Achieving High Reliability, Low Latency, Deterministic IP Network

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• What do these requirements mean?

• How can they be addressed?
High Reliability – Solution Wide View

- System
- Traffic/Network Resiliency
- Match Service to Network
- Timing Distribution
- Location Backup
- Performance indicators
- Wireless backup
Resiliency and Protection

System Resiliency
- Power supplies
- CPU

Network Resiliency and Protection
- TDM protection (T1/SONET)
- Ethernet
- Traffic duplication
Sample Equipment Redundancy

- Eliminate service outages from single equipment failure
TDM Protection – T1

Dual Cable (Parallel TX)

Primary (Working) Link

Redundant (Protection) Link

I/O Module with T1 Ports

I/O Module with T1 Ports

Y-Cable Redundancy

I/O Module with T1 Ports

T1 Ring Protection

Primary Ring

Secondary Ring
TDM Protection – SONET

Automatic Protection Switching (APS)

Normal Operation

Internal Protection Switch

Working Link

Protection Link

Operation after Protection Switching

Internal Protection Switch
TDM Protection – SONET

Path Protection (VT-1.5)

- Bandwidth is assigned on both network links
- The same payload is transmitted on both links
- Upon signal fail/degradation on the primary link, the receive side selects the other signal
Ethernet Protection

Port - LAG with LACP (Link Aggregation Control Protocol)

Ethernet over SONET

Ethernet Ring Protection (ERP) G.8032V2
What is Traffic Duplication?

• A unique technology that allows networks with mission-critical applications to enhance reliability and performance.

• Can be used to minimize delay on critical utility applications (e.g. Teleprotection) by capitalizing on Carrier Ethernet’s reduced latency at higher speeds.

• Mission-critical traffic can be transported over a new Carrier Ethernet network running in parallel with the existing SONET/SDH, while preparing for future full service migration.

Traffic Duplication Benefits:

• Better resiliency

• Gradually build up a PSN through the enablement of redundancy

• Make available additional bandwidth for non-mission critical IT traffic

• Future-proof network readiness for phased or full migration to PSN. The power utility may maintain a dual network topology and gradually migrate to a complete Carrier-grade Ethernet network.
Traffic Duplication for Gradual Network Migration

- Stay with dual network topology or choose to migrate to complete Packet
“Traffic Duplication” Topologies

SONET/SDH and Ethernet Rings

SONET/SDH and connected to an external PSN network
“Traffic Duplication” Topologies

Connectivity to an existing SONET/SDH and existing PSN network

Connectivity to an existing SONET/SDH build Ethernet ring
Traffic Duplication as a Reliable Migration Path for TDM Traffic

- Three duplications of the TDM traffic – 2 x OC-3/12 uplinks and Ethernet uplink
- E2E protection over two technologies – SDH and PSN
- Recovery in sub 50msec in all failure scenarios
- Better resiliency
- Future-proof network readiness for phased or full migration to PSN
Ethernet Protection with Traffic Duplication

- E2E protection over two technologies
- Recovery in sub 50 msec
- Hardware protection over SONET/SDH
- Better resiliency
Benefits of Traffic Duplication

• Increased reliability
  – Added protection path through packet technology

• Migration path development
  – By building the new PSN, the new backup network can serve as a future primary network
Match end service to network

• Not all end services are equal
  – Some are mission critical, can not fail
  – Some are more sensitive to impairments

• Technology maturation, user confidence impact acceptance

• Communications network meets the needs now and going forward
Matching end service to network

- Teleprotection a top priority
- TDM has been proven solution
- Carrier Ethernet offers SONET like experience
- Network type selection per service
Timing Distribution

- Timing distribution important
  - Timing for synchronous services
  - Time stamping for logs/audit trail/fault recorders/etc.

