Network-Centric Performance Monitoring

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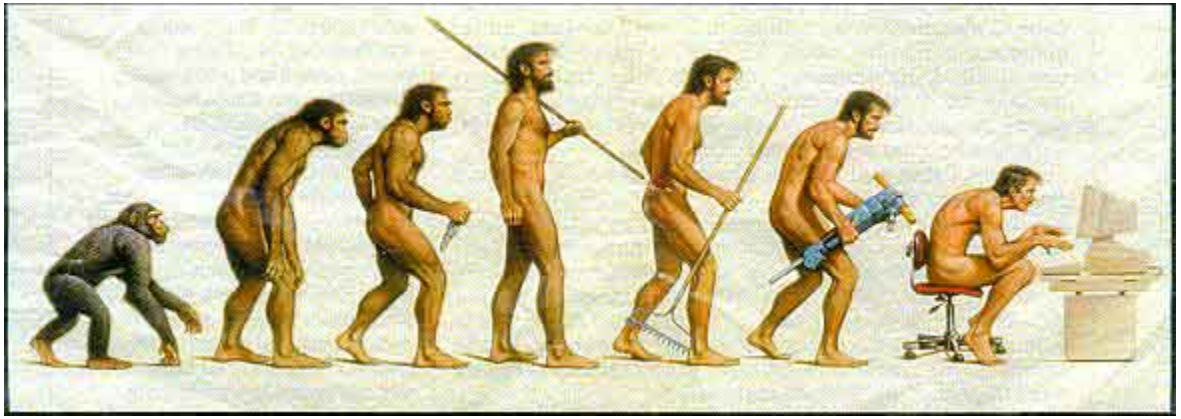
TDM to Packet Evolution

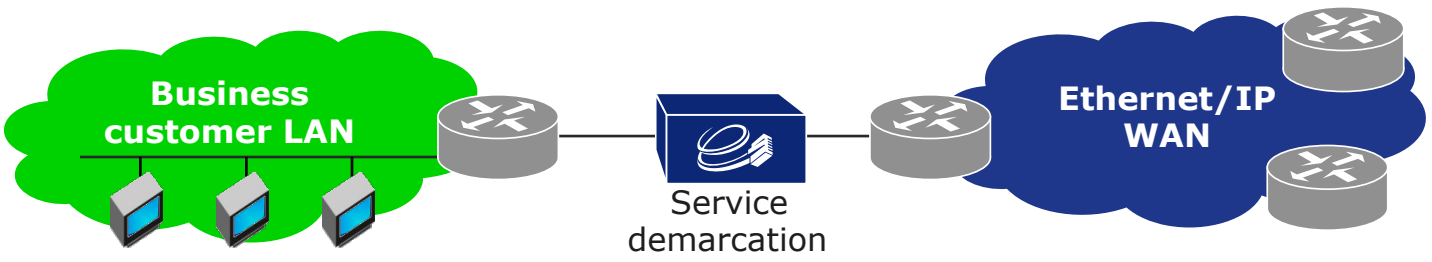
Population growth and higher computing sophistication leads to more endpoints and more bandwidth, which can only be served economically by a packet-based infrastructure, so…

