Power Matters

Deploying SyncE and IEEE 1588 in Wireless Backhaul

Mondy Lim
mondy.lim@microsemi.com
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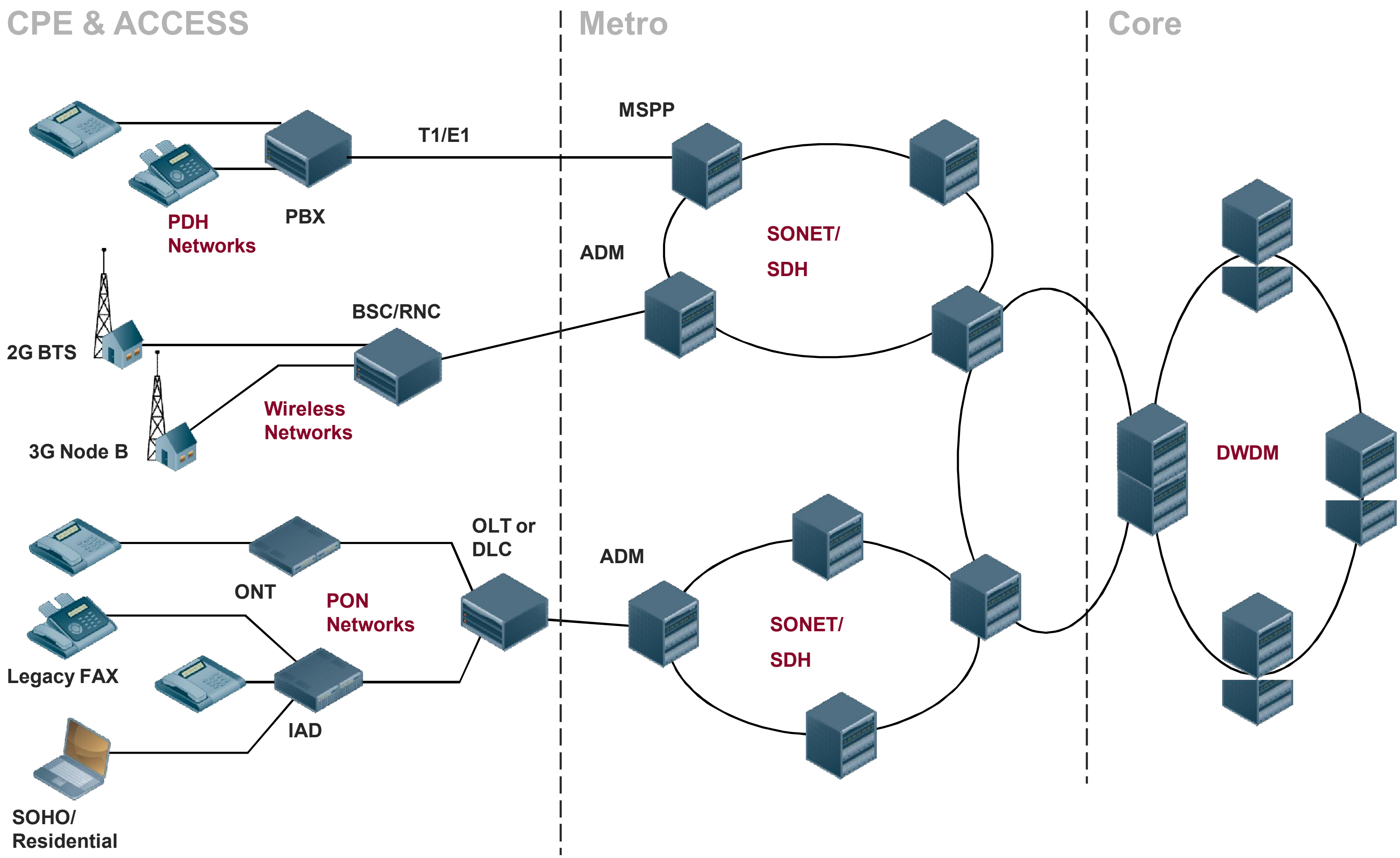
Outline

- Why is Synchronization required in mobile networks?
- Synchronization in legacy mobile networks
- Synchronization for Packet Networks
  - Å SyncE
  - Å IEEE 1588 2008
  - Å Combining SyncE and IEEE1588
- Conclusion

