ADVA™ Optical Networking

Synchronization in Mobile Backhaul

Deployment Topologies & Synchronization Service Tools

Anthony Magee, ITSF 2011, Edinburgh

Agenda

- Deployment Topologies
  - Managing Multiple Mobile Operators
  - LTE Advanced – and beyond…
- Synchronization as a Service
  - Service Level Agreement Tools

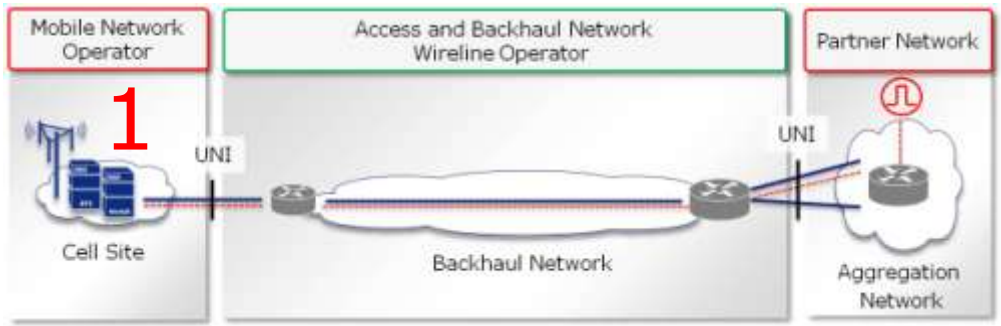
Is telling the time accurately ever as simple as child's play?

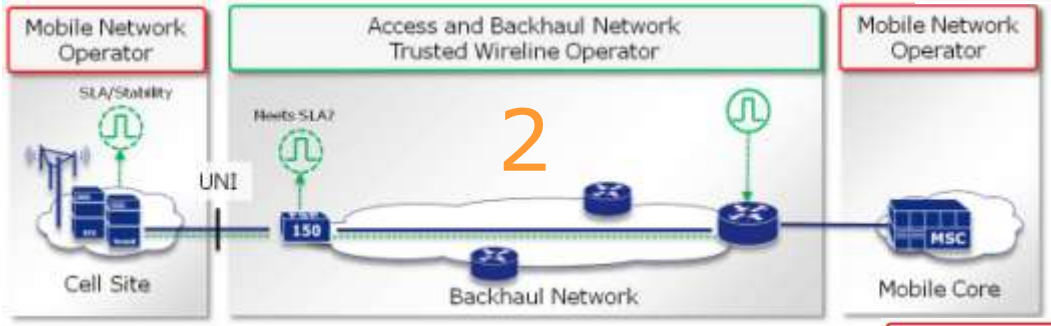
Courtesy: The Early Learning Centre

Synchronization Deployment Topologies

Multiple Operating Environments
Operational & Technology Perspective

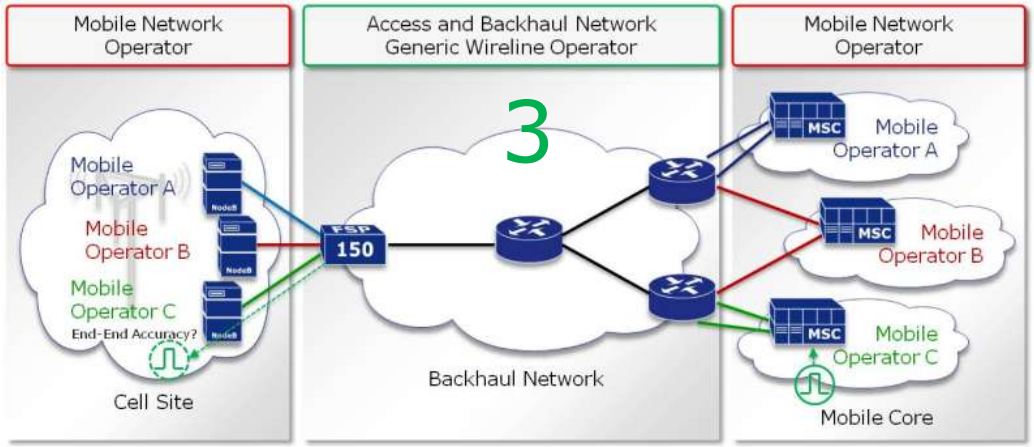
Customer of Synchronization Service
MOBILE OPERATOR
2G, 3G - E1/T1 and Ethernet
LTE – Frequency & Time





Synchronization Service Provider
TRUSTED WIRELINE OPERATOR
E1/T1, Synchronous Ethernet, Time of Day

Synchronization Transport
GENERIC WIRELINE OPERATOR
Multiple frequency references
Multiple time of day sources