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…

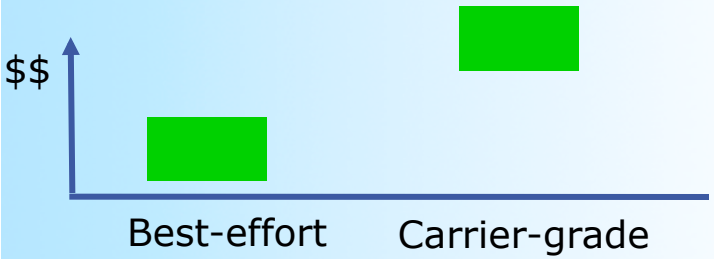
Primary Objectives

Reduce truck rolls

Accurate and scalable PM

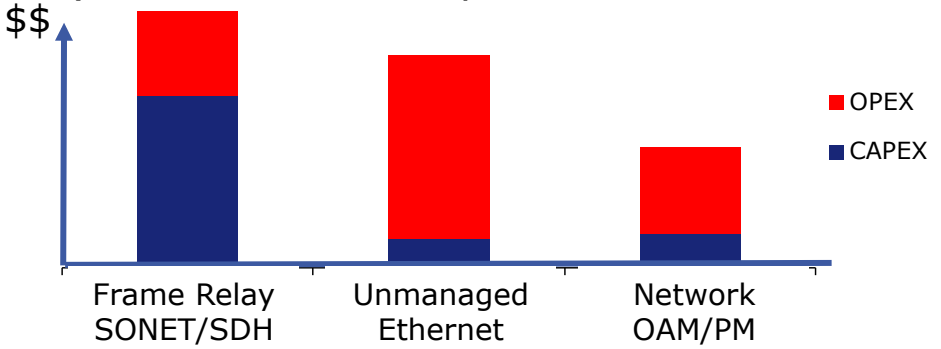
Business case for Network OAM/PM

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



	Before Costs without OAM/PM		**After Costs with OAM/PM**		
Cause of outage	**Percent of outages**	**Truck rolls per year**	**Truck roll reductions w/demarc**	**Truck rolls per year w/demarc**	**Net improvement**
Equipment	**45%**	**0.9**	**80%**	**0.18**	**36%**
Cable	**5%**	**0.1**	**80%**	**0.02**	**4%**
Power	**30%**	**0.6**	**80%**	**0.12**	**24%**
Provisioning	**10%**	**0.2**	**95%**	**0.01**	**10%**
No trouble found	**10%**	**0.2**	**95%**	**0.01**	**10%**
		2		**0.34**	**83%**