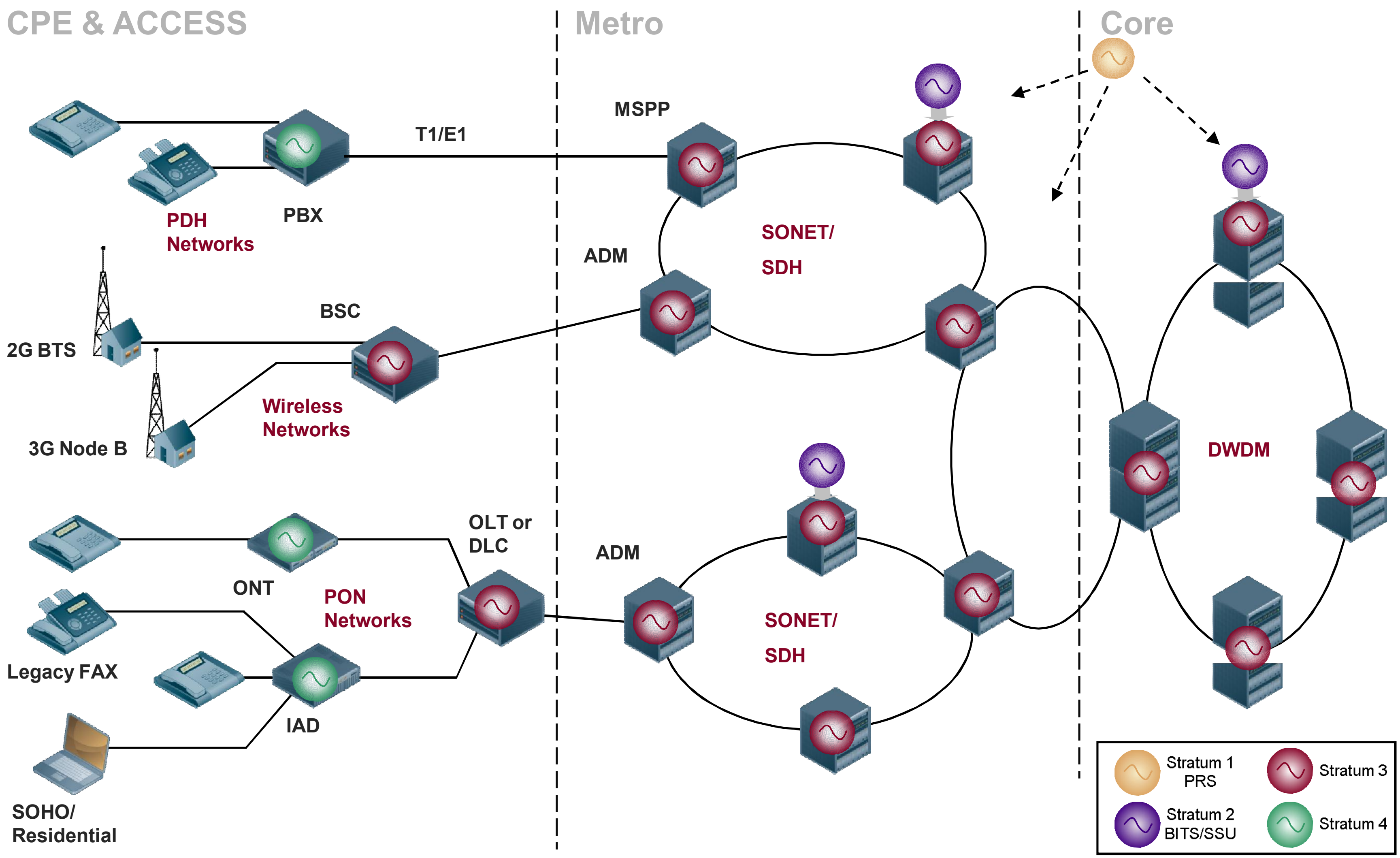
Why Sync is needed at the basestation?

- For mobile providers, the need to maintain sync comes from:
  - Need to align frequencies of the basestation radio air interface
    - Control wander so that it does not lose connections to handsets
    - Ability to properly hand-off from one basestation to another
  - TDD applications require phase alignment
    - This allows for efficient use of the spectrum while providing seamless handover of the handset from one basestation to the other

Generic Circuit Switched Network - Where is the Synchronization?



Generic Circuit Switched Network



Legacy SONET/SDH

- SONET/SDH build from the óground-upô for synchronization
- SONET/SDH has a set of specifications that cover all necessary capability to effectively and reliably deploy synchronization within a network using a synchronization chain
- Distribution of timing is from a PRS/PRC towards the end equipment