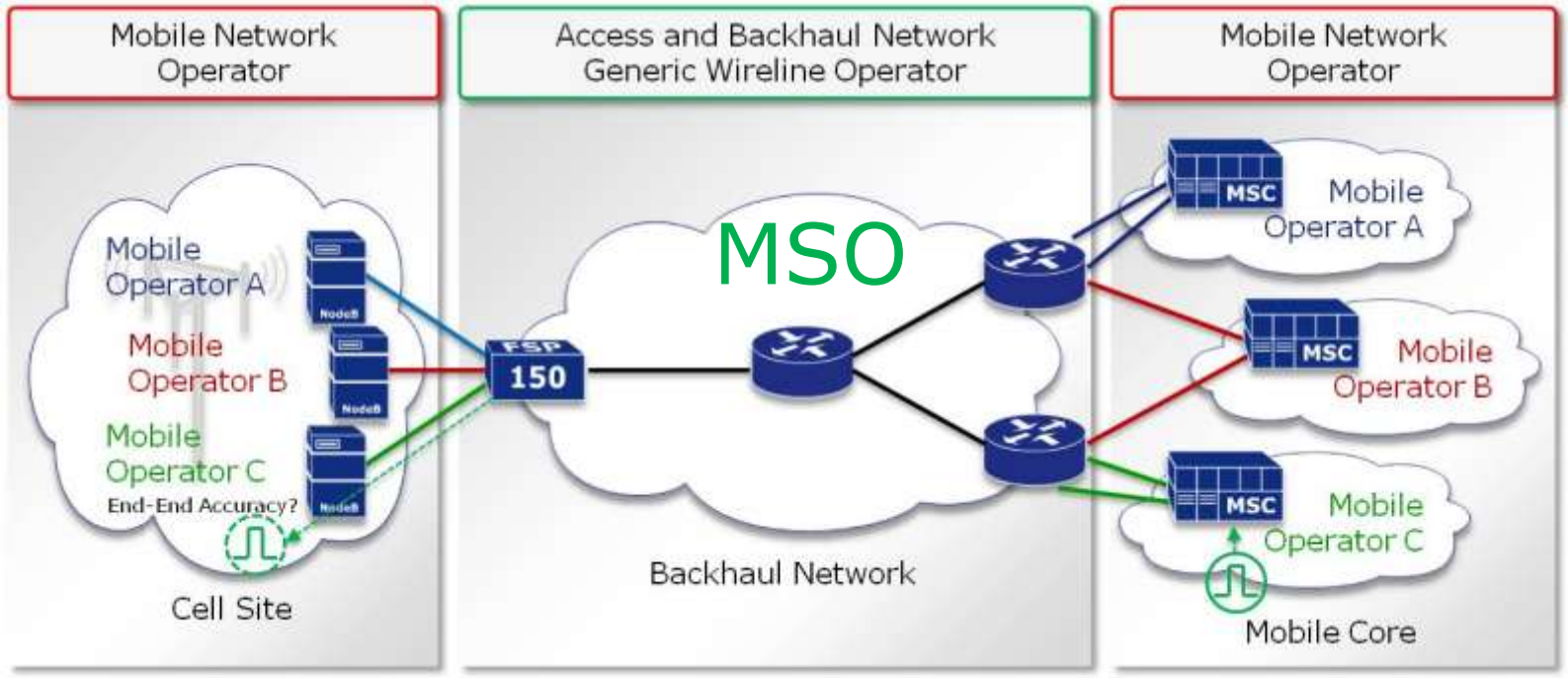


Challenges facing the MSO

Synchronization Transport

GENERIC WIRELINE OPERATOR

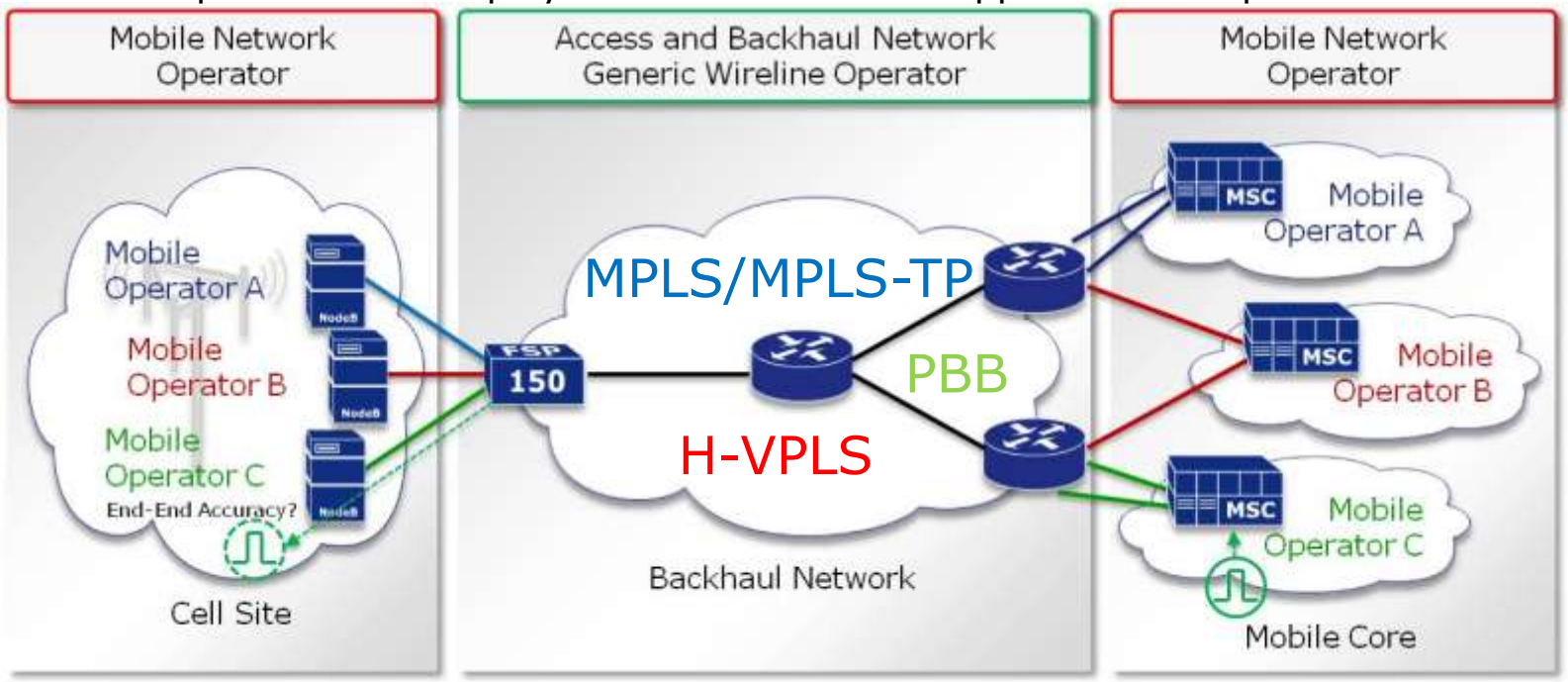
Multiple frequency references + Multiple time of day sources



- Backhaul Network Evolution
  - Especially with the move towards LTE - What factors will affect the MSO?

LTE Migration – MSO Challenge

- On-path 1588v2 over alphabet soup of backhaul technologies - complexity
- Security and layer ownership of timing becomes a grey area
- Delay asymmetry in mesh (Traffic Engineering – co-routed bidirectional pairs)
- Fault finding in the event of synchronization failure is more challenging
- Choice of Boundary Clock – implies multiple Boundary Clock Instances
  - Transparent Clock deployment with inherent support for multiple 1588 flows?



Vendors need to enable Synchronization as a Service for the MSO regardless of backhaul technology

LTE Advanced

- Antenna Clusters for MIMO architectures
  - Base station hotels more likely
- Driving change in the backhaul topology
  - Increased bandwidth to the cell-site
  - Broadband access in rural areas – Fixed Mobile Convergence
  - Different traffic patterns – PDV profiles changeable
- More stringent time of day alignment – 1us margin to 500ns
  - Trend will surely be towards increased levels of accuracy
  - Previous presentations to ITSF have mentioned references to 200ns for location based services
  - What works for todays requirements may not satisfy tomorrows network…

