

Outage/Downtime Characterization of an MPLS-Enabled Router Network

Mark Sundt



Outline/Goals

- Identify and quantify sources of downtime in AT&T's MPLS-enabled IP network
- Model potential proposed changes/improvements to quantify their relative benefits
 - Correlate probe tool failures with routing protocol events to give Top-down view of downtime in AT&T's network
 - Build Bottom-up Failure Mode and Effects Analysis (FMEA) model of downtime based on reference "connection"
 - Rationalize the two and resolve the differences in order to validate the FMEA model

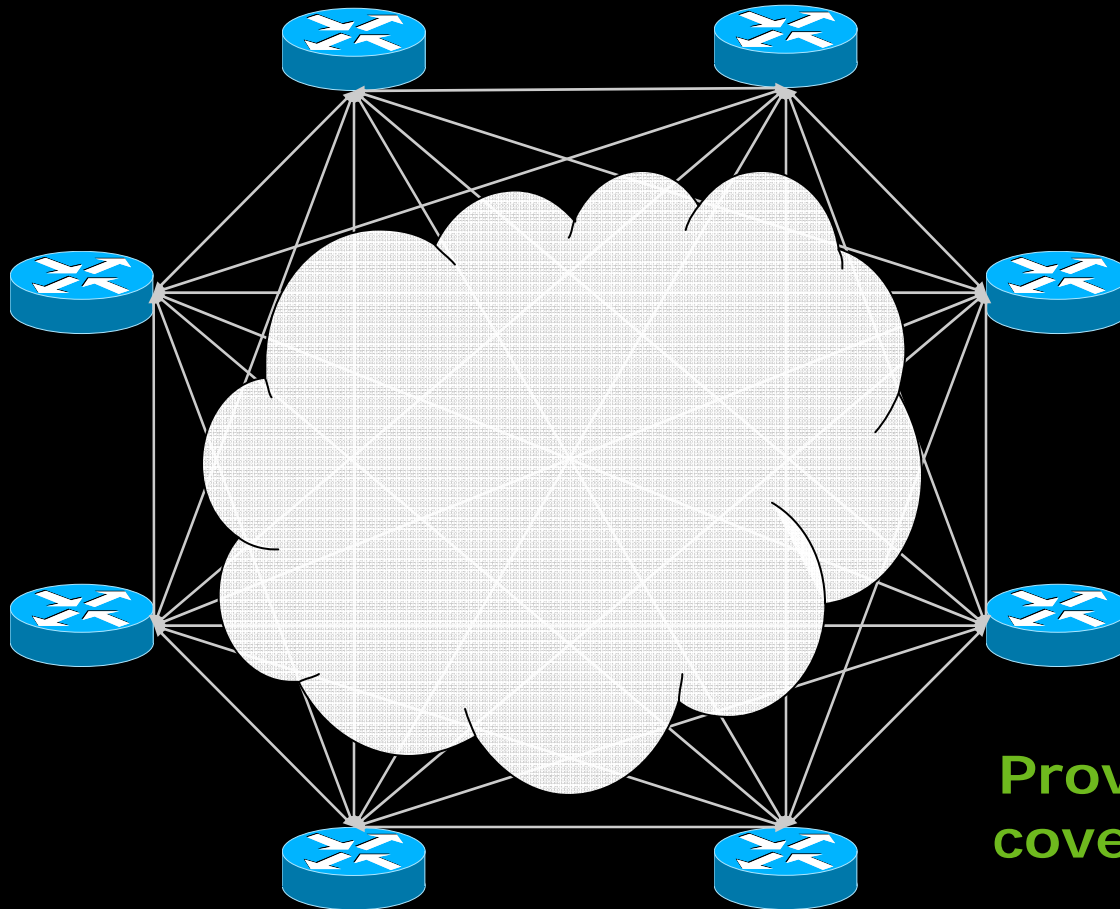
Necessary Information

- Probe tool data ("failures")
- Routing protocol events (e.g. OSPF LSAs)
- Observed router reset data
- Observed hardware failure rate data
- Observed link failure data