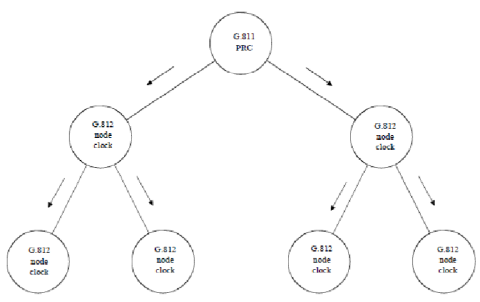


Figure 8-2/G.803 – Synchronization network architecture inter-node distribution

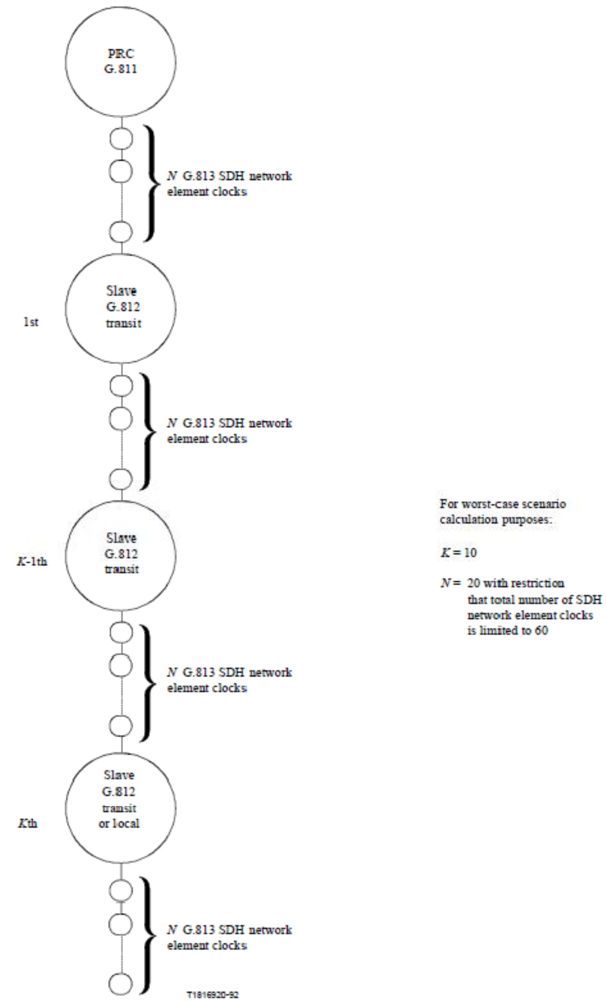
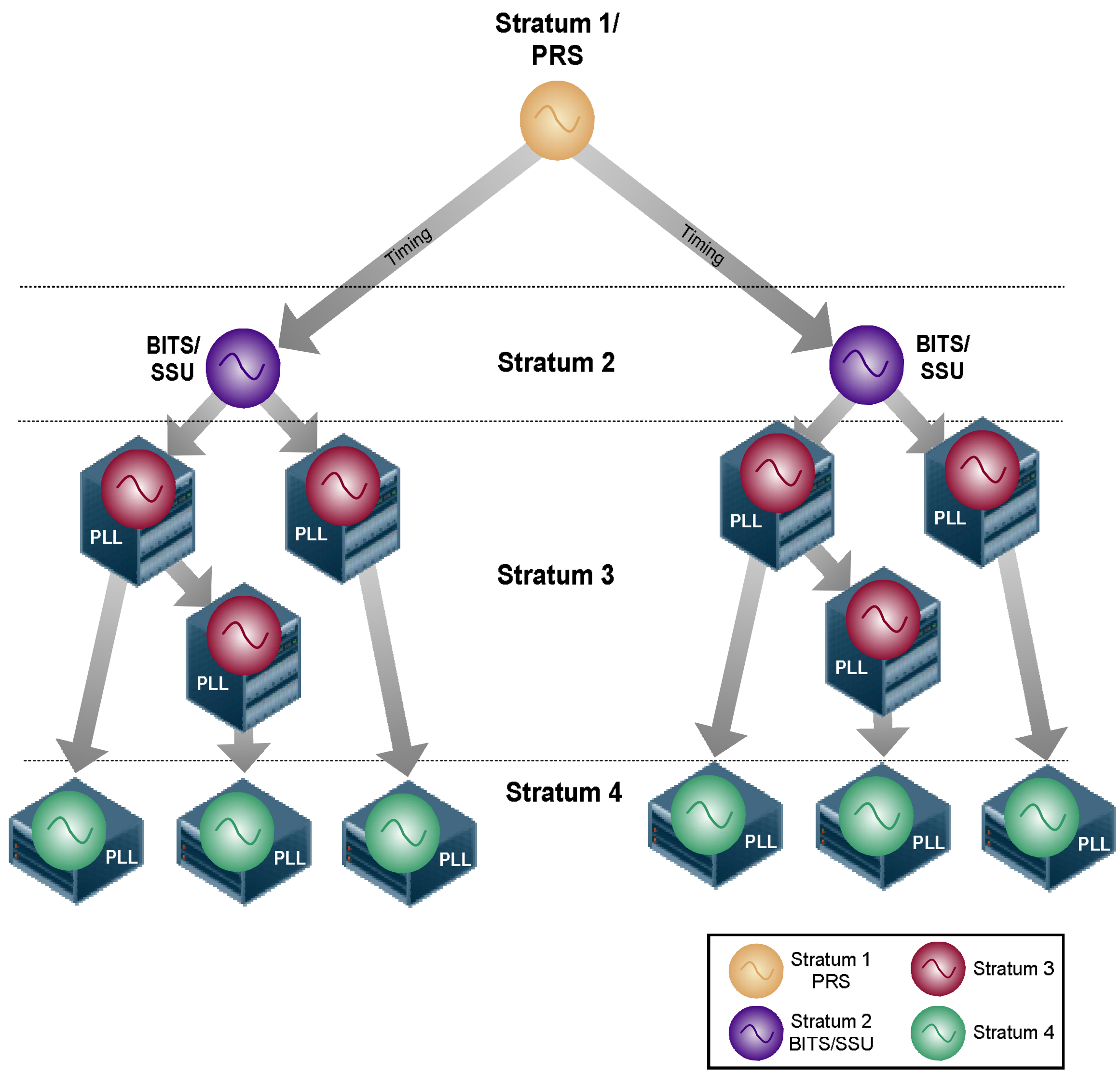