Multiple Operating Environments
Requires Flexible Solutions

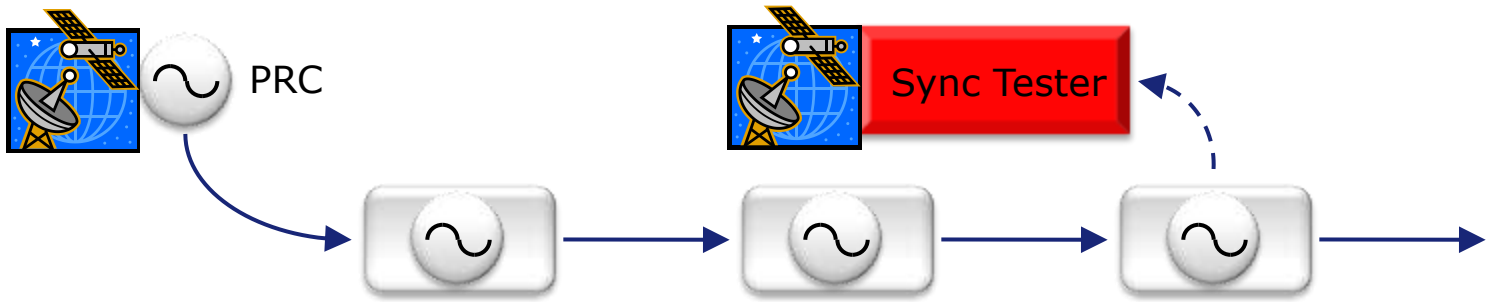
The Mobile Backhaul Synchronization Network of the future:

- Support multiple technologies
  - SyncE
  - 1588 – individually in OOF or hybrid (with SyncE) if needed
- Provide solutions for different types of operators
  - Mobile, Synchronization Service, and Synchronization Transport
- Support multiple time domains
- Strive for even greater levels of accuracy <1us…500ns…200ns
- Traffic engineered packet based synchronization flows
- Support the operator in monitoring, fault finding and resolving issues

Synchronization as a Service Deployment & Monitoring SLA Tools

Traditional Accuracy Test
Deployment Test/Diagnostics

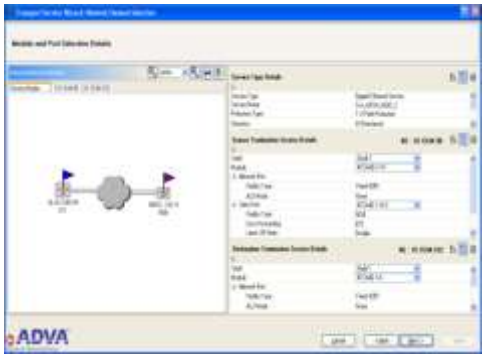
- Commissioning test at time of deployment
- Traceability to a PRC such as GPS is needed to prove quality of the recovered clock
- Expensive test equipment – only feasible at deployment or fault finding



Not suitable for 24 x 7 in-service monitoring and statistics
- Only provides End-to-End coverage
- Only feasible at deployment or during fault finding (requires truck roll)

Is an accuracy test enough?
- Synchronization OAM tools are needed – fault isolation – more efficient operations
- Synchronization Service Level Agreement

Synchronization Service Verification
Syncjack™ - SLA Tool Suite



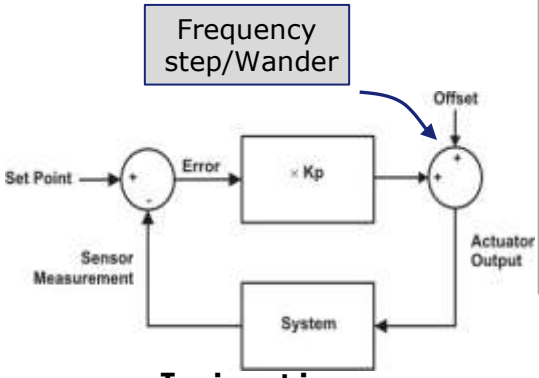
Mapping

Clock Accuracy

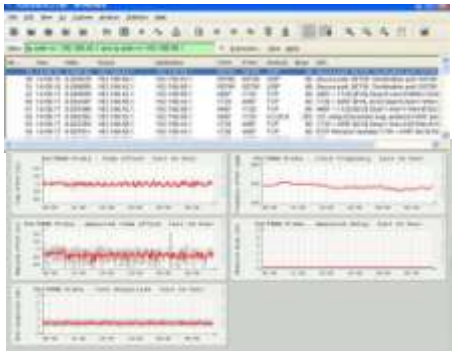
Clock Analysis

- Mapping
  - Sync distribution topology / status
- Clock Accuracy
  - Frequency and phase accuracy
- Clock Analysis
  - Clock performance monitoring
- PTP Network Analysis
  - PTP path monitoring / testing
- Injection
  - Check locking of slaves to masters

Syncjack™



Injection

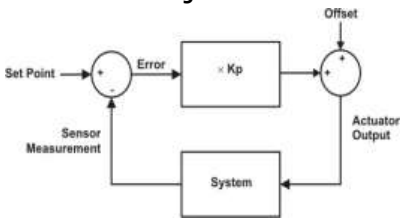


PTP Network Analysis

Synchronization Service Timeline

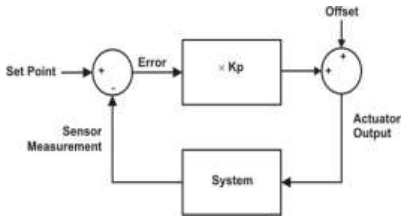
Mapping

Injection

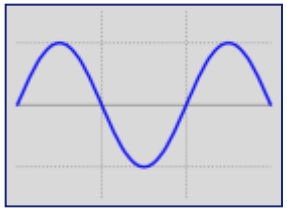


Mapping

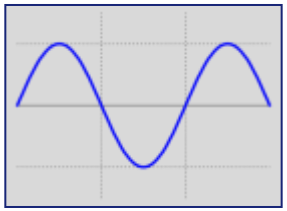
Injection



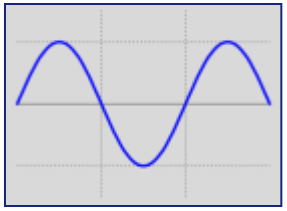
Clock Analysis



Clock Analysis



Clock Analysis



Syncjack

Clock Accuracy

PTP Network Analysis

Clock Accuracy

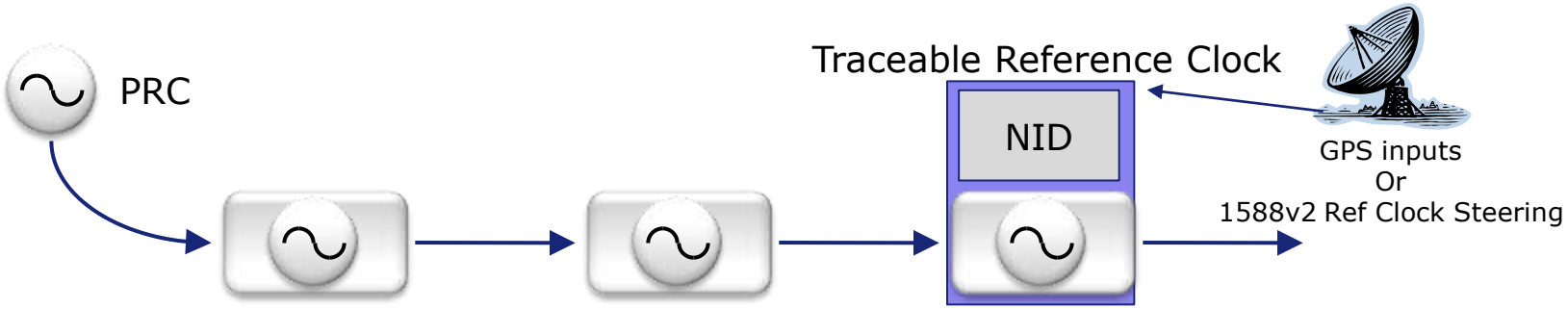
Planning | Deployment | Operation | Diagnostics

