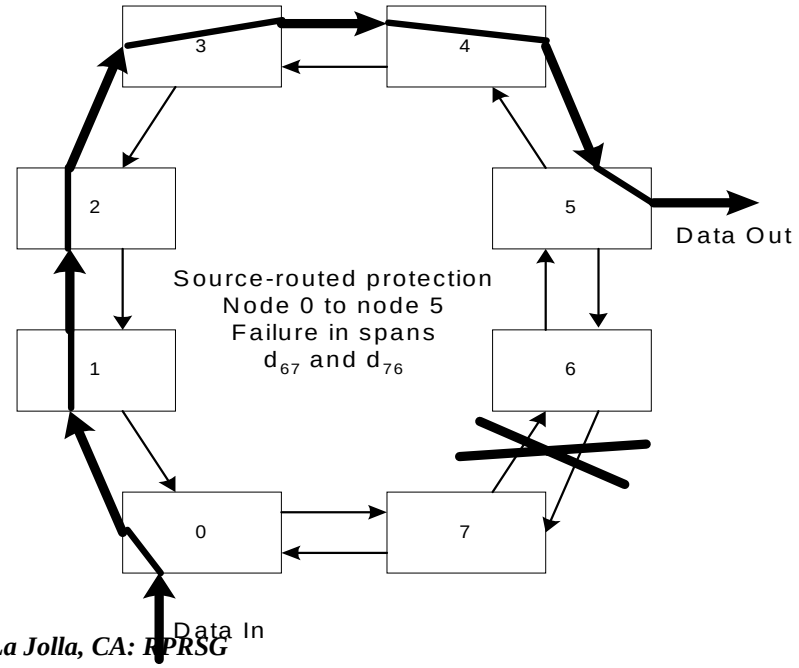
- Motivation
  - Enables sub-50 ms ring restoration
  - Does not require reservation of protection bandwidth
  - Does not cause span usage inefficiency of BLSR
  - Takes advantage of information available from topology discovery
  - Layer 2 protocol

Features

- All protected traffic restored in less than 50 ms
- Nodes individually re-evaluate routes towards all destinations
- Integrated with topology discovery
- No wrap-arounds





Protection Switching Triggers

- Automatic:
  - Loss of signal
  - Signal degrade
  - Wait-to-restore (if revertive)
  - Receipt of protection switching message
- Operator:
  - Span down
  - Revert to use of span

Automatic Triggers

- Loss of signal
  - Caused by loss of signal on media or node keep-alive failure
  - Results in local protection switching and broadcast notification of other nodes
- Signal degrade
  - Caused by excessive line bit error rate
  - Results in local protection switching and broadcast notification of other nodes
- Wait to restore
  - Occurs based on topology discovery time at each node
  - After topology discovery completes, span may be used (in revertive mode)

Manual Triggers

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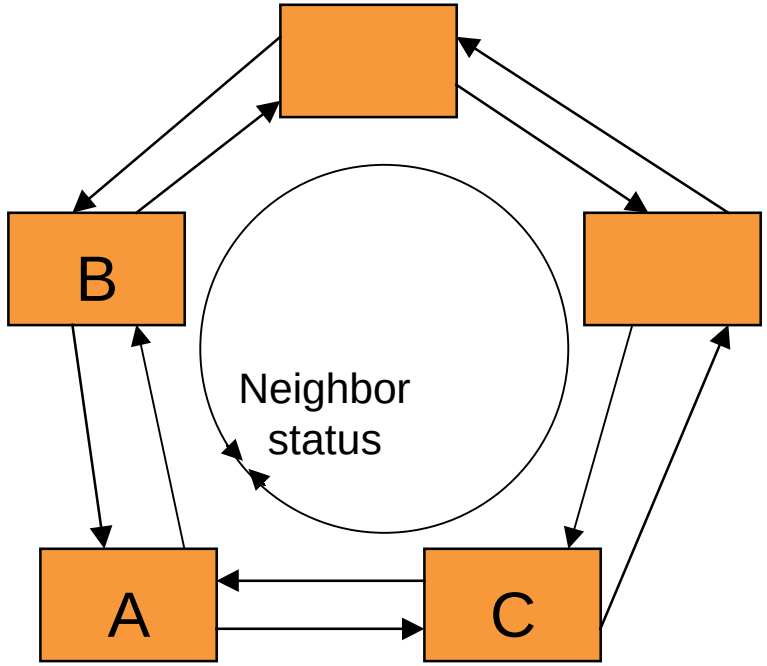
- Span down
  - Administrative removal of a span from service
- Revert to use of a span
  - Administrative command to reuse a span

Control Messaging Types

- Protection switching message (highest priority)
  - Contains:
    - Node MAC address
    - Session ID
    - Neighbor MAC addresses
    - Measured BER on each ingress span
  - Broadcast with TTL = 255
    - Normally removed by source



Configurable Parameters

- Signal degrade BER threshold
- Signal fail BER threshold
- Wait-to-restore time (topology discovery time)

Execution Steps

- Protection switching trigger occurs
- If trigger is loss of signal, signal degrade, or commanded span down
  - Send protection switching broadcast
  - Perform layer 2 rerouting internally to node
- Else if trigger is an automatic protection switching message
  - Perform layer 2 rerouting internally to node
- Else if trigger is commanded revert to use of span
  - Start topology discovery
  - Upon completion of topology discovery, update layer 2 directional information as needed