Figure 8-5/G.803 – Synchronization network reference chain

Re-organizing the Synchronization into a Logical Flow

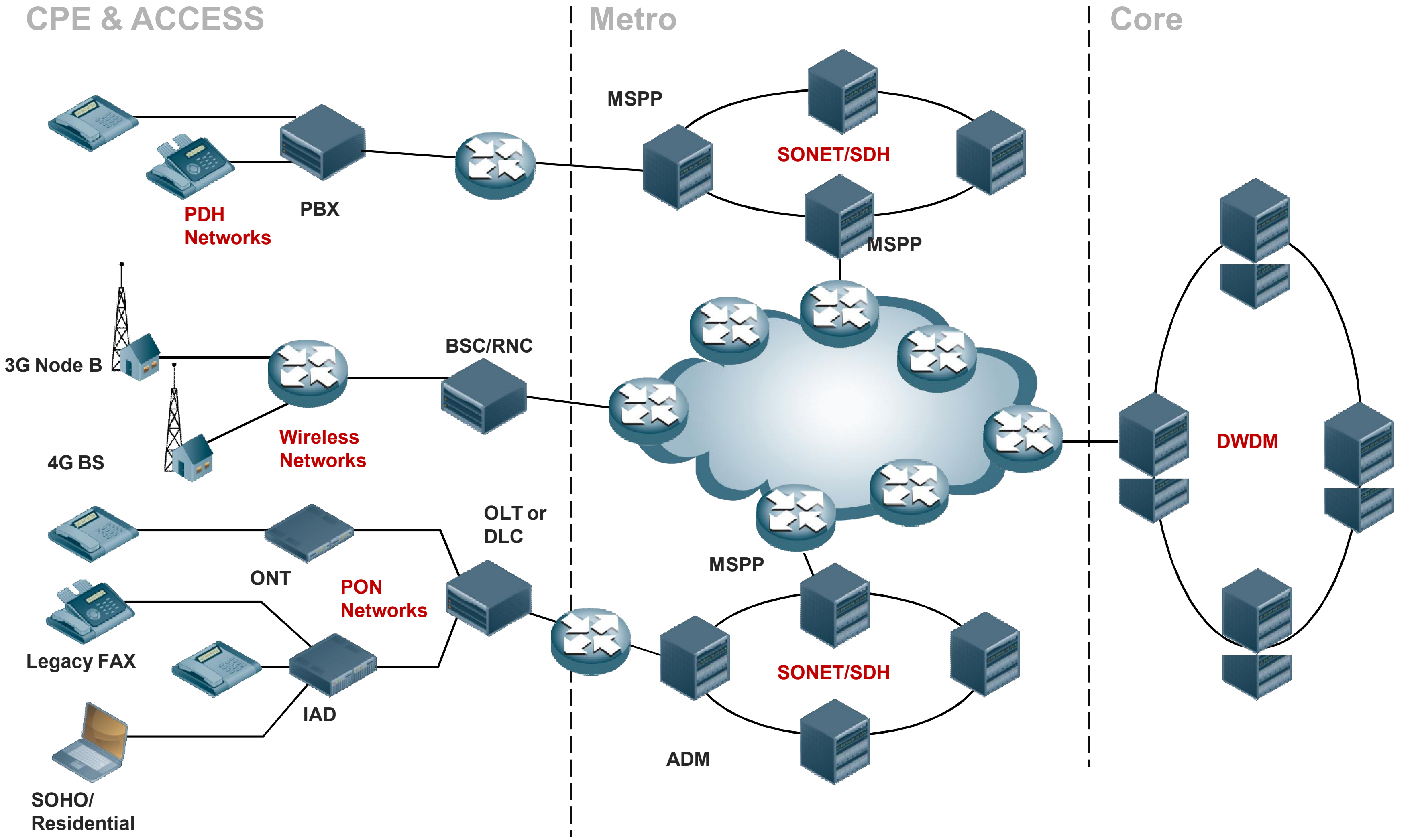
- A Stratum 1 clock (or PRS) provides a highly accurate reference for the entire network
- Stratum 1 provides the highest level of frequency accuracy followed by the Stratum 2, the Stratum 3, and the Stratum 4
- PLLs synchronized to the PRS are used in the timing distribution chain to ñtransferò the PRSôs frequency accuracy throughout the network
- In the case where a PLL in the timing distribution chain is isolated (not synchronized to the PRS), it generates timing at its own frequency accuracy



Evolution of Synchronization

- Carriers are under pressure
  - To reduce operational cost of their network despite the explosion in data traffic in the access and core networks
  - To increase flexibility of their network in order to be able to carry different types of services
- To address those issues, operators are migrating their TDM networks to a packet switched network
  - According to Infonetics, by 2015, 79% of all installed cell sites wireless backhaul connections will migrate to IP or Ethernet.
- There are tremendous technical challenges to transport synchronization over packet-based networks as they, inherently asynchronous by nature, are not designed to carry timing and synchronization.

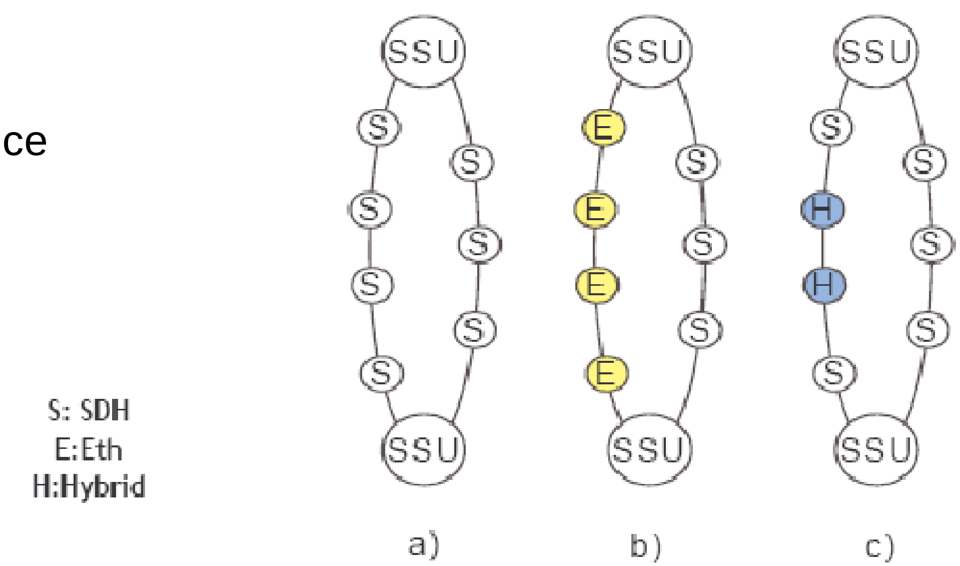
Generic Packet Switched Network - Where is the Synchronization?