Mapping Tool

- Mapping tool
  - Showing topology map of synchronization network
  - Detecting topology change during normal operation
  - Managing congruency between SyncE and 1588 layers
  - Displaying synchronization paths overlaid on network view
    - Problematic paths in red/highlighted
  - Managing protection and alternate synchronization paths
- Used in conjunction with EMS for configuration/control of SLA tools
  - Setting threshold crossing alerts in nodes
  - Raising alarms/warnings if nodes detect threshold crossing events
  - Displaying probe data
  - Configuring Injection for diagnostics

Accuracy Test
Deployment & Diagnostic Test

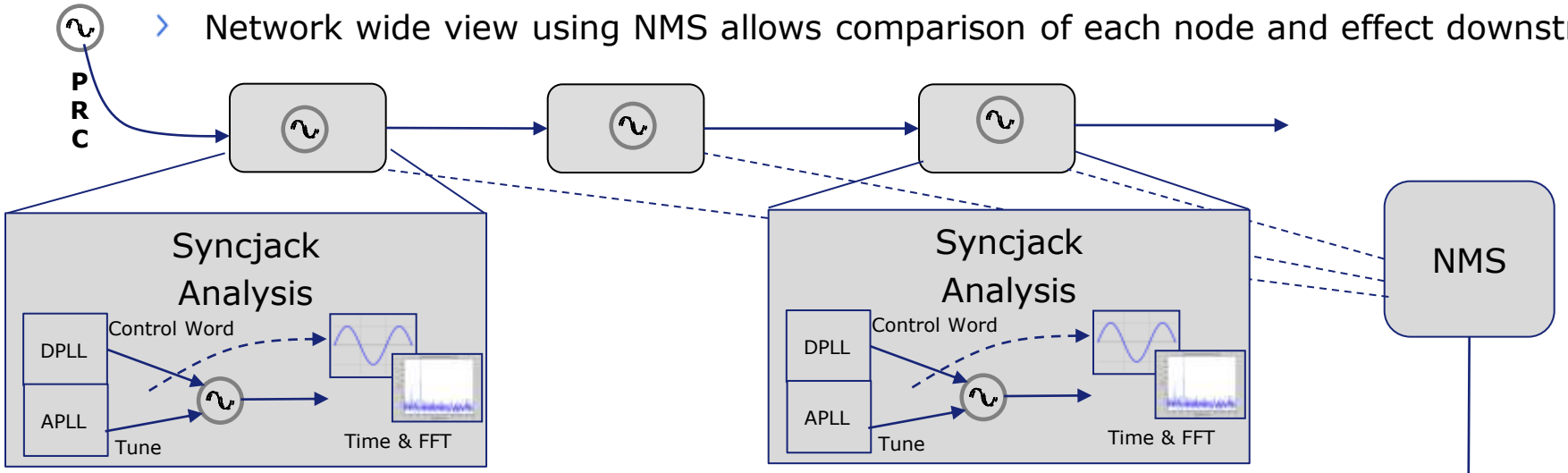
- NID device as a reference based synchronization tester
  - NID already in network – don't need to deploy another box
    - NID already providing OAM for packet based services – natural to extend to sync
  - GPS inputs for traceable reference clock
  - Frequency comparisons over observation windows
  - Time alignment comparisons
  - Packet Statistical analysis features
  - Provide standards based mask test plots
    - TIE, MTIE, TDEV
    - PDV, MATIE, MAFE, MEF18
    - Catering for ITU-T G.8262 performance Masks, and FDD/TDD base station specs
  - Interaction with Independent Verification Tools – cross launching of GUIs

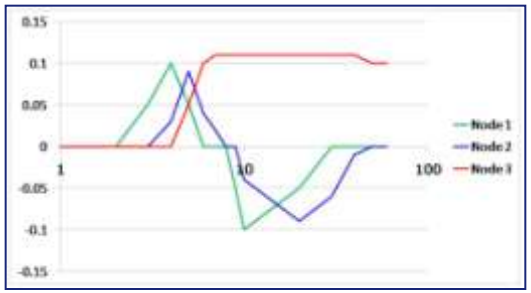


Planning | Deployment | Operation | Diagnostics

Clock Analysis
Frequency and Time Variation Monitoring

- Clock Analysis – Proactive in every node – aggregation/demarcation
  - In-service analysis function operates continuously without need for PRC traceability
  - Monitor variance of frequency and time (trends in PLL control signals vs baseline)
  - Time Domain analysis and Frequency domain of PLL trends per node
  - Network wide view using NMS allows comparison of each node and effect downstream



