Network-Centric Performance Monitoring

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August 2012
TDM to Packet Evolution

Population growth and higher computing sophistication leads to more endpoints and more bandwidth, which can only be served economically by a packet-based infrastructure, so...

What are people buying now?

• Tools to operate and troubleshoot Ethernet/IP like SONET/SDH
• SLA’s with substance, at TDM price per performance
• Synchronization, e.g. for mobile backhaul or algorithmic trading
Components of carrier-class operation

- Turn-up and test
  - Low-touch provisioning
  - Bandwidth profile validation with RFC-2544 or Y.1564

- Service Assurance
  - Hardware implementation required at endpoints for timing accuracy
  - Threshold crossing alarms for all PM attributes

- Troubleshooting without truck rolls
  - Throughput/latency test to loopback
  - Synchronization testing tools

- EMS/NMS/OSS integration
  - Inventory, alarming, monthly SLA reports...

Primary Objectives
Reduce truck rolls
Accurate and scalable PM
Business case for Network OAM/PM

1) Carrier grade service = more revenue
   - More $$ per service
   - More services sold

2) End-to-end visibility = lower cost

Before Costs without OAM/PM

<table>
<thead>
<tr>
<th>Cause of outage</th>
<th>Percent of outages</th>
<th>Truck rolls per year w/demarc</th>
<th>Truck roll reductions w/demarc</th>
<th>Net improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment</td>
<td>45%</td>
<td>0.9</td>
<td>80%</td>
<td>36%</td>
</tr>
<tr>
<td>Cable</td>
<td>5%</td>
<td>0.1</td>
<td>80%</td>
<td>4%</td>
</tr>
<tr>
<td>Power</td>
<td>30%</td>
<td>0.6</td>
<td>80%</td>
<td>24%</td>
</tr>
<tr>
<td>Provisioning</td>
<td>10%</td>
<td>0.2</td>
<td>95%</td>
<td>10%</td>
</tr>
<tr>
<td>No trouble found</td>
<td>10%</td>
<td>0.2</td>
<td>95%</td>
<td>10%</td>
</tr>
</tbody>
</table>

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After Costs with OAM/PM

<table>
<thead>
<tr>
<th></th>
<th>Truck rolls per year w/demarc</th>
<th>Yearly savings</th>
<th>SLA rebate savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame Relay</td>
<td></td>
<td>$250</td>
<td></td>
</tr>
<tr>
<td>Unmanaged Ethernet</td>
<td></td>
<td>$500</td>
<td></td>
</tr>
<tr>
<td>Network OAM/PM</td>
<td></td>
<td>$75</td>
<td>$425</td>
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</table>

Increase revenue – Reduce cost
Ethernet OAM
Areas of standards activities

- 802.1ag CFM – Connectivity Fault Management
- Y.1731 OAM (Operations, Administration and Maintenance) – Service Assurance
- 802.3ah EFM (Ethernet in the First Mile) – Dying Gasp
In-Service Delay/Jitter Measurement

- Time-stamps are only as good as system clock synchronization
- Time-stamping must be done in hardware
  - No software interrupts or queuing delays
  - Accurate results regardless of load and scale
  - Nanosecond resolution
- Must customize test frame size, priority, rate, burst & schedule to mimic application traffic
Making sense of all that data...

- Need a scalable architecture for thousands of endpoints
- Data accumulation methods such as Telcordia GR-820 timebins
- Historical data storage at endpoints in case of lost connectivity
- Centralized collection and reporting with interface to OSS
- Comprehensive and efficient MIB for multivendor environments
- Threshold Crossing Alarms to pinpoint anomalies
Timing Distribution and Verification

• GPS timing distribution is costly to install and maintain
• Trusted wireline provider may provide synchronization service
• Mobile operator may distribute synchronization over-the-top
• Both need tools to deliver timing and monitor quality
  • Prove accuracy at time of network deployment
  • Monitor stability in normal operation
  • Diagnose problem if things go wrong
Synchronization Network PM

- Sync distribution topology?
- Slave clock performance?
- Connectivity performance?
- Are slaves tracking the masters?
- ...

Diagram showing a network with masters, slaves, and synchronization clocks.
Multiple operators and clock domains

Separate clocks vs. synchronization to UTC standard time and frequency
Backup/Reference Slides
IEEE 802.1ag – OAM Maintenance Entities

Up MEP – CFM traffic is sent towards the bridge (e.g. from LAN towards WAN through the device)

Down MEP – CFM traffic is sent away from the bridge (e.g. from WAN towards the network)
ITU Y.1731 – Service Assurance OAM

- Builds on 802.1ag functionality and adds:
  - Performance monitoring
    - Delay Measurement (DM), Loss Measurement (LM)
    - Under Study: Synthetic Loss Measurement (SLM)
  - Additional Fault Management: AIS & RDI
  - Test pattern and test mode (TST)
    - But no test methodology or standard test suite
  - Automatic Protection Switching (APS)
  - Other not so-common functions: MCC, VSM/EXM, 1DM.

- Y.1731 Defines its own hierarchical structure and Terminology
  - MEG – Maintenance Entity Group (Similar to MD + MA)
  - MEPs and MIPs keep CFM Definitions
Measuring One-Way Delay

- Delay from hops (inherit delay) and network congestion
- Time of Day Synchronization between end-points required
  - e.g. NTP, GPS and 1588v2
  - Endpoints should reference the same Time of Day source
- Synchronization errors occur when there is a negative time different between the TX and RX
  - Different Time of Day sources
  - Poor quality TOD source (precision and stratum level) or DCN congestion
  - Inaccurate time client algorithm
- Delay between timestamp and packet send/receive causes inaccuracy
  - Must timestamp at the moment of send/receive
  - Without hardware-based timestamping software interrupts cause problems
Ethernet Loss Measurement

- **ETH-LM**: Loss Measurement of customer data frames
  - Single-ended, on-demand, using ETH-LMM/ETH-LMR
  - Frame Loss measurements are calculated per Y.1731...
  - Frame Loss (far-end) = |TxFCf[tc] – TxFCf[tp]| - |RxFCf[tc] – RxFCf[tp]|
  - Frame Loss (near-end) = |TxFCb[tc] – TxFCb[tp]| - |RxFCl[tc] – RxFCl[tp]|

- **ETH-SLM**: Synthetic Loss Measurement
  - New OAM function defines a way to measure Frame Loss Ratio
  - **Multipoint** support, in addition to Point-to-Point connectivity
  - Use sequence numbers for ETH-SLM/SLR synthetic frames
  - Count transmitted and received synthetic frames between MEPs