Time and Phase Delivery

Time and Phase Delivery and Assurance in Mobile Networks

Gil Biran, ITSF 2013, Lisbon Portugal

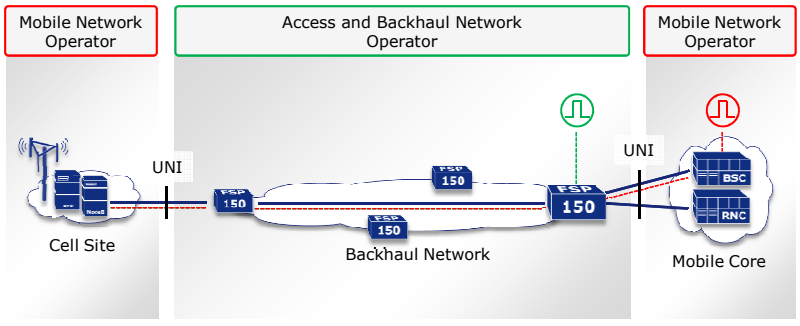
Agenda

- Delivering time and phase in Mobile Backhaul networks
- Addressing the LTE-A challenges
- Implementing Synchronization Delivery and Assurance in Brownfield MBH Networks
- Sync Manager Requirements
- Summery

clock tower
in mount tabor
Catholic Church

Delivery and Assurance of time and phase in Mobile Backhaul networks

Synchronization as a Service Scenarios



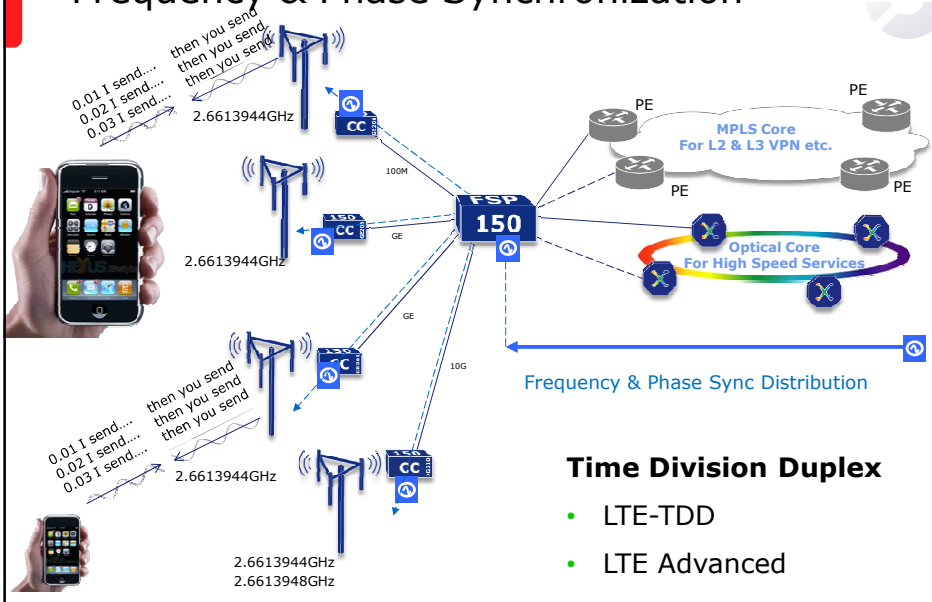
- Mobile Backhaul Network Scenarios
  - Owned by the MNO transport division or MNO sister company
  - Owned by 3rd party Mobile Backhaul wholesale provider

LTE Synchronization Challenges

LTE Standard	What	Why	Impact
LTE (FDD)	16 / 50 ppb	Call Initiation & basic Mobility Services	Call **Interference** Dropped calls
LTE (TDD)	16 / 50 ppb; +/- 1.5 µs	+ Time slot alignment	**Packet loss/collisions** Bandwidth efficiency
LTE MBSFN	16 / 50 ppb; +/- 1-32 µs	+ Time alignment of video signals from multiple BTS	Video broadcast **interruption**
LTE-A MIMO/COMP	16 / 50 ppb; +/- 0.5 µs	+ Coordination of signals to/from multiple base stations	Call **interruption**, interference & **dropped** calls