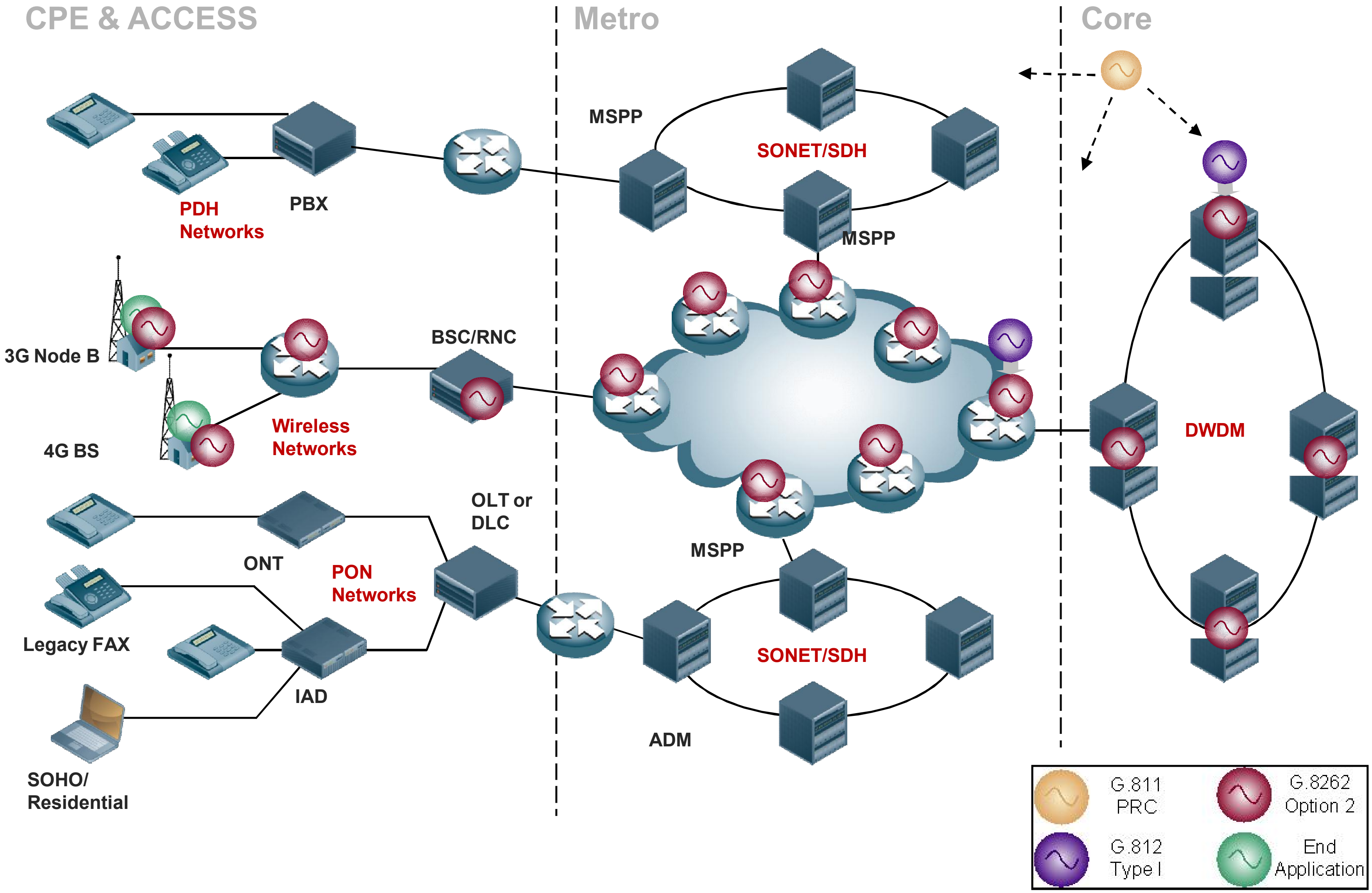
Option 1: SyncE Only

SyncE ï A technology based on SONET/SDH

- Deployment Options
  - Existing SDH/SONET Network (a)
    - An SSU provides a clock to the SDH equipment
    - Each SDH equipment recovers the clock and uses it to transmit to the next node
    - Eventually the SDH feeds into a SSU for re-distribution
  - SyncE Network (b)
    - An SSU provides a clock to the SyncE equipment
    - Unlike Native Ethernet, the clock is recovered and used for transmission
  - Hybrid Network (c)
    - SyncE may co-exist in the same ADM/switch/router
    - SyncE and SONET/SDH may be an input or output of the same device