- GPS traditional method

- Packet options 1588v2, Synchronous Ethernet, Adaptive Clock recovery
  - Need to plan network design
Classic IEEE 1588v2 Clock Distribution

Master clock

Slave clock

Slave clock

Slave clock

bidirectional time-stamps information exchange

ETH/IP

Transparent clock

time sensitive application
Distributed GM Clock

- No need for supporting long BC/TC chains across the whole network
- No need for GPS at each remote site
Location Backup – Dual Data Centers

Legend:
Solid Line=Primary
Dashed Line= Backup Connection
Location Backup

• Hot Standby Communications Network
• Dual Data Center Support Through Bridging
  – Using existing substation equipment
  – Analog and digital
• Selectable Priority Services
Performance Indicators

• Best reliability is to avoid issues
• How can I know something is wrong with my packet network?
• Packet monitoring technologies like Y.1731 and TWAMP. SONET like experience.
Example Packet Network Indicators

Performance Portal

Welcome, root
| Logout | About | Help

Dashboards of 2013 July

Total Services:
- Normal (54.55%)
- Warning (18.18%)
- Error (27.27%)

Availability:
- Normal (91.82%)
- Warning (18.18%)

Frame Loss Ratio:
- Normal (72.73%)
- Error (27.27%)

Frame Delay:
- Normal (72.73%)
- Error (27.27%)

Frame Delay Variation:
- Normal (72.73%)
- Error (27.27%)
Wireless Backup

- Licensed/Unlicensed/Cellular
- Can offer TDM like performance (dedicated bandwidth)
- Point to point and Point to Multipoint
- Secure options
Distribution Automation and Smart Meter Backhaul

P2MP Radio

Radio Terminal

Transformer

Encryption

LV Transformer Site

Power Quality Meter/Fault Indicator/RTU

2G/3G/LTE Comm.

IEC-101/DNP3

RS-232

IP CCTV

Meters Concentrator

ETH

Power

Transformer

Radio Terminal
Low Latency

- Tight delay constraints for teleprotection
- Jitter hurts timing recovery
- Want TDM like experience.

But, what can be done to help?
Latency Mitigation

- Ethernet is inherently faster than legacy TDM interfaces
- Networks using technology like Carrier Ethernet implement circuits like TDM.
- Product performance
  - Minimal PW conversion delays
  - Internal traffic classification, quality of service, queue management, etc.
- Phase in move of critical services to packet
Why is IP not deterministic?

- Store and forward in network
- Alternate path usage
- Some devices do routing in software
- Routing table updates
What to do about this?

- Use network like Carrier Ethernet to connect nodes
- Use PM tools to benchmark and monitor network
- Migrate less sensitive circuits first
- Careful network design
Teleprotection – Main Considerations

- The following are the main factors to be considered when comparing Teleprotection transport over SDH/SONET and Carrier Ethernet (assuming a typical scenario with up to 16 ring nodes):
  1. E2E delay - typically should be < 6 msec
  2. Delay asymmetry < 250 µsec
  3. Resilience required
  4. Security considerations
  5. Future proof technology
Differential Teleprotection Transport

TP traffic can be transported over

- TDM/PDH
- SDH/SONET
- Pseudowire (PW) over Carrier Ethernet networks
Use Case: Teleprotection Connectivity over PSN

- Deliver Teleprotection signals with mission-critical accuracy over a packet switched network
- Ensure low end-to-end propagation delay, minimal jitter and maximum resiliency
- Maintain performance levels (dependability and security) over PSN with hard QoS, Ethernet OAM and performance monitoring
End-to-End Delay

- Requirement: Nominally 6 msec end-to-end delay

- SDH/SONET ✔
- CE (using PW) ✔

- Conclusion:
  - Both technologies are sufficient for Teleprotection transport
Delay Asymmetry

• Requirement: < 250 µsec

• SDH/SONET
  – SDH/SONET rings are usually ADM causing constant delay asymmetry
  – Proprietary solutions compensate for this asymmetry

• Carrier Ethernet
  – Co-routed Ethernet is fundamentally symmetric
  – Pseudowire (PW) leads to small buffer asymmetry

• Conclusion:
  – Carrier Ethernet technology is as good as SDH/SONET
Key Takeaways

• Reliability is a Solution Wide Issue
  – Products
  – Networks
  – Timing
  – Etc.

• Packet Networks – Delay & Jitter
  – Legitimate Issues
  – Can meet SONET Standards