Source: Symmetricom

Frequency & Phase Synchronization



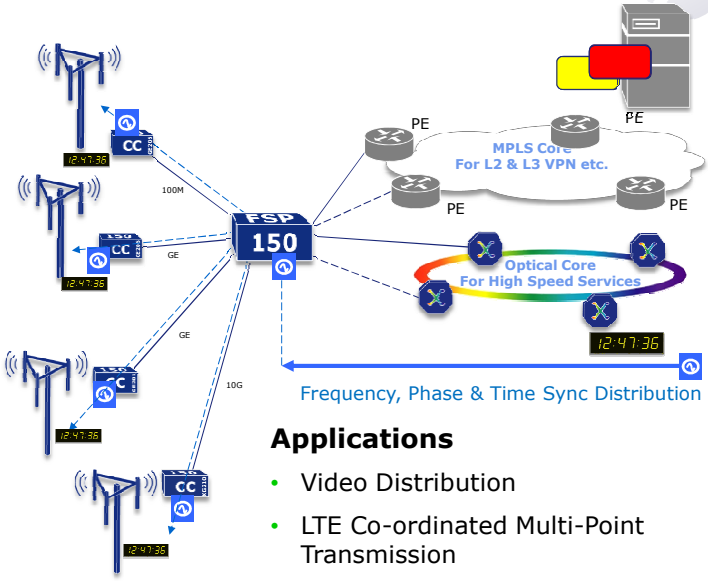
Time Division Duplex

- LTE-TDD
- LTE Advanced

Frequency, Phase and Time Synchronization

Channel Change

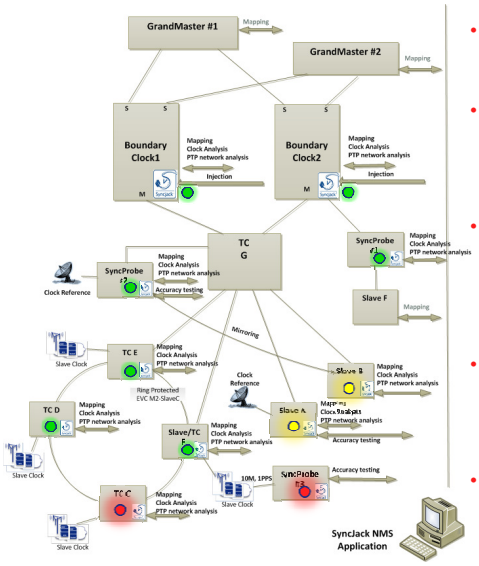
- 2 Streams of video
- Cut over exactly between two frames
- e.g.12:47:36:150



Applications

- Video Distribution
- LTE Co-ordinated Multi-Point Transmission

Time and Phase Assurance in Mobile Synchronization Network



- **Q.** What is the Sync distribution topology?
  - **A.** Sync topology discovery
- **Q.** What is the PTP clock devices performance?
  - **A.** Clock performance measurement and monitoring on frequency and packet domains
- **Q.** What is the communication path performance?
  - **A.** PTP communication path PDV and Asymmetry measurements and monitoring
- **Q.** What is the Slave clock status and performance?
  - **A.** Slave clock performance estimation even if the sync reference is not available in same location
- ...

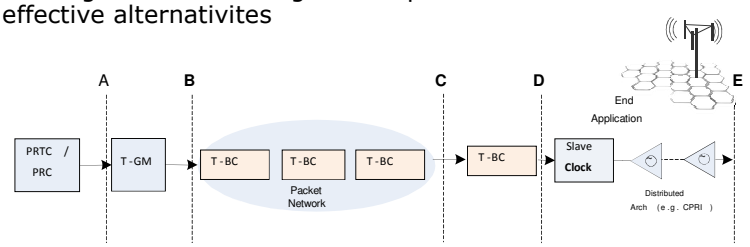
Addressing the LTE-A challenges

The 500nsec Phase Synchronization challenge

- LTE-Advanced requires phase synchronization accuracy of 500ns for handovers and high-quality real-time services
  - LTE CoMP - LTE supports Coordinated Multi-Point Transmission
  - LTE eICIC application -LTE-Advanced has been developing enhanced inter-cell interference coordination (eICIC) techniques
- Achieving this level of phase accuracy is very challenging considering Packet Delay Variation performance and difficulties of estimation of the delay asymmetry in the Mobile Backhaul Network
- 500ns phase synchronization accuracy may be achieved in one or more of the following options
  - On Path Support (OPS) as define in G.8275.1 profile
  - Deploying Mini Grandmaster near or at the Cell Site as define in G.8272 Appendix 4
  - New Telecom PTP profile with partial support from the network as define in G.8275.2, including PRTC (GNSS) near the Cell Site

