Design Rules for Mission Critical Networks

OTN Systems
Who is OTN Systems?

• OTN Systems develops and supplies fiber optic communication networks for critical infrastructures such as Public Transit Systems, Railways, Oil & Gas pipelines and Mines.

• More than 15 years of experience with installations world-wide:
  – US: Amtrak, SEPTA, San Diego Sprinter, Las Vegas Monorail, ...
3 design rules for mission critical networks

- Keep it simple
- Keep it separated
- Make it reliable

- Following these basic rules in network design will result in networks that are easier to configure, troubleshoot and maintain.
- The end result is a reliable network with low operational costs.
Simplicity
Keep it simple: Why?

• Operational simplicity is a key element to keep operational cost low
  – Simplification of network design & planning
  – Speed-up troubleshooting and maintenance
  – Project risk reduction by lowering project complexity
  – Reduction of training costs / knowledge obsolescence
  – Avoidance of human error
Keep it simple: How?

- Work at the lowest network layer possible (L1/L2/L3).
- Use hot-swap modular hardware.
- Use system-wide graphical network management tools, preferably with configuration wizards.
- Separate the network into smaller, easy to manage application sub-networks (see rule #2).
Simplicity: L1/L2 where possible, L3 where required

• As networks use higher layers of the OSI model, they become more complex.

• Provide the required features at the lowest complexity possible
  – Hardware protection and Network protection at L1 if possible
    • no RSTP (L2) or OSPF (L3) needed
  – Each network segment should be able to work at L2 or L3 as required by the individual application
  – Non-Ethernet & IP applications (e.g. serial data, analog voice) can be connected at L1 (native interface) without port servers.
The dilemma: Layer 2 or Layer 3?

- **L2: Switches**
  - Filtering based on MAC
  - No broadcast suppression
  - **Limited complexity**
    - But usually not suitable for large multiservice networks

- **L3: Routers**
  - Filtering based on IP
  - Broadcast suppression
  - Protocols needed to control traffic flows in the network
  - **Complexity is high**
Instead of one large complex L3 network, the network is divided into smaller independent application networks that can each run at L2 or L3 as required.

- Smaller independent networks are easier to control
- Decide for each individual application SLAN if it operates at L2 or L3
- Overall complexity is reduced by mix of L2&L3
- Choose to tunnel or peer L2/L3 control protocols
Keep things separated
Separation: why?

• In multi-service networks different applications are combined on a single network infrastructure.

• For each application it should be as if it runs on a separate dedicated network.
  – In this way each application network can be treated independently.

• No mutual interference between applications may occur.
  – E.g. bandwidth contention when new applications are added
  – E.g. a faulty application that disturbs the other network based applications

• Rogue users should remain isolated.
Separation: how?

• A dedicated amount of bandwidth is allocated to each application or service on the network, which provides hard QoS for each service.
• Ports that must be able to communicate are configured in a network service with a reserved amount of bandwidth (point-to-point or multipoint SLAN).
• L3 routing between the application networks is possible if required.
Separation by providing dedicated & guaranteed bandwidth to each application (Hard QoS)

Network capacity

10Gbps

- Telephony-VoIP
- WiFi access points
- SCADA (e.g. Profinet)
- Administration LAN
- Operations/Control LAN
- IP Video Surveillance
- Network Management Communication

Each application gets a dedicated amount of bandwidth.
Bandwidth is always available: 100% QoS
No unwanted interference between applications.

Bandwidth allocation is managed by the Management System. Bandwidth is used efficiently thanks to flexible allocation.

Network management communication uses a dedicated channel.
Separation: Different application layers can be configured onto a single network.

Network Management

VOICE Network Layer

SCADA Network Layer

Video Network Layer

Physical OTN Network

N50/N70
# Separation: Example for different Metro & Rail applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Mapping in dedicated services</th>
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<tbody>
<tr>
<td>Operations &amp; Control</td>
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<tr>
<td>Signaling/CBTC</td>
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<td>SCADA</td>
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<td>Control systems</td>
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<td>Traffic monitoring</td>
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<td>Security</td>
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<td>Video Surveillance (CCTV)</td>
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<td>Emergency call box</td>
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<td>Access control</td>
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<tr>
<td>Information</td>
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<td>Public Address (PA)</td>
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<tr>
<td>Passenger Information (PIS)</td>
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<td>Public Wi-Fi AP</td>
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<td>Communication</td>
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<td>Operational Telephony</td>
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<td>Hotline</td>
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<td>Train radio</td>
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<td>Operational radio</td>
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<td>Administration</td>
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<td>Office LAN</td>
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<tr>
<td>Commercial</td>
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<td>Ticket vending</td>
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Make it reliable: always on!
Make it reliable: Why?

• Network has to work reliably in harsh conditions
  – dust, EMC, temperature

• Network downtime has to be avoided
  – No operational losses, maintenance & service costs

• Network needs to have a long operational lifetime (>15y)
  – No cost for replacement

• Network needs to be future proof
  – No cost for upgrading or replacement
Make it reliable: How?

Availability = \frac{MTBF}{MTBF+MTTR}

- High MTBF (Mean Time Between Failures)
  - Network should be reliable under harsh conditions
    => industrial grade equipment
  - Provide hardware redundancy & network redundancy
- Low MTTR (Mean Time To Repair)
  - Network should be easy & fast to repair
    => simplicity, network management tools & modular design
Conclusions
Operations & maintenance costs can be greatly reduced by simplicity and reliability!

**Total Cost of Ownership**

(source: UITP Core Brief on Life Cycle Cost Optimization, September 2009)
Conclusion: simplicity, separation and reliability guarantee low OPEX
Conclusion: what does it mean for your Company?

Reliability
- Redundancy (in hardware, L1, L2 & L3)
- Long-term availability
- Harsh environments

Reliable service & Reduction of TCO

Separation
- Single network for all applications
- 100% QoS guaranteed for each application
- L2 or L3 as required per SLAN

Simplicity
- Reduction of network complexity
- User friendly management & wizards
- L2 where possible, L3 where required
Conclusion: what does it mean for You?

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Peace of mind!

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