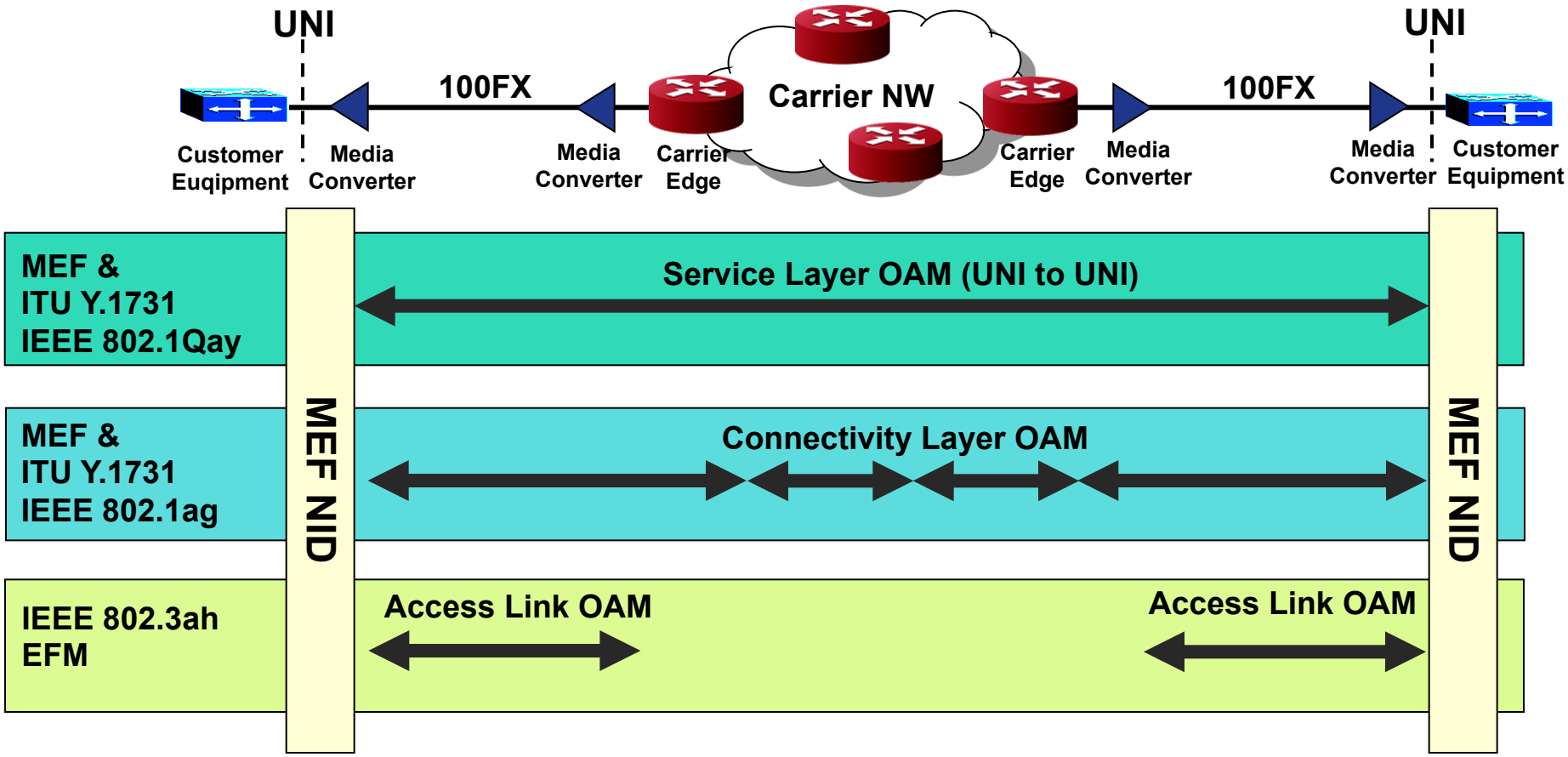
2) End-to-end visibility = lower cost



- Average cost per Truck Roll $250
- Current Yearly Truck Roll Cost W/O Demarc $500
- Expected Yearly Truck Roll Cost w/Demarc $75
- Yearly savings $425
- SLA rebate savings ????