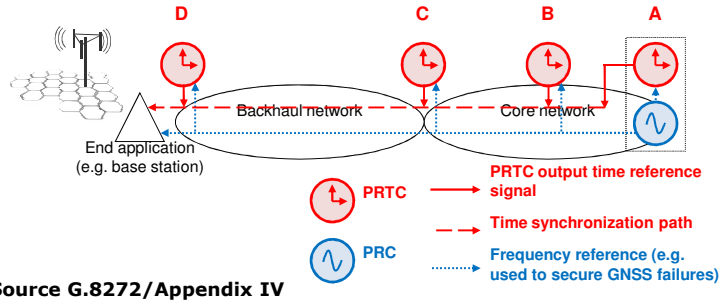
G.8275.1 Synchronization Model

- Synchronization model set forth in G.8275.1 mandates for full On Path Support of PTP plus SyncE
  - Timing support from the network is required to meet the stringent requirements for time/phase accuracy (500nsec) in mobile networks
- On Path Support may require
  - Hardware swap out, or
  - A completly new network (Greenfield)
- G.8275.1 architecture may require major CAPEX to upgrade existing networks forcing service providers to look for more cost effective alternativites



Bringing Primary Time Reference Clock with Mini Grand Master close to the Cell Site

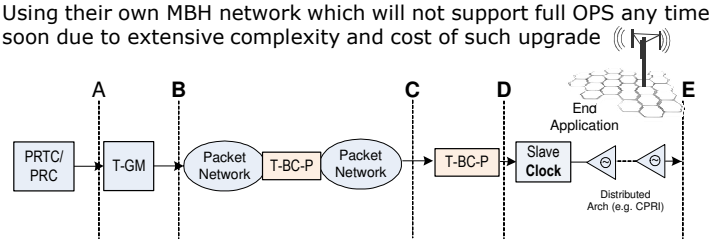
- When considering phase/time distribution, the PRTC functions can be located at different positions, depending on the overall architecture that the network operator wishes to follow.
- These can be summarized into the four generic locations A, B, C and D described in the figure below
- Bringing PRTC close to the End user improves synchronization delivery performance



Source G.8272/Appendix IV

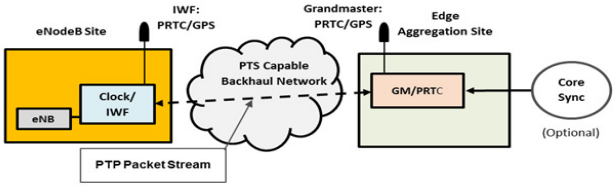
G.8275.2 Synchronization Model

- Synchronization model set forth in G.8275.2 (under study) is calling for Two options for Partial On Path Support
  - Pure Partial Timing Support as described below
  - Assisted Partial Timing Support as describe in next slides
- Pure Partial Timing Support without PRTC support near the Cell Site
- Assisted Partial Timing Support with PRTC support near the Cell Site
- G.8275.2 architecture address a real pain of Mobile Operators
  - Using multiple 3rd party MBH wholesale providers without full OPS
  - Using their own MBH network which will not support full OPS any time soon due to extensive complexity and cost of such upgrade



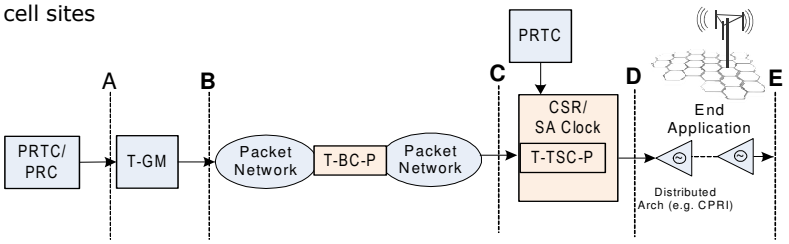
Assisted Partial Timing Support (APTS)

- The concept was introduced by Sprint at SG15/Q13 ITU meeting in Kansas on 10/2013
- Some operators already have GNSS (GPS) for synchronization of base stations for legacy network synchronization
- Known vulnerability of GNSS causing operators to seek for methods of backing up local GNSS failures with PTP
- The presence of a GNSS reference provides accurate frequency and time information that may be utilized by the PTP clock in the event of a GNSS failure. This is referred to as Assisted Partial Timing Support (APTS)

