Spanning tree protection in Ethernet microwave radio networks using adaptive modulation

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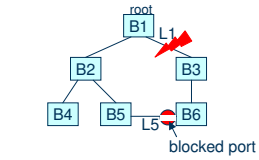
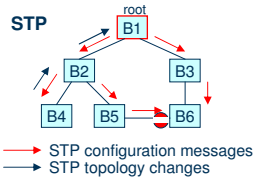
Introduction

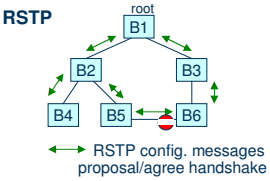
- Microwave radio
  - Important application: mobile backhaul - today mainly E1
  - Future:
    - capacity increase, best effort services (HSPA)
    - other applications (fiber extension, enterprise)
    - Ethernet
- Ethernet protection
  - Based on spanning tree protocol - various versions - xSTP
  - Question: Recovery time after failures? Which issues influence the recovery time?
- Propagation conditions
  - Influenced by rain fading
  - Adaptive modulation on a single link:
    - high availability for “guaranteed traffic”
    - high data rate for best effort traffic but lower availability
  - Additional optimization in network: rerouting of best effort traffic using xSTP -> high availability for best effort traffic

The Spanning Tree Protocols

- Purpose
  - eliminate loops
  - can be used as protection mechanism
  - various versions defined by IEEE
- Spanning Tree Protocol (STP)
  - root node regularly generates BPDUs
  - other nodes relay BPDUs
  - transitions between port states:
    - timer based operation
    - recovery time: 18s…130s
- Rapid STP (RSTP)
  - independent exchange of BPDUs between nodes
  - rapid transitions on point to point links
  - Investigation: recovery time
- Multiple STP (MSTP)
  - multiple instances, rapid transitions as RSTP



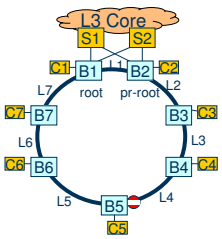




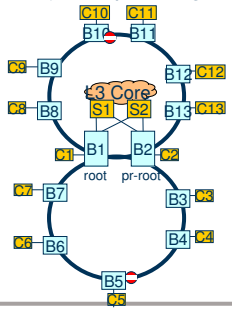
Investigations of RSTP protection time

- Methodology: Discrete event simulation
  - using an exact bridge model
- Main interest: total recovery time
  - time between error and when all end stations can communicate with each other
- Various network topologies

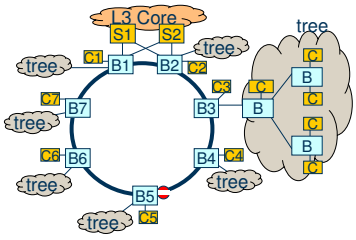
a) Ring



b) Multiple Ring

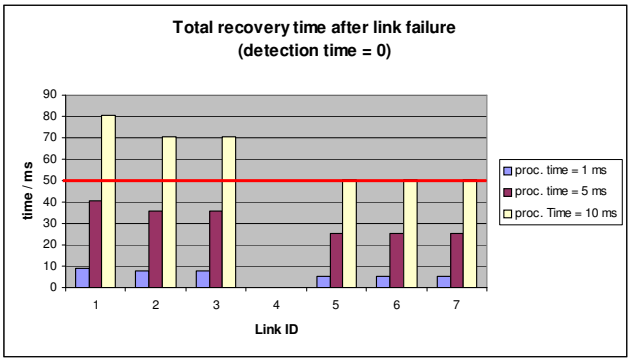


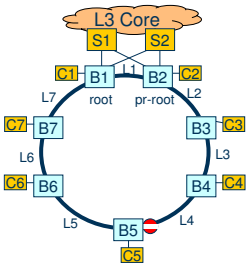
c) Ring with Tree



RSTP protection in a ring

Link failure - BPDU processing time



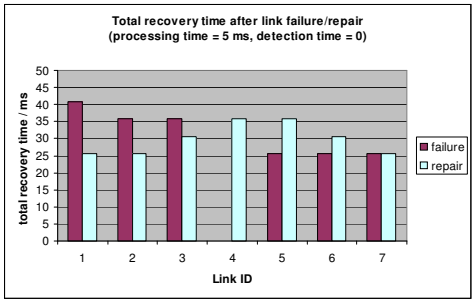


- important factor: BPDU processing time
- worst case in typical ring: $t_{recovery} = t_{detect} + (N+2) \cdot (t_{proc} + \underbrace{t_{queue} + t_{trans} + t_{prop}}_{\text{negligible}}) + t_{flush}$
- fast protection: optimize processing time
- orders of magnitude faster than STP