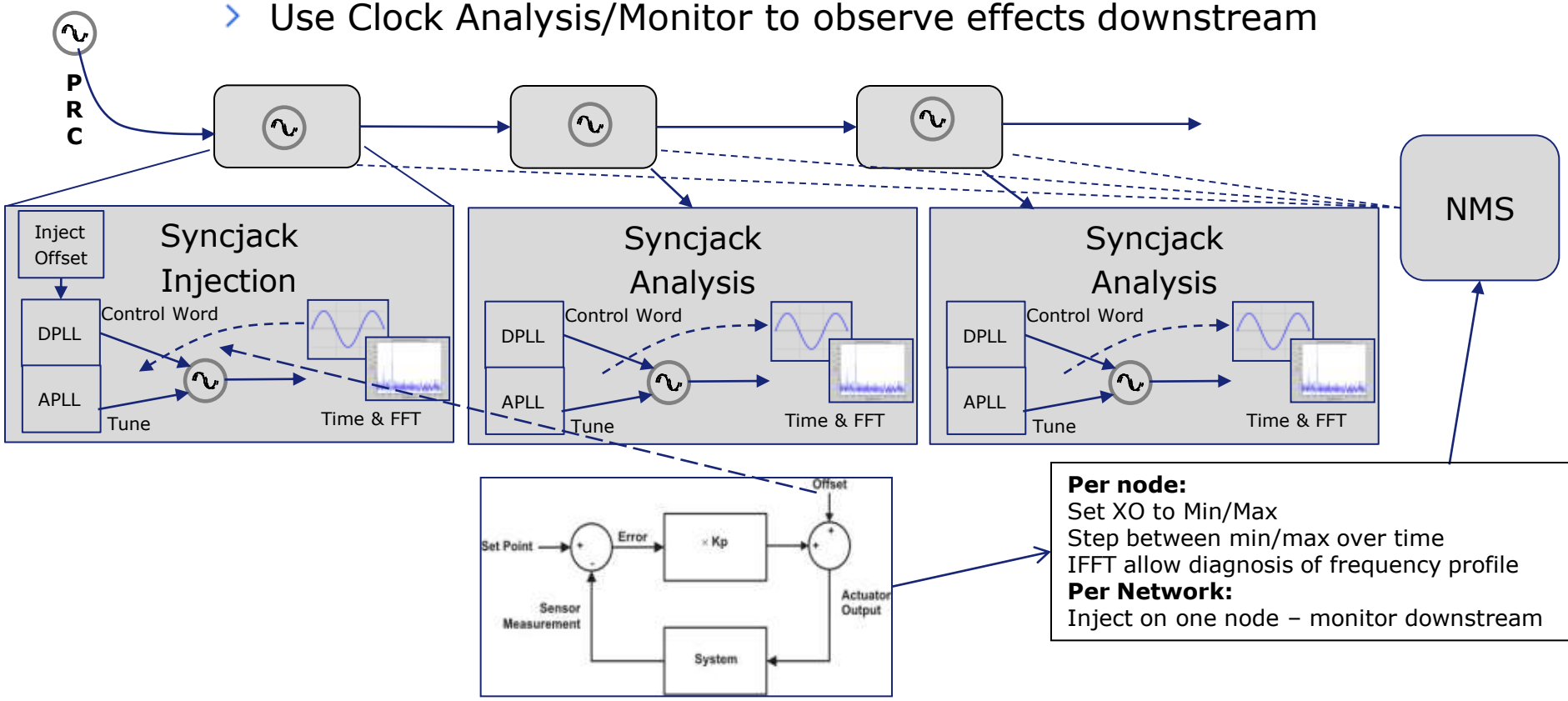


Per node:
Min/Max
Time offset
FFT of CW updates/ Tune line
Per Network:
Overlay of FFT plots

Planning | Deployment | Operation | Diagnostics

Injection Tool
Used for Diagnostics to offset Frequency or Time

- Injection tool – out of service
  - Inject an off-set/disturbance for frequency/time control
  - Use tool to inject step offset at first node
  - Use Clock Analysis/Monitor to observe effects downstream

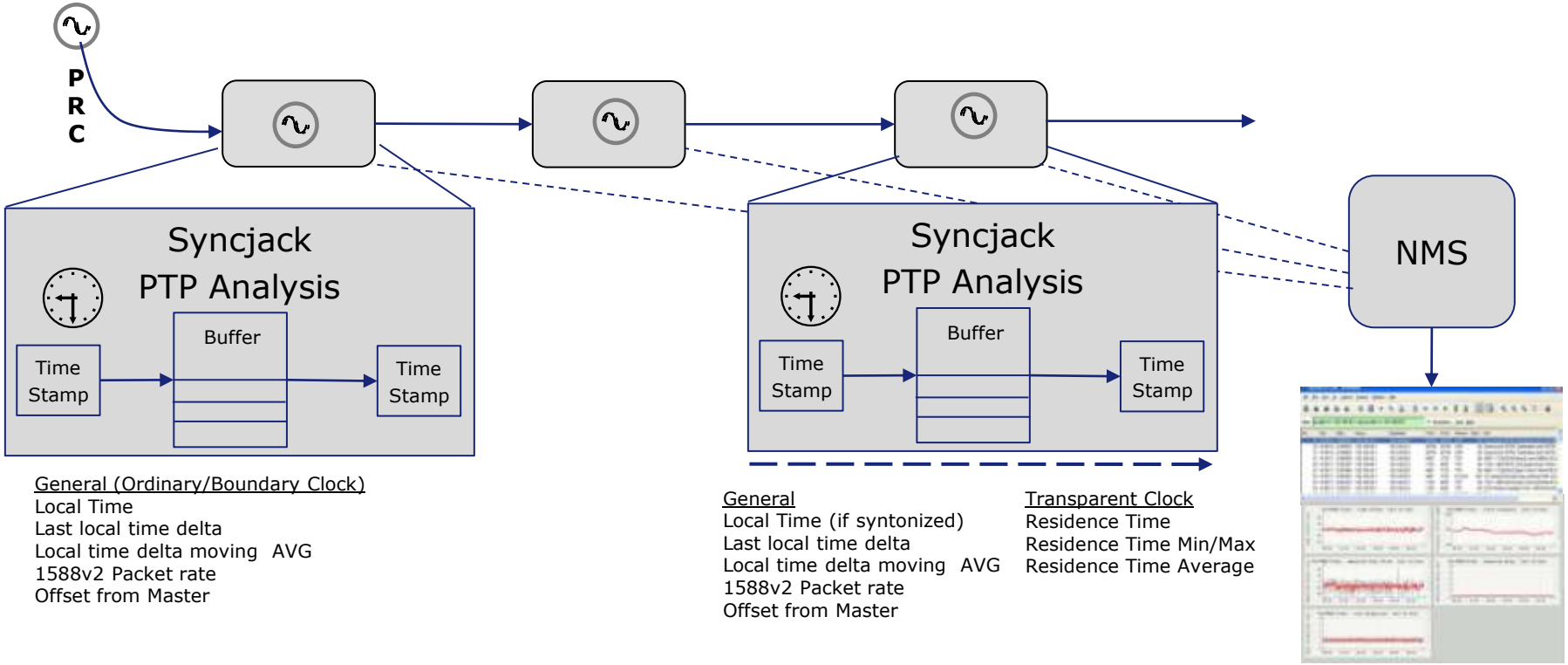


Per node:
Set XO to Min/Max
Step between min/max over time
IFFT allow diagnosis of frequency profile
Per Network:
Inject on one node – monitor downstream

Planning | Deployment | Operation | Diagnostics

PTP Network Analysis

- PTP Network Monitoring Tool
  - A packet based analysis tool – PDV analysis
  - Compliments and interacts with 1588v2 PTP clock recovery algorithm
  - Supports time alignment monitoring over packet switched network