Correlating Probe Tool Data with Routing Protocol Events

- ~95% of probe failures
 - Are not isolated failures
 - Represent >5 seconds of “outage”
- Events have specific signatures and are categorizable as:
 - Link failures
 - Router failures
 - Congestion related
 - Cost-Out/Cost-In (Planned maintenance)
- Manual process – not automatable
- Good accuracy (~90%)

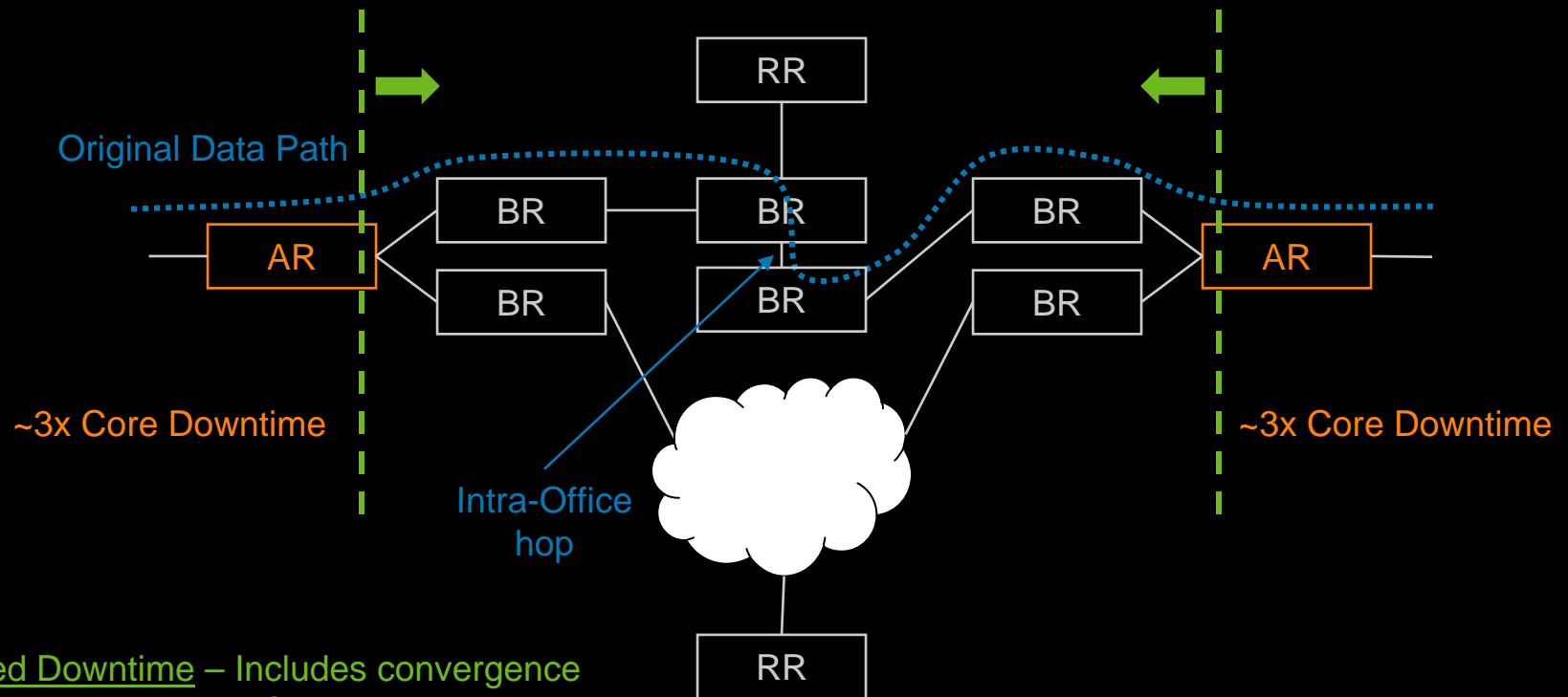
Full Mesh of Probe Paths Between Backbone Offices



Provides excellent coverage of faults!