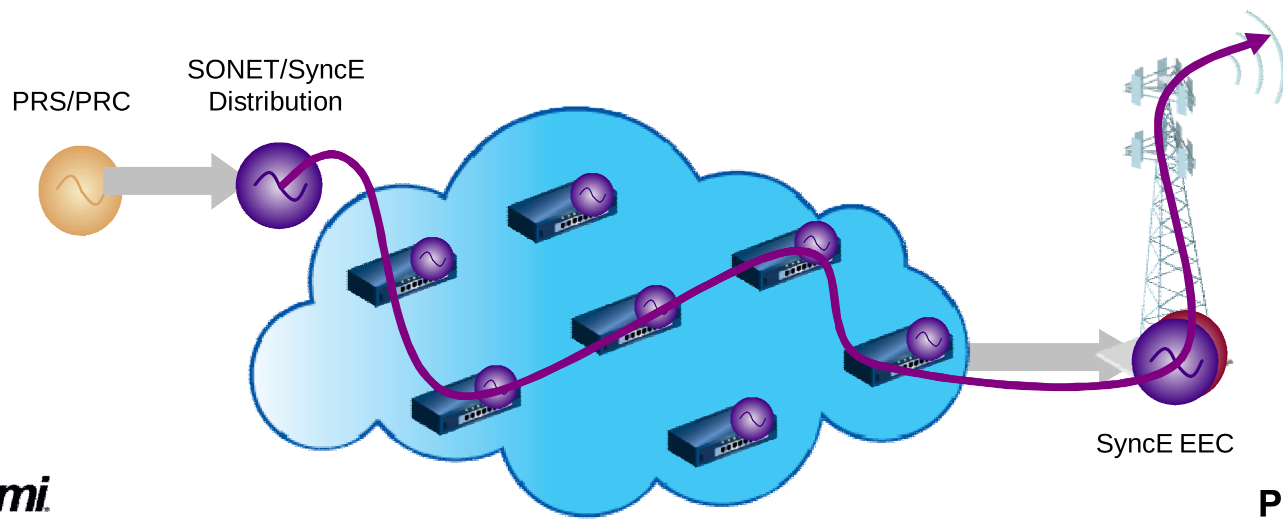


Generic Packet Switched Network Diagram - Deployment of SyncE



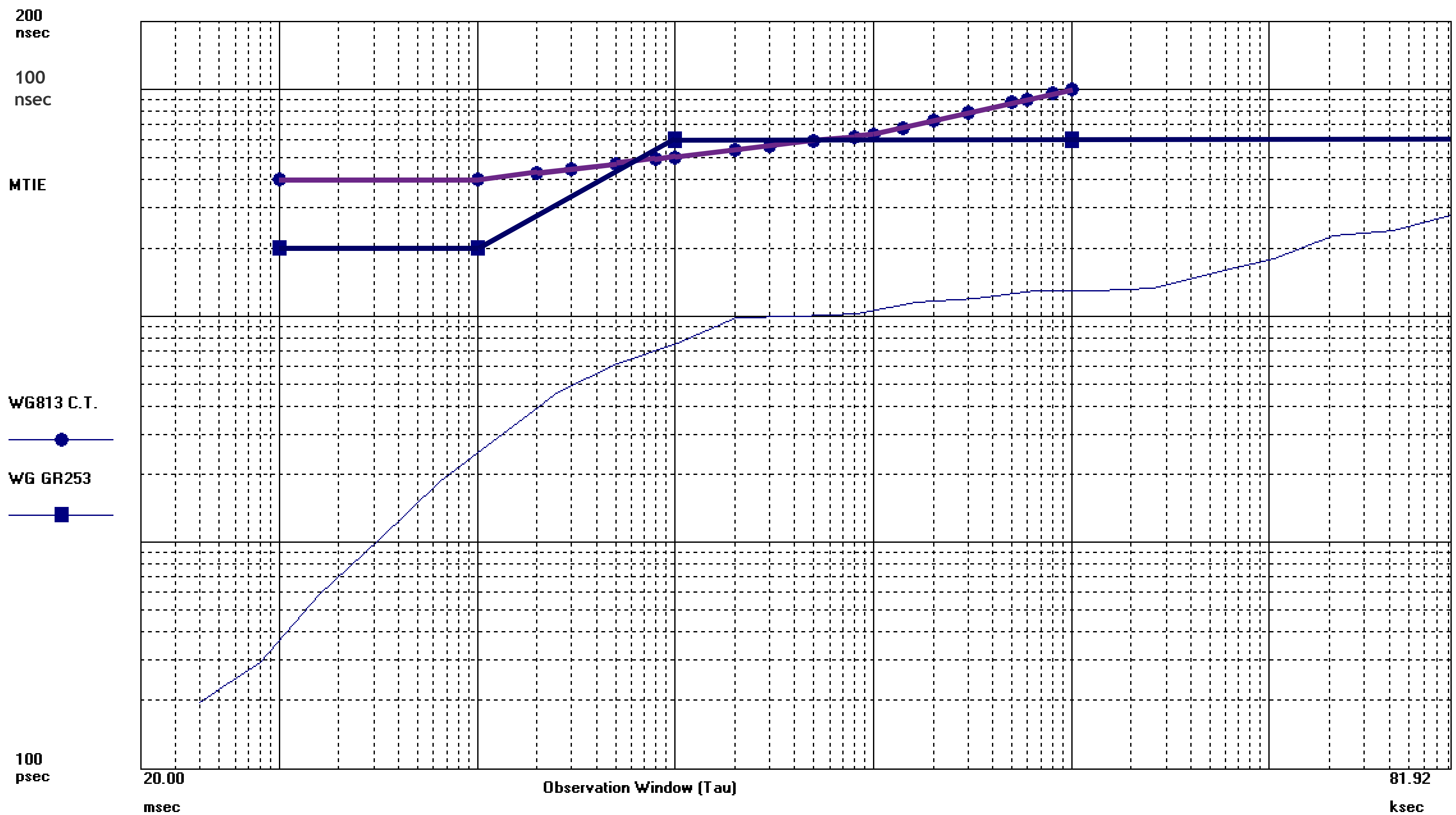
Using SyncE and SONET in Synchronization Chains