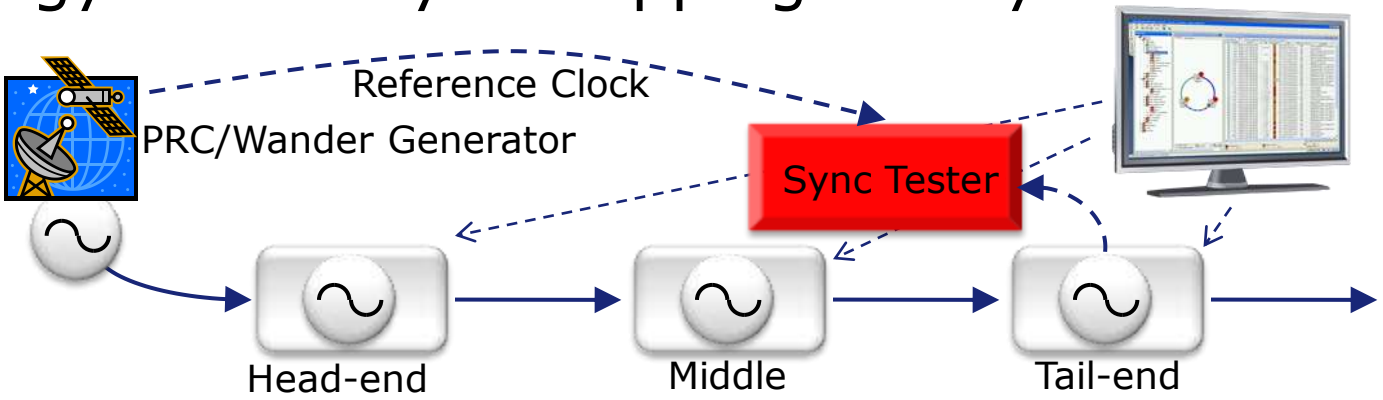
General (Ordinary/Boundary Clock)
Local Time
Last local time delta
Local time delta moving AVG
1588v2 Packet rate
Offset from Master

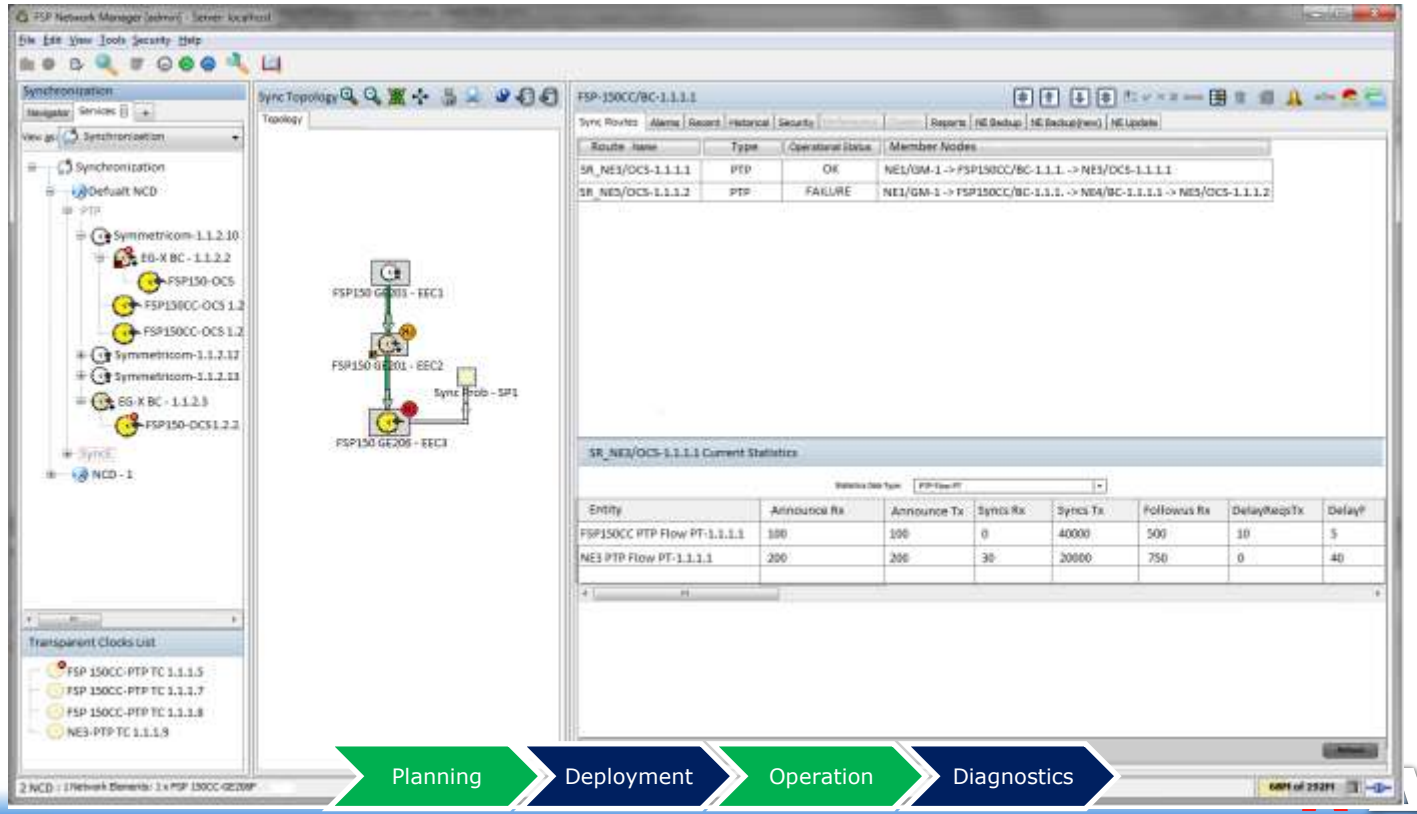
General
Local Time (if syntonized)
Last local time delta
Local time delta moving AVG
1588v2 Packet rate
Offset from Master