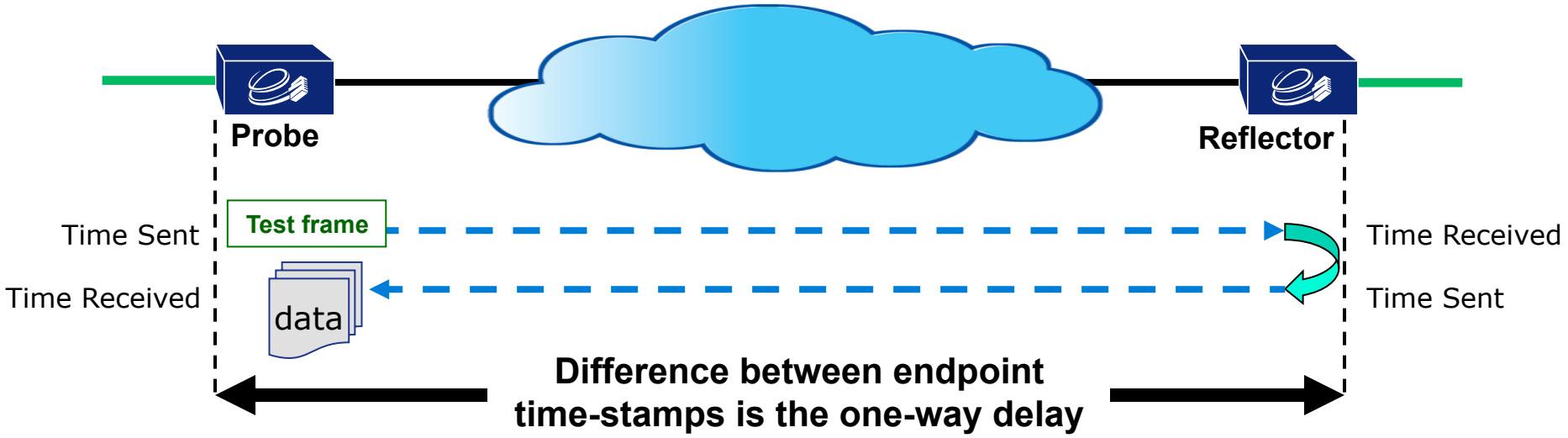
Increase revenue – Reduce cost

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

Entity ID: ESA PROBE-1-1-1-2 **Probe ID: L3test**

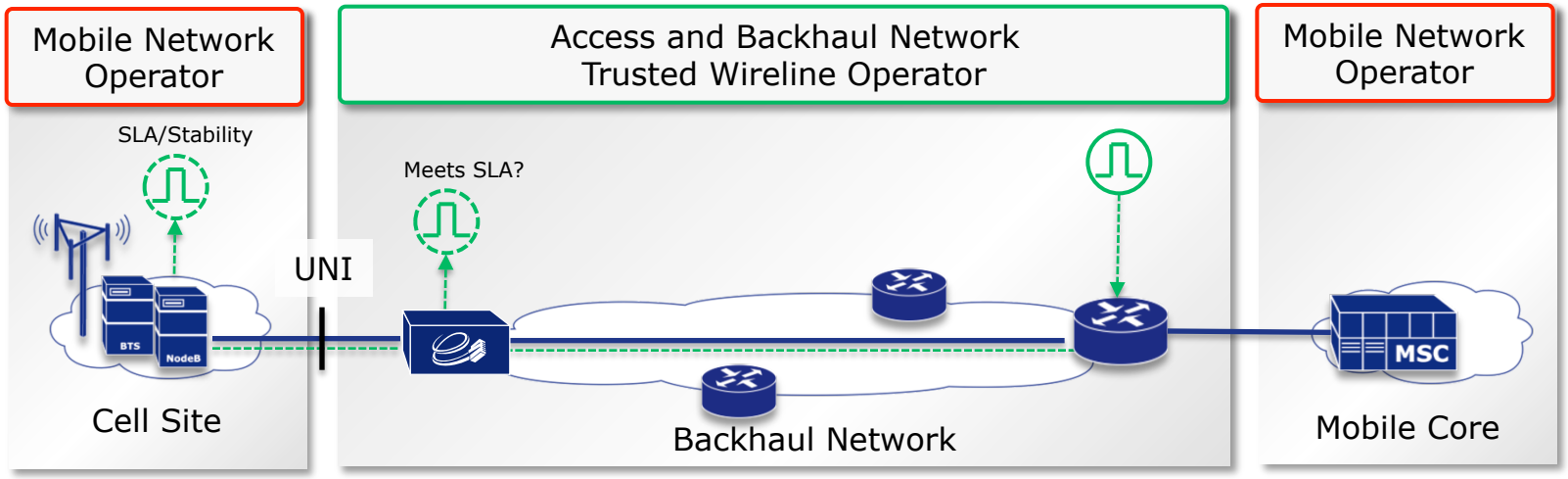
Configuration | StatsConfig | Statistics | Thresholds