- As Ethernet network elements are added, inter-mix SyncE with existing SONET synchronization chain
- For greenfield Ethernet networks deploy SyncE throughout
- The performance is Not affected by Packet Delay Variation and independent of network loading
- Robust, reliable technology for applications
- Supports frequency accuracy for basestations (GSM, WCDMA-FDD, LTE-FDD)
- SyncE Standards are completed and published (G.8261, G.8262)
- Does not support phase or time synchronization (CDMA2000, WCDMA-TDD, TD-SCDMA, Mobile WiMAX) ï still need GPS
- SyncE is a point to point frequency transfer mechanism. If a single SyncE node in the chain is broken, syntonization in all the lower nodes in the hierarchy will be broken

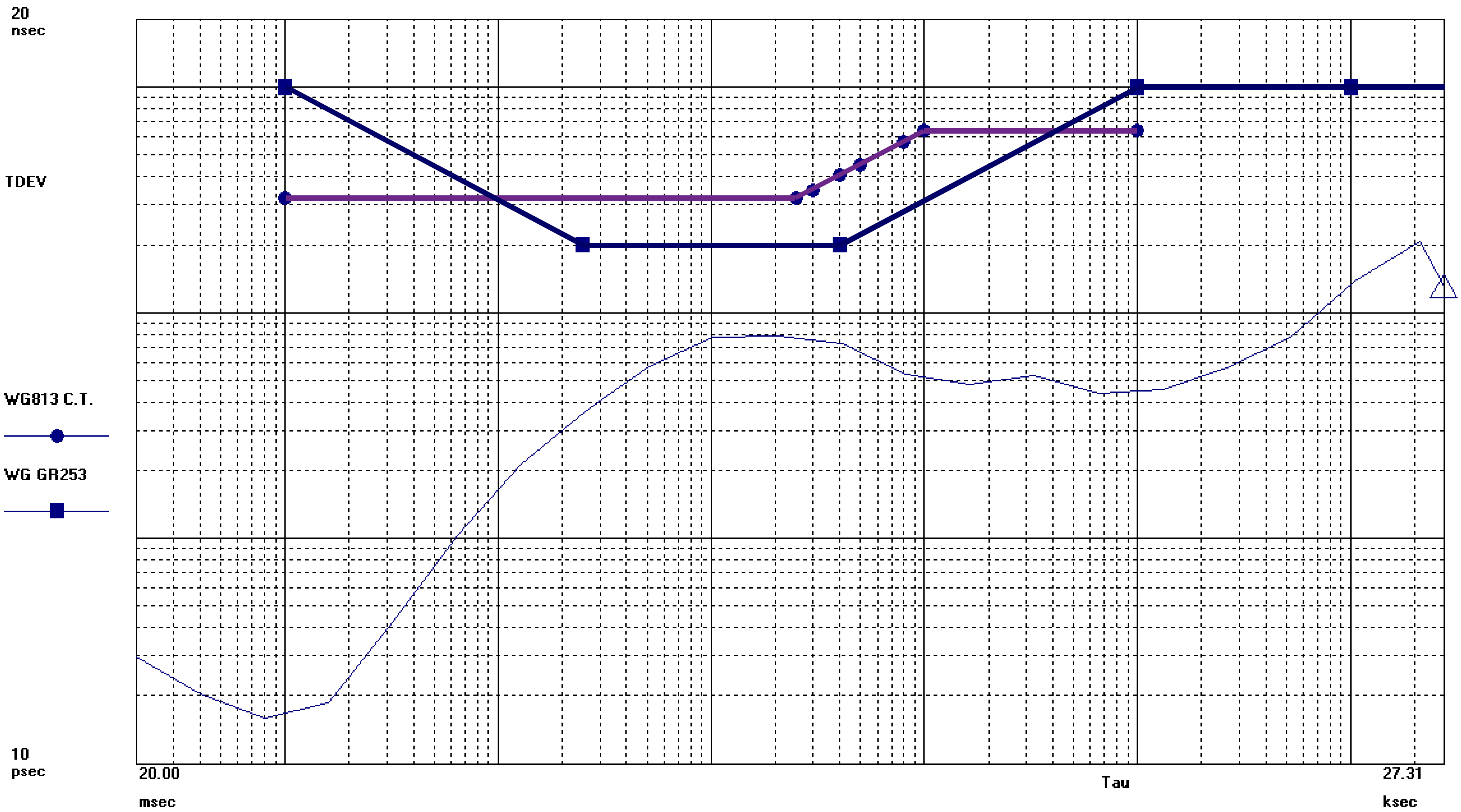


Test results for SyncE Only

SyncE, 10 Node MTIE Results



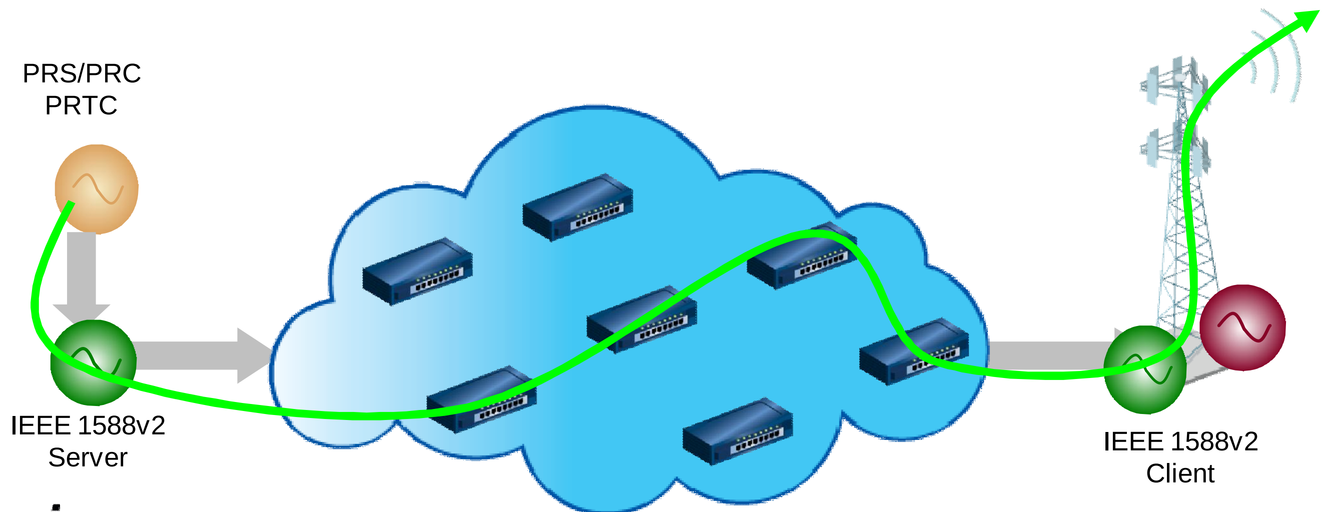
SyncE, 10 Node TDEV Results



Option 2: IEEE-1588 V2 in unaware networks

Upgrade RAN end points with IEEE 1588v2

- Supports GSM, WCDMA-FDD and LTE-FDD applications requiring frequency accuracy (50 ppb)