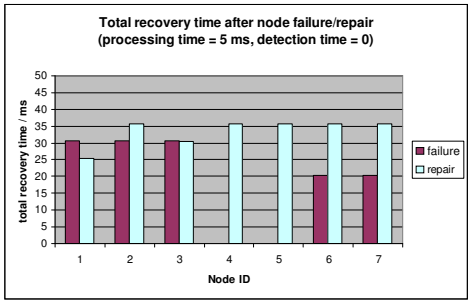
Other failure scenarios

Link failure/repair and Node failure/repair

Link failure / link repair



Node failure / node repair



- Repair is not hitless
- Recovery time for link failure/repair and node failure/repair are in the same range

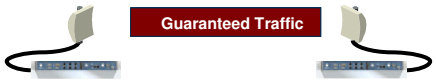
Adaptive Modulation on a link

Example with 2 PHY modes

Maximum capacity: 64-QAM – 116 Mbit/s

364 days

Guaranteed capacity: 4-QAM - 25 Mbit/s



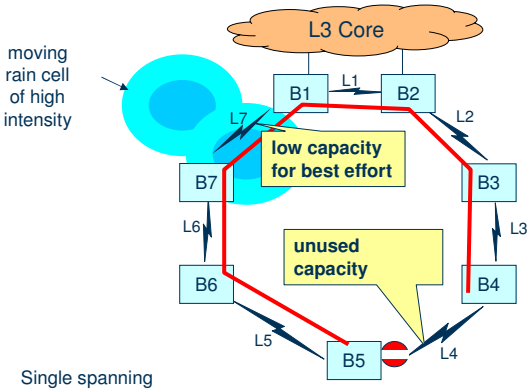
9 hours

Non-availability: 0 Mbit/s

5 minutes

Adaptive Modulation in a network

Capacity in network without rerouting

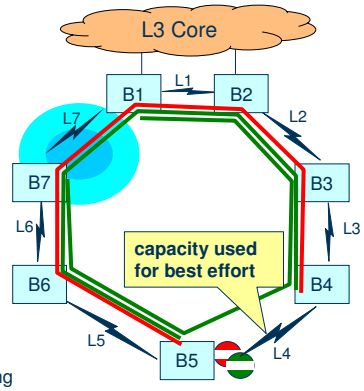


Example
- PHY modes
  - 64QAM: 116 Mbit/s
  - 4QAM: 25 Mbit/s
- traffic per node
  - guaranteed traffic: 8 Mbit/s
  - best effort: elastic
    -> w/o failure: 30.6 Mbit/s
    -> low capacity: 0.333 Mbit/s

Legend
- Bx — microwave radio NE with integrated Layer 2 switching
- microwave link (adaptive modulation, CoS support)

Adaptive Modulation

Rerouting of best effort traffic



Example
- PHY modes
  - 64QAM: 116 Mbit/s
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- traffic per node
  - guaranteed traffic: 8 Mbit/s
  - best effort: elastic
    -> w/o failure: 30.6 Mbit/s
    -> rerouting capacity 20.0 Mbit/s

Separate spanning tree topologies for:
- guaranteed traffic
- best effort traffic

rerouting of best effort traffic
➔ efficient network usage

Legend
- Bx: microwave radio NE with integrated Layer 2 switching
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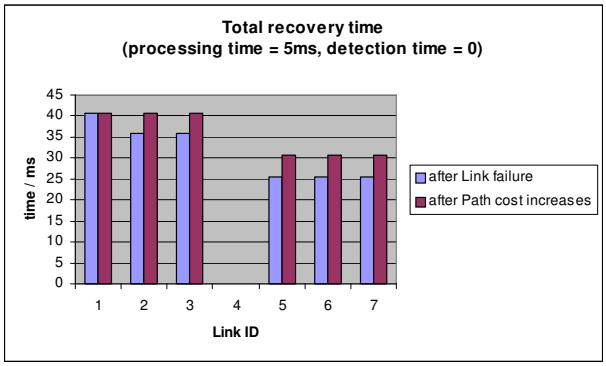
Recovery time - path cost change

- Rerouting: dynamically change spanning tree path cost



- Total recovery time for best effort traffic similar to link failure: one additional flush

Summary & Conclusions

- RSTP performance
  - RSTP provides fast recovery in realistic network topologies
  - Significant advantage over STP (several order of magnitude)
  - Fast recovery time achievable
- Adaptive Modulation
  - High availability for guaranteed traffic
  - Dynamic rerouting increases availability for best effort traffic
  - Rerouting using RSTP/MSTP dynamic path cost change
  - Interruptions for best effort traffic are short
- Acknowledgement
  - This work has been performed as part of the EIBONE research project funded by the German Federal Ministry of Education and Research

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