Display: Table | Counters: General | Filter | Export | ☑ History

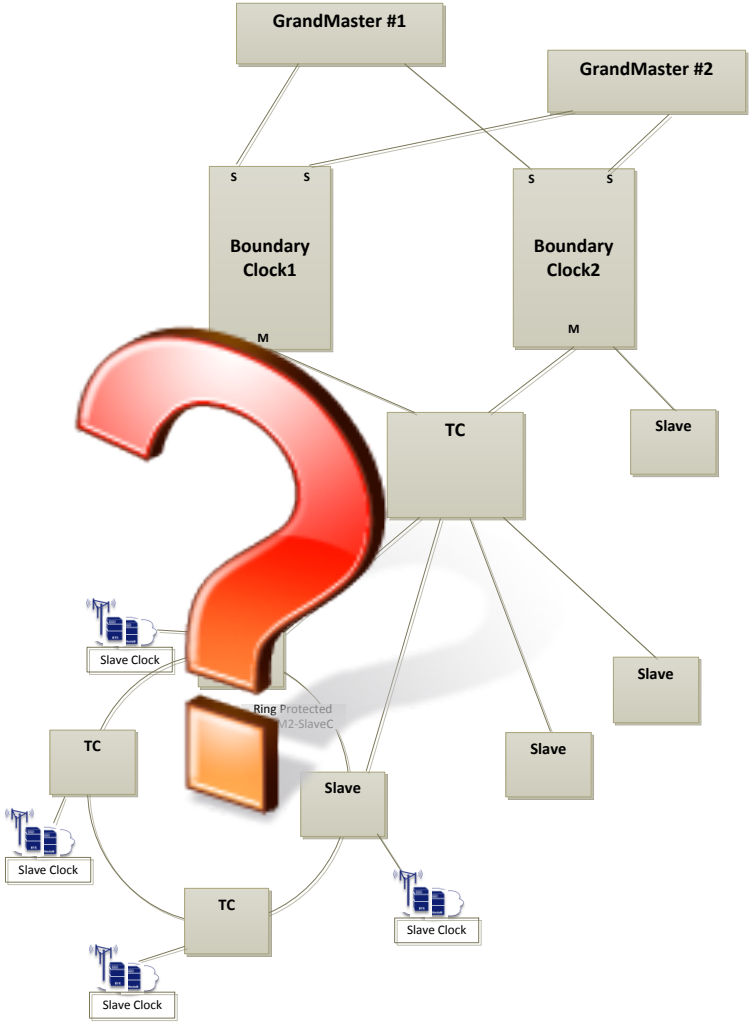
TS	P2R-PKTS	R2P-PKTS	P2R-ERR-PKTS	R2P-ERR-PKTS	LOST-PKTS	SEQ-GAPS	OUTOFSEQ-ERR	P2R-LOST-PKTS	R2P-LOST-PKTS	P2I
current	2329	2329	0	0	0	0	0	0	0	
18:15:00	4171	4171	0	0	0	0	0	0	0	
18:00:00	922	922	0	0	0	0	0	0	0	
17:45:00	7501	4181	0	0	3320	1	0	38	3282	
17:30:00	7500	0	0	0	7500	0	0	0	7500	
17:15:00	7494	1825	0	0	5669	1	0	44	5625	
17:00:00	7499	7499	0	0	0	0	0	0	0	
16:45:00	7499	7499	0	0	0	0	0	0	0	
16:30:00	7498	6639	0	0	859	1	0	40	819	