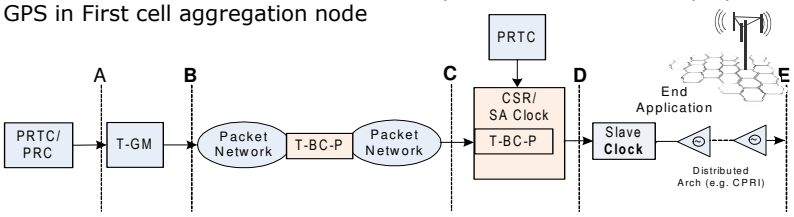


Assisted Partial Timing Support (APTS) Deployment Cases

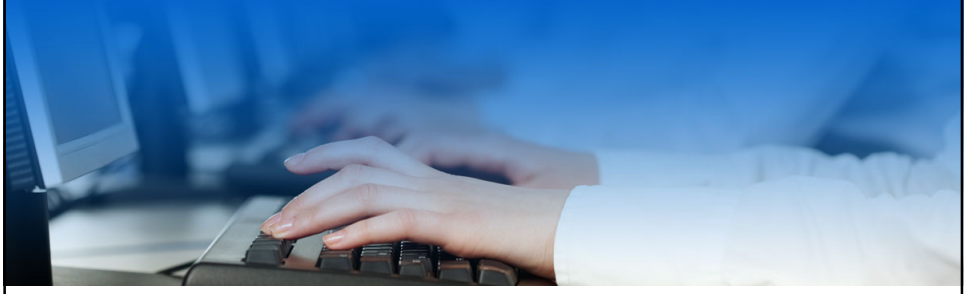
- The PRTC is co-located with the Slave Clock - Legacy deployment of GPS in cell sites



- The PRTC is co-located with the Boundary Clock – Greenfield deployment of GPS in First cell aggregation node

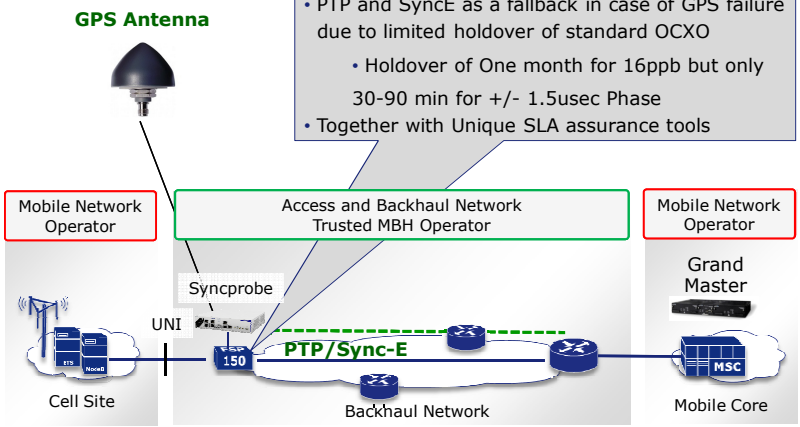


Implementing Synchronization Delivery and Assurance in Brownfield Mobile Backhaul Networks