Transparent Clock
Residence Time
Residence Time Min/Max
Residence Time Average

Synchronization SLA Tools in Practice

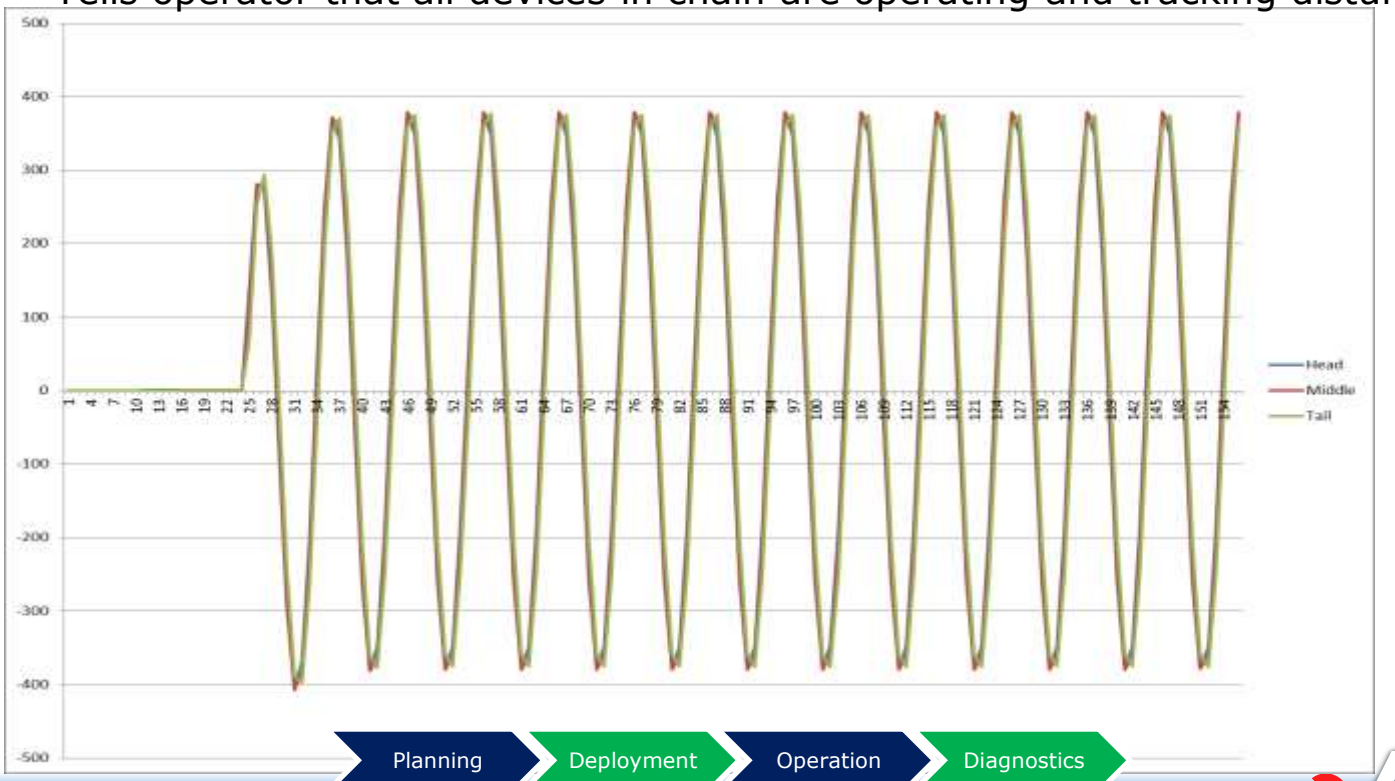
Mapping In Practice
Topology Discovery & Mapping the Sync Network





Clock Analysis In Practice
Deployment Tests

- Applying wander at Head of the chain - analysing downstream effects
  - All devices configured to same operation
  - Analysing a PLL control variable
    - Sampling once per second – thus not a massive processing load on hardware/NMS
  - Wander inside PLL bandwidth - devices observed to track the wander
    - Tells operator that all devices in chain are operating and tracking disturbance



Planning | Deployment | Operation | Diagnostics

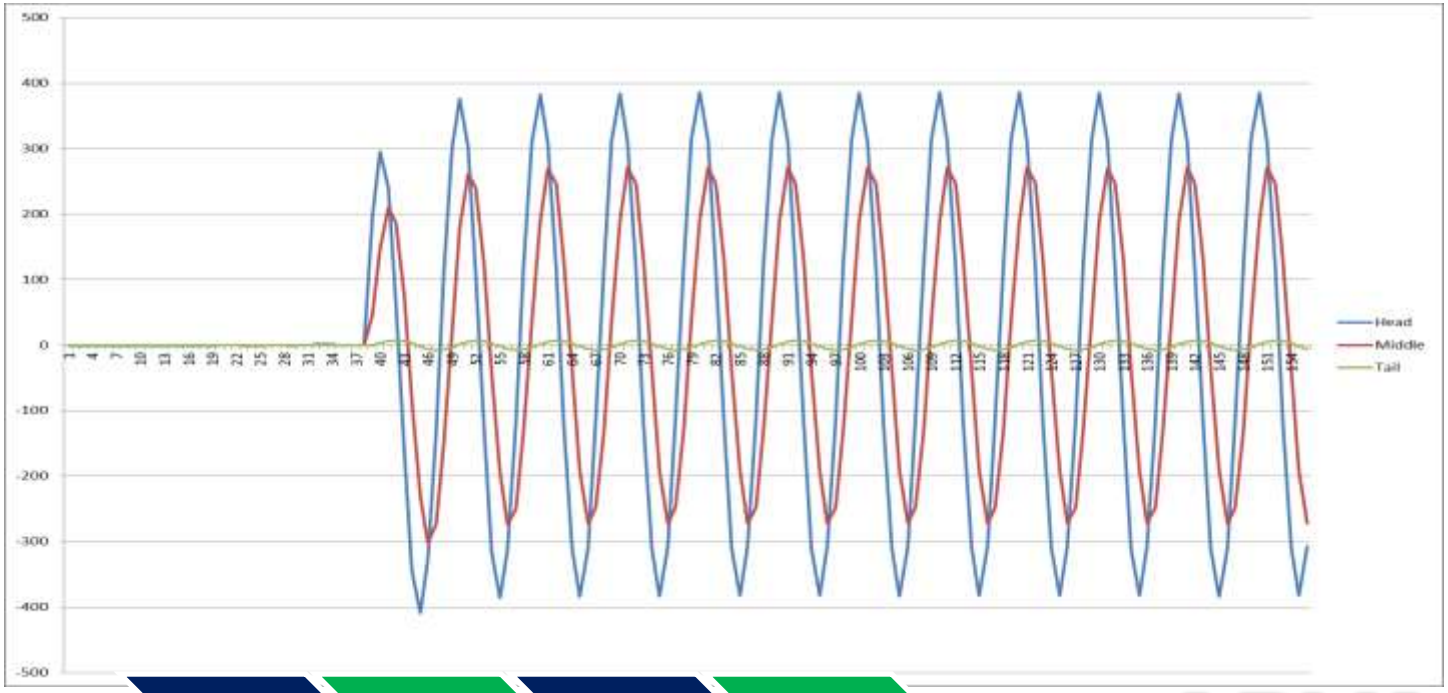
Clock Analysis In Practice
Simulated Fault Detection/Isolation - 1

- Middle device
  - Applying the same level of wander as previous slide
  - Middle device Configured for EEC-Option 2
    - ITU-T G.8262
    - Could be provisioning error or similar
    - Effect is to attenuate the wander transferred across the middle box
    - So the Tail does not see the wander

In out of footprint scenario, only have access to head and tail end for monitoring the PLL.

Able to predict that there appears to be a fault in the chain – without having yet deployed test equipment.