VPN Reference "Connection"

AR – Access Router
BR – Backbone Router
RR – Route Reflector



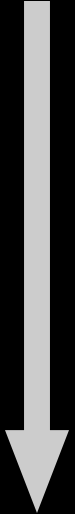
Modeled Downtime – Includes convergence events, traditional HW&SW, and planned upgrades. Does not include Operational Errors and Congestion-Related loss.

Note: Necessarily similar to average probe path.

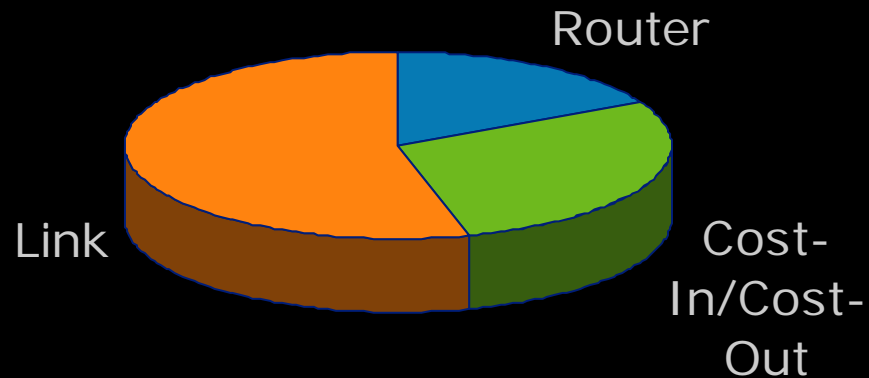
Network Design Notes

- Router network design separates the access router functionality from the backbone router functionality
 - Scale Issues
 - Router Design Issues
 - Software Functionality
 - Card Functionality
 - Port Speeds/Router Size (Backplane)
- Access Routers are dual-homed to pair of Backbone Routers
 - Reliability
 - Link Cards are unprotected

FMEA Detail

Failure Mode	Recovery	Failure Rate	# of Failure Modes	Outage Duration
Router switchover (Unplanned)	OSPF Reconvergence 		4	
Router planned maintenance (Upgrade, ...)			4	
Link card failure			8	
Link failure - Electronics			2	
Link failure – Fiber Cut			2	
UpLink/DownLink failure			2	