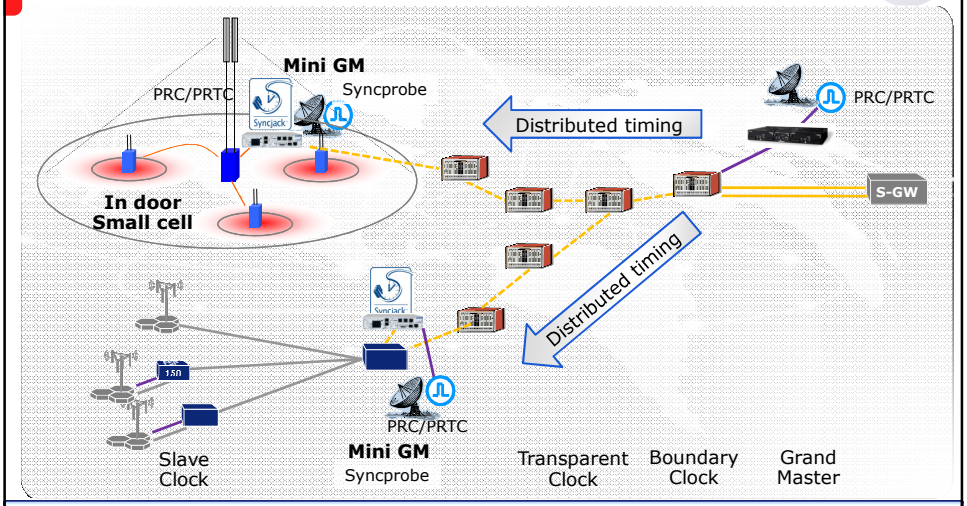


Mini Grand Master Plus with Syncprobe

- Mini Grand Master in Syncprobe
- Built In GPS receiver
- Receiving clock from GPS as main source
- PTP and SyncE as a fallback in case of GPS failure due to limited holdover of standard OCXO
  - Holdover of One month for 16ppb but only 30-90 min for +/- 1.5usec Phase
- Together with Unique SLA assurance tools



Mini Grand Master Plus Deployment



GNSS/GPS as primary reference and PTP/PTP+SyncE as secondary reference(i.e. APTS) or Vice Versa, depend on PTP reliability and accuracy

Main Features for Mini Grand Master Plus

- Frequency, phase and time delivery with Mini GM/BC
  - Reference A : GNSS based PRTC – G.8272
  - Reference B : PTP or PTP+SyncE
  - Ref A as Primary and Ref B and Secondary clock source without good PTP On Path Support or vice versa with On Path Support
  - Support relevant holdover requirements during GNSS outage
  - GNSS based asymmetric delay calibration which improve PTP accuracy

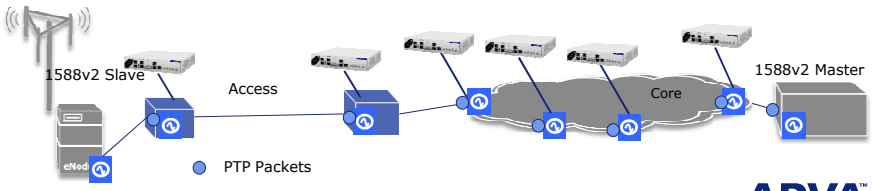
- Frequency, phase and time assurance with Mini GM/BC
  - Measurement of the relevant KPI related to Network and PTP recovered clock/phase/time
    - BC quality in the same node
    - Slave clock quality in the remote Macro and Small Cells nodes
  - Collect slave clock quality of multiple eNB at a time by using multiple PTP passive probes in one Syncprobe device

eNB Sync Key Performance Indicators

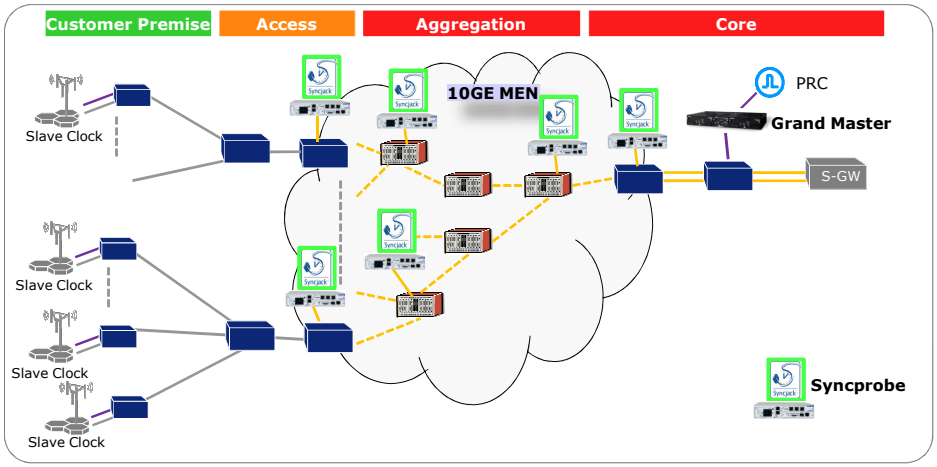
- The GNSS/GPS reference can be used for calculation of the relevant sync KPI
- Clock related KPI
  - TIE and MTIE Masks
  - Maximal Time Error (TE)
- Clock related KPI measurement can be done in 2 ways
  - Based on measurement of physical clock (i.e. 1PPS)
  - Based on measurement of packet timing signal (i.e. timestamps embedded in the PTP event messages)
- PTP Network related KPI
  - PTP Packet counters (received /lost)
  - Network Asymmetry
  - Path delay /Mean path delay (min, max, average)
  - Floor Packet Percentage (based on G.8260)