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

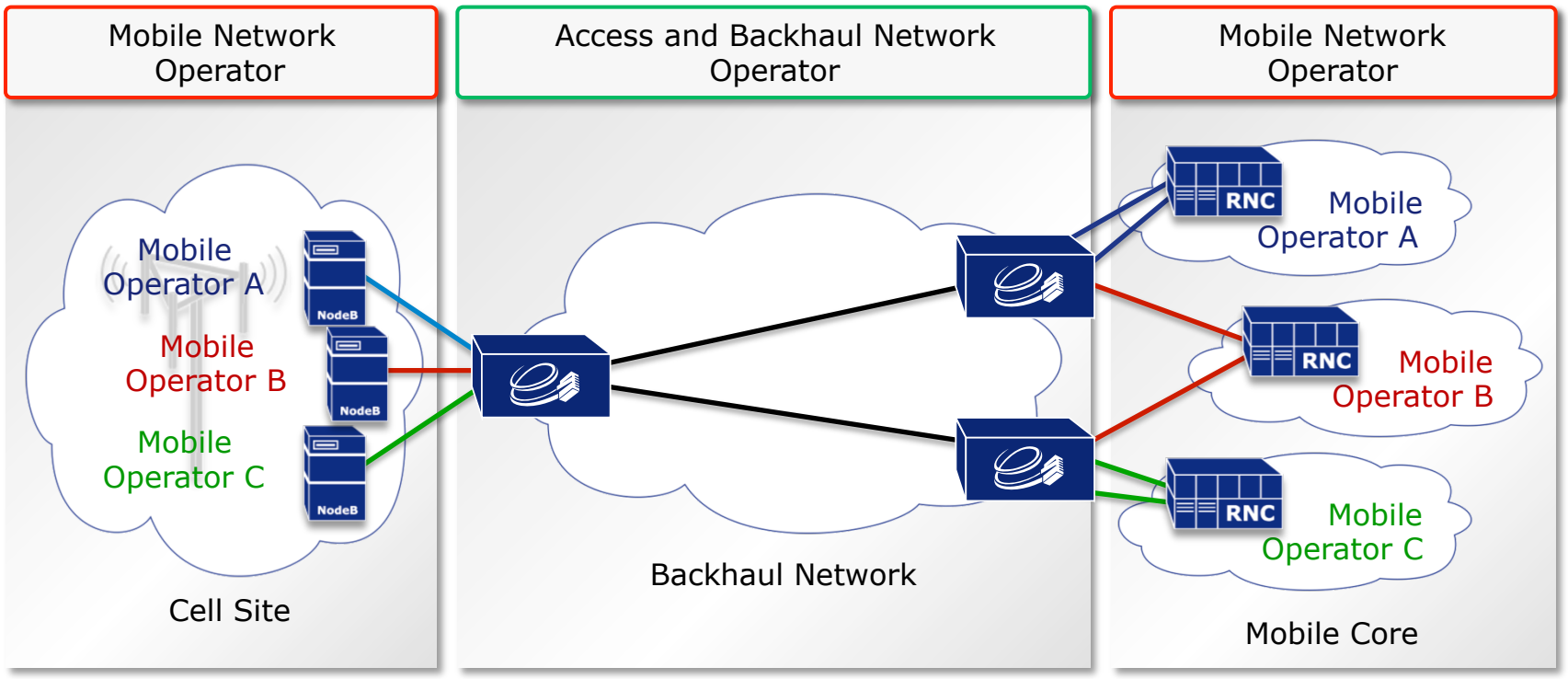


Synchronization Network PM



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

Multiple operators and clock domains



Separate clocks vs. synchronization to UTC standard time and frequency

ADVA™ Optical Networking

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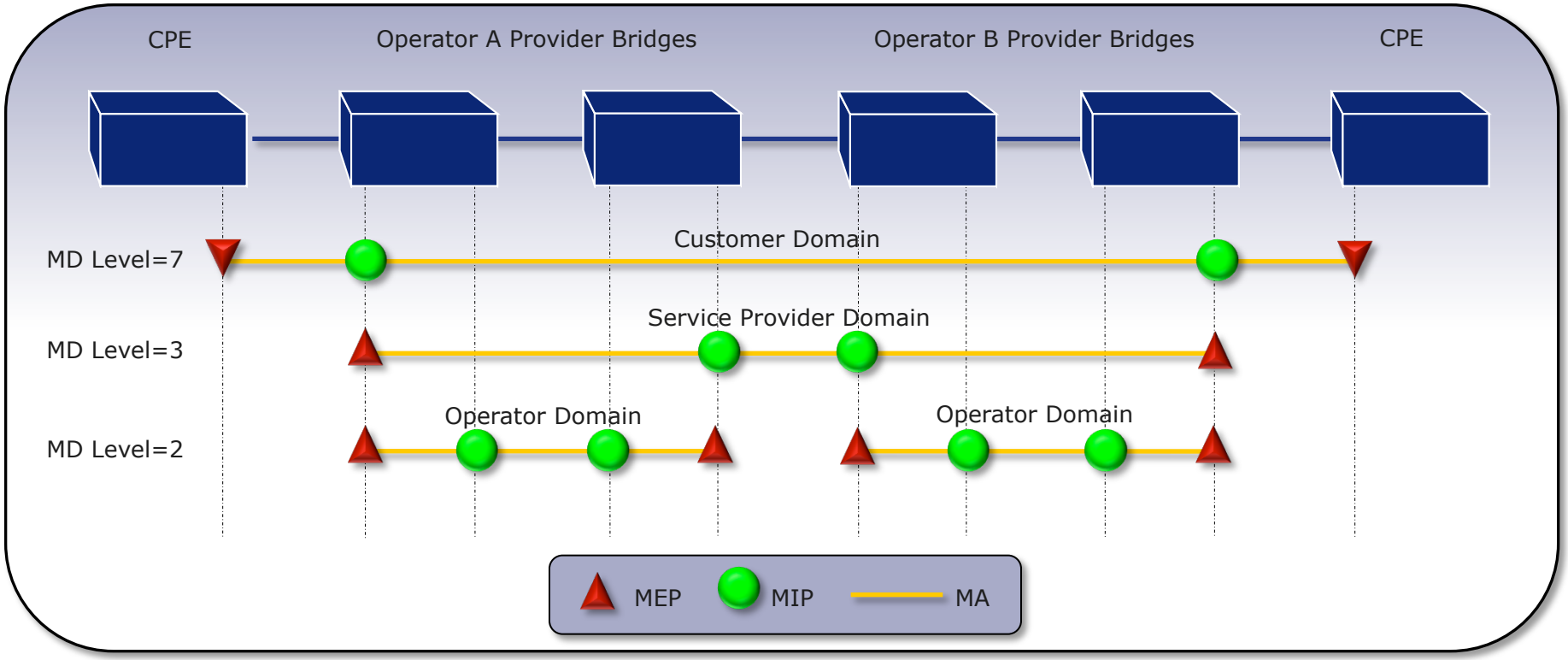
Optical Networking