No van deployment needed yet…

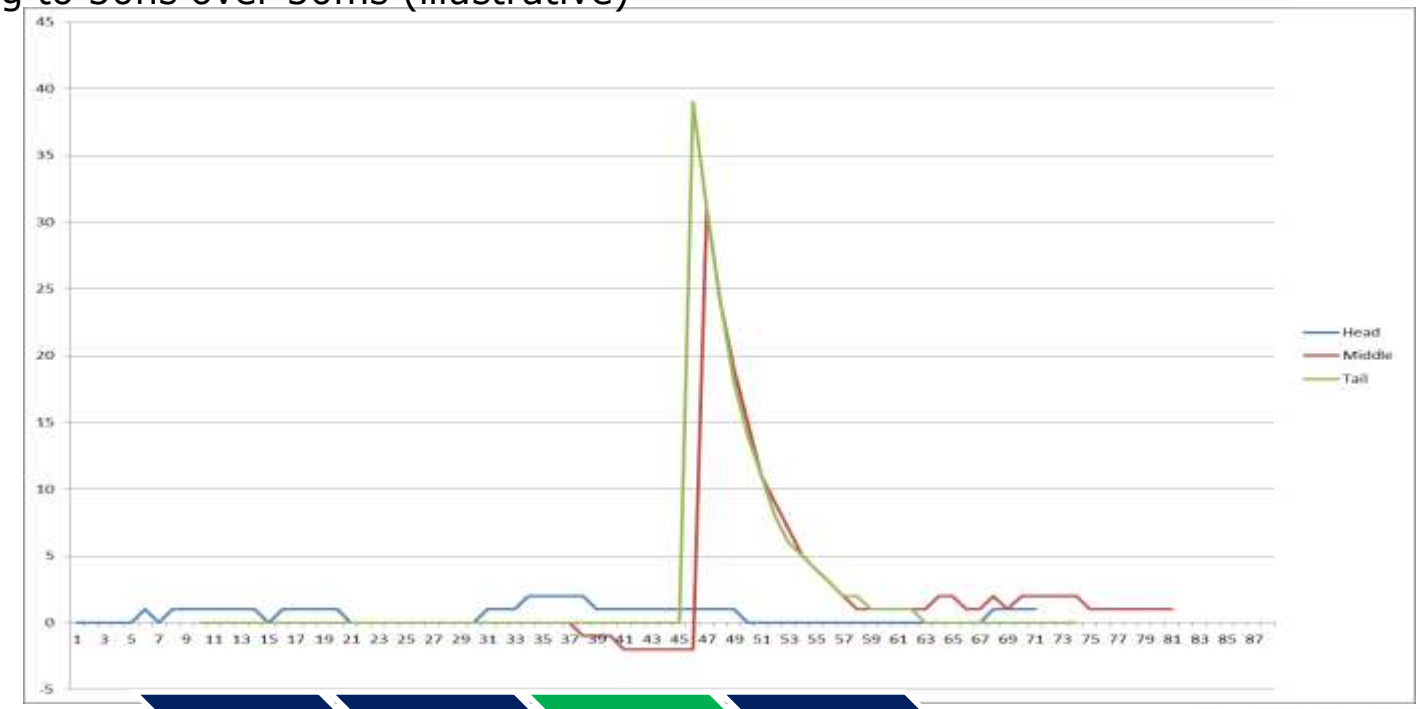


Planning | Deployment | Operation | Diagnostics

Clock Analysis In Practice
Simulated Fault Detection/Isolation - 2

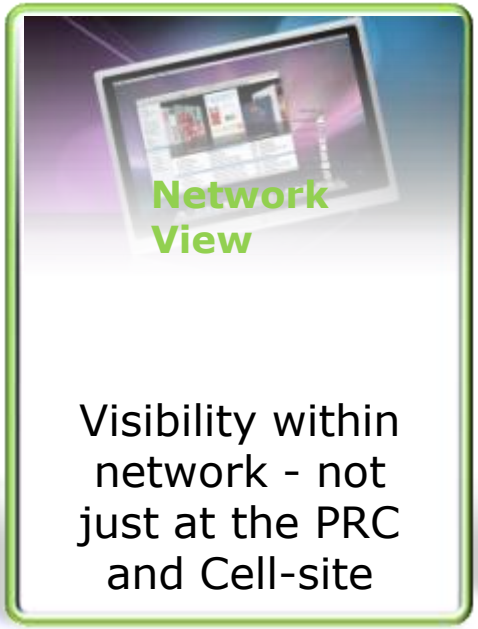
- Transient Response Example
  - Removed the Wander from previous slides
    - Restored middle device to Option 1
  - Simulating a protection event within an operators network
    - Protection event not visible to the end operator using that service
    - Underlying operators device does a phase build-out between protection ports - equating to 50ns over 50ms (illustrative)

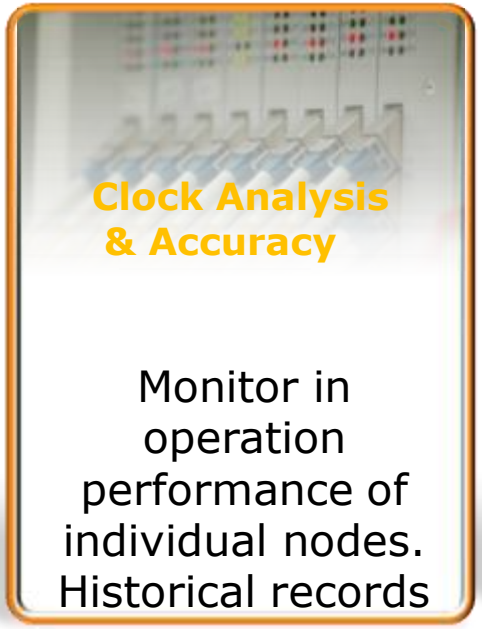
If only had access to Head end and tail end, would be able to observe that a transient occurred between Head and tail.
If have access to middle device, then can derive transient between the Head and Middle device – if this was repetitive, could send a van and test equipment to that node

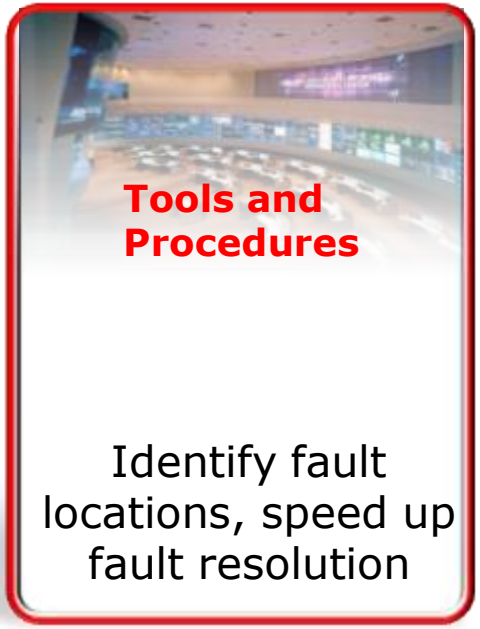


Planning | Deployment | Operation | Diagnostics

Managing Synchronization Networks







Keep the customer informed
Maintain customer loyalty
Reduce OPEX $$$

Adoption by industry and standards to capture a baseline feature set
Goal: With the right tools, managing the Sync SLA should be as simple as…
child's play!

Thank you – Any Questions

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