Add On Hybrid Synchronization Network without a pain

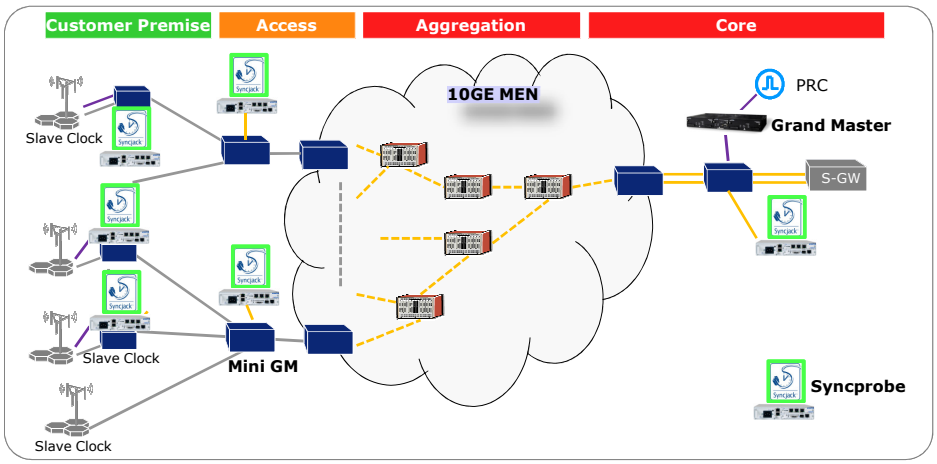
- The majority of the Mobile Backhaul (MBH) Networks has limited support of Synchronization
- Syncprobe as add on to Existing (Brownfield) mobile backhaul networks
  - Fits Mobile Backhaul Operators and Mobile Network Operators
  - Allows delivery and assurance of the synchronization services
- Operating as TS, TC or BC and attached to existing Network Nodes
  - Enabling PTP overlay on top of existing MBH Networks
- Low cost, ease of installation and operation, PTP performance monitoring and diagnostic, Synchronization management



Enabling Time/Phase G.827x PTP Network Mobile Backhaul Operator case



Enabling Time/Phase G.827x PTP Network Mobile Operator case



Sync Manager Requirements

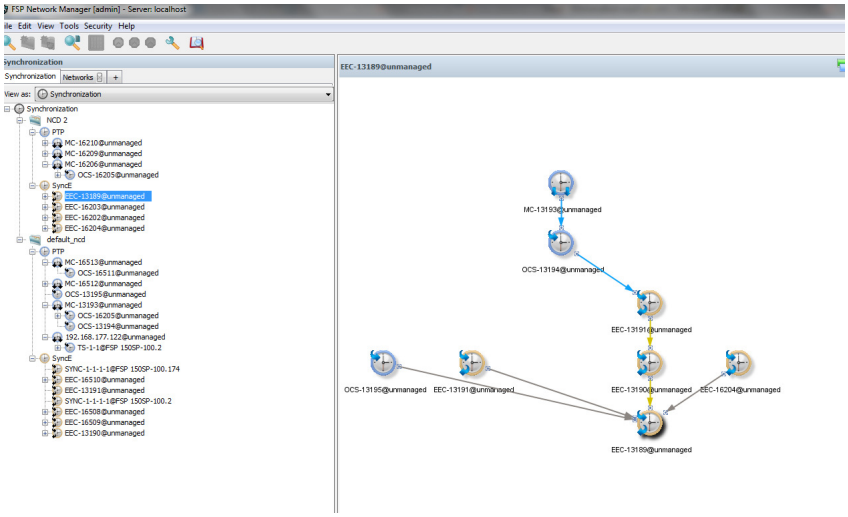
Sync Manager requirements overview

- Sync Manager need to learn, monitor, configure and display synchronization network topologies (IEEE 1588/PTP, SyncE and hybrid), a.k.a. Sync Map
- Sync Manager need to displays *Sync Routes* in order to identify an active clock stream from Master to Slave
- The *Sync Routes* should enable to identify problems in any of the nodes and also allows recognizing loops
- Sync Manager should allow user to initiate, configure, schedule, and display Sync probe tests and test results
- The Sync Manager should present Sync Health status per Sync Node and also aggregated Sync Health status e.g. in Network Clock Domain (NCD) or in selected Master-Slave Hierarchy.