- IEEE 1588v2 client may be embedded in the basestation
- May support relaxed frequency requirements (traffic MTIE) for enterprise (PBX) or CES
- Challenging to support some frequency requirements (synchronization MTIE & TDEV masks)
- Difficult to support phase and time (CDMA2000, WCDMA-TDD, TD-SCDMA, Mobile WiMAX) unless the MEN is small and the performance of the client oscillator is high
- Does not require a change to existing switches & routers in the MEN

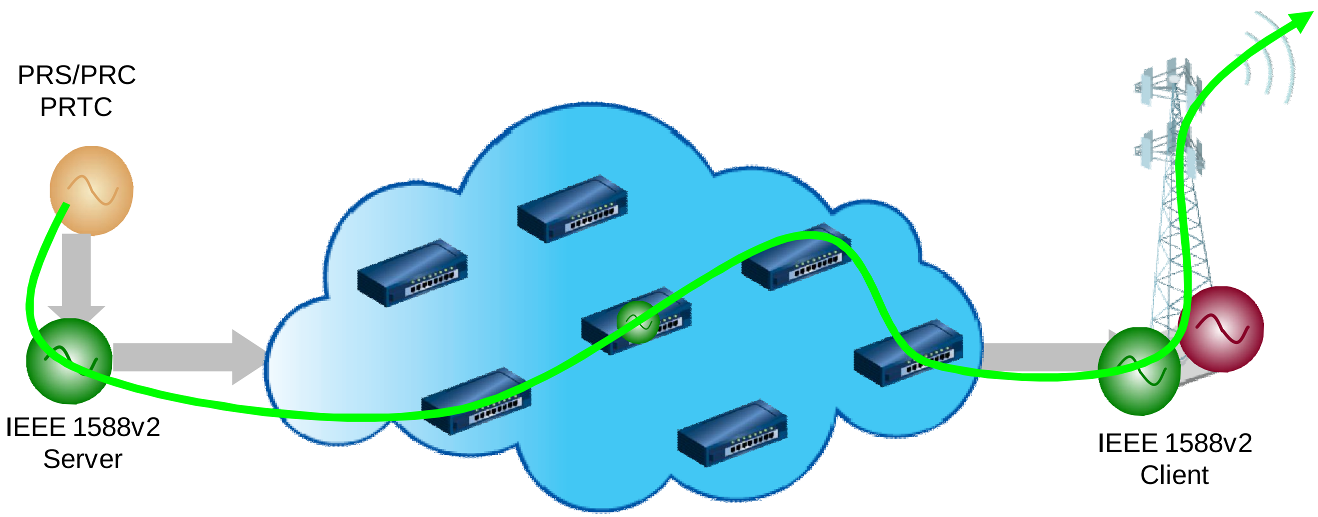


Challenges for Time of Day Alignment

1. Wander of the recovered clock
   - Network Packet Delay Variation: size and loading of a given network
   - Client oscillator stability: cost performance trade off
2. Link delay asymmetry
   - Path Asymmetry: forward and reverse path are different
   - Load Asymmetry: forward and reverse path asymmetry
     - Will vary with network conditions

Upgrade some MEN Nodes with IEEE 1588v2 Boundary Clock

- Enabling intermediate nodes with IEEE 1588v2 Boundary Clocks reduces the size of the MEN and increases the performance of IEEE 1588v2