Backup/Reference Slides

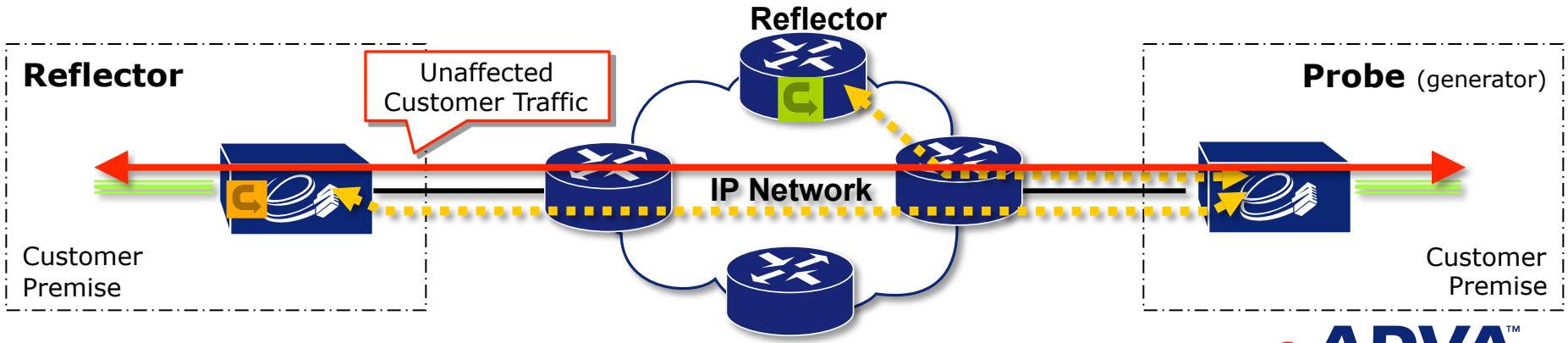
IEEE 802.1ag – OAM Maintenance Entities



- 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)

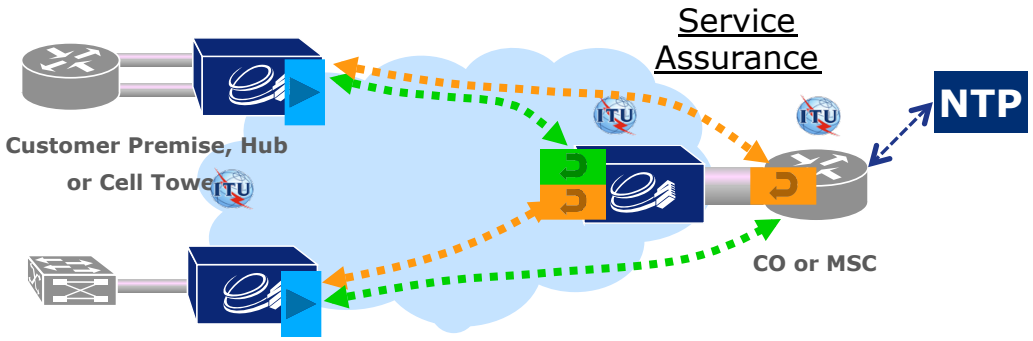
ITU Y.1731 – Service Assurance OAM

- 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]|

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- 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