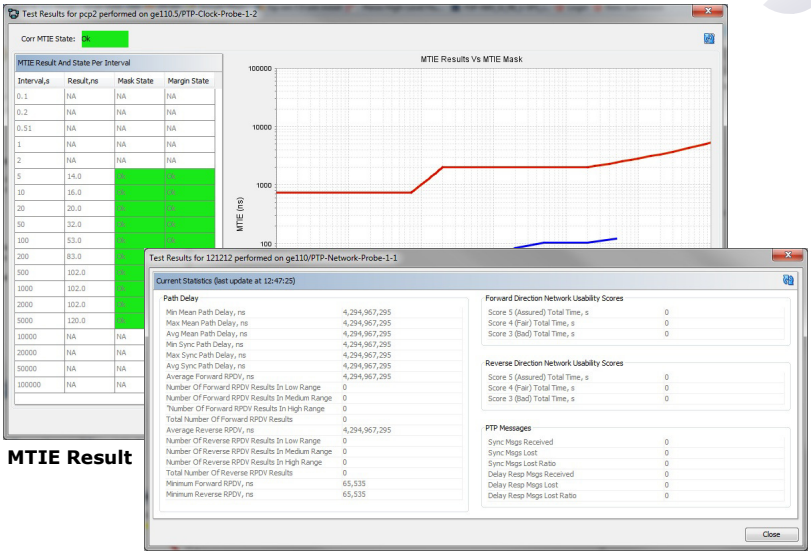
Sync Manager functions

- Sync Map
  - Topology Map and Tree
  - Hierarchy and clock distribution
  - Clock status
  - Sync Health
- Sync Routes
  - Route Info
  - Route alarm and status
  - Route Statistics
- Sync Components
  - SyncE Node
  - PTP TC
  - PTP BC
  - PTP MC
  - PTP OC-S
  - Network Clock Domains
- Syncprobe monitoring and diagnostics for Clock Accuracy, Clock Analysis, PTP Network Analysis

Sync Map with active Sync Route



Syncprobe Tests– Test Results Display

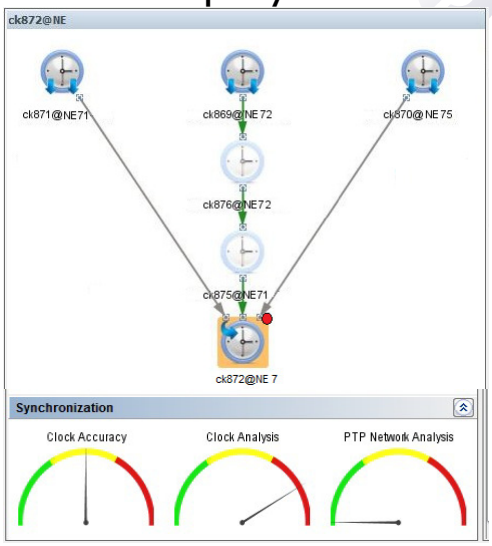


MTIE Result

PTP Network Statistics Results

Sync Monitoring Status Display

- Sync Map provides visual indication for Sync Components that are monitored by Syncjack tools.The icon color indicates the status of In-Service Telecom Slave(s) scores and/or on-going tests.
- Synchronization pane presents correlated overall SJ Health status per Sync Node(s)/NCD(s)/Route
- Several levels of details allows step by step troubleshooting
  - Global – High level, based on all Syncjack tests monitoring results
  - Detailed - based on Syncjack tests monitoring results per Category and TS Score



Synchronization services Enabling with the Syncprobe as Sync Tool Box

- Synchronization Interface Demarcation (SID) allows Synchronization as a service
- Sync services assurance with proactive PTP communication path and clock recovery performance monitoring and diagnostic
- Enhanced PTP Slave clock capabilities with self calibration based on network PDV and Asymmetry, performance monitoring and diagnostics
  - Unique self calibration which is based on self learning of the network
- Mini Grand Master with fallback to PTP recovered clock or Sync-E timing reference
- PTP enabling mode with BC and TC capabilities
  - Allow full or partial On Path Support for Brownfield mobile backhaul networks without PTP support

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Thank you

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