Sources of Core Network Downtime

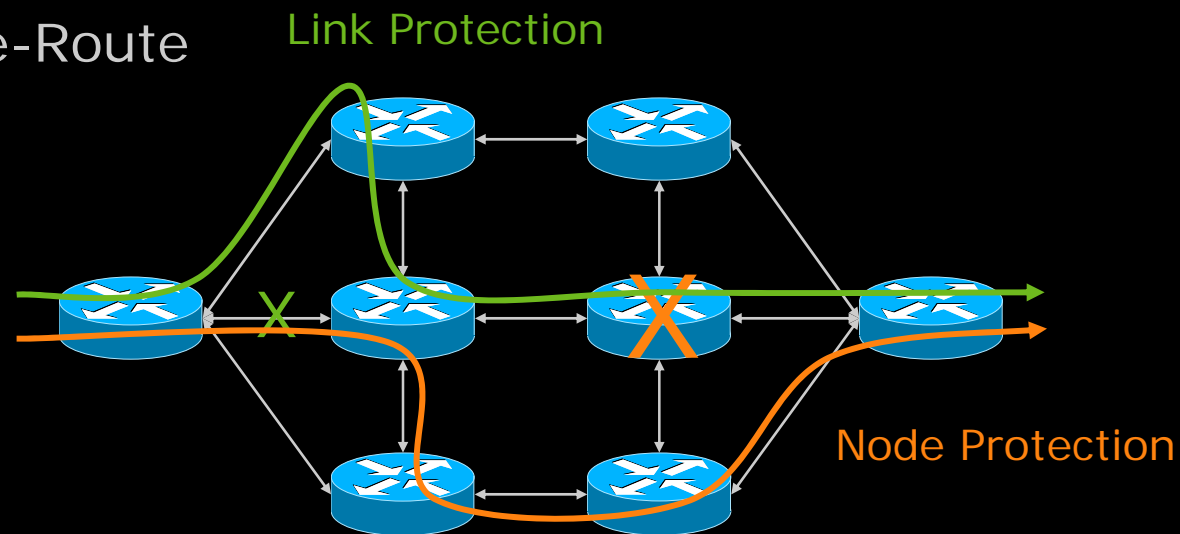


**Initial configuration
with unbundled links**

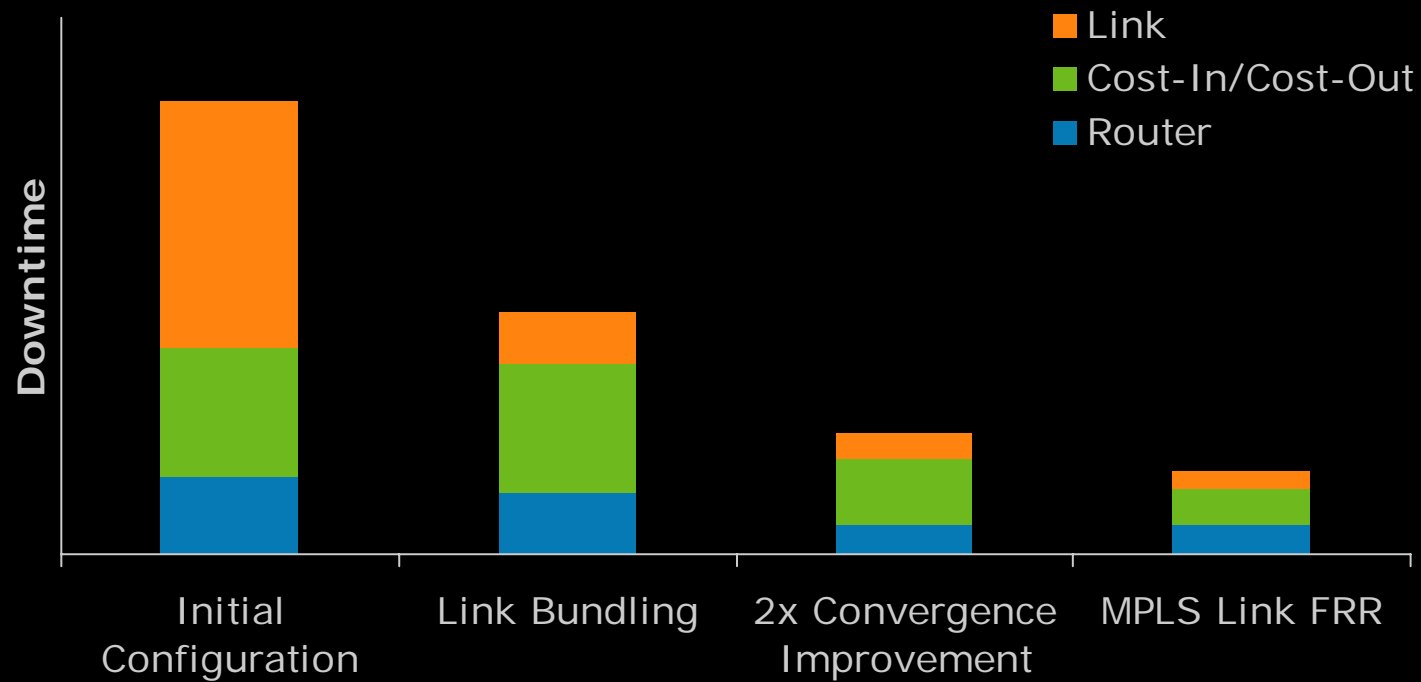
Changes/Improvements Modeled

- Link Bundling
 - Multiple physical links treated as single logical link
- Convergence Improvements
 - L1/L2: Detection/Hold timers
 - Multiple L3 Protocols: Hello/Timeout/Propagation timers
 - Interaction of L3 Protocols
- MPLS Fast Re-Route

- Link
- Link+Node



Modeled Results



Conclusions/Observations

- Correlation of probe tool failures with network events is invaluable for understanding sources of downtime in a core router network
- Link Bundling and Convergence Improvements have provided large reductions in core network downtime
- FRR for links has been identified as an area for future improvement
- Backbone routers remain a significant source of Unplanned and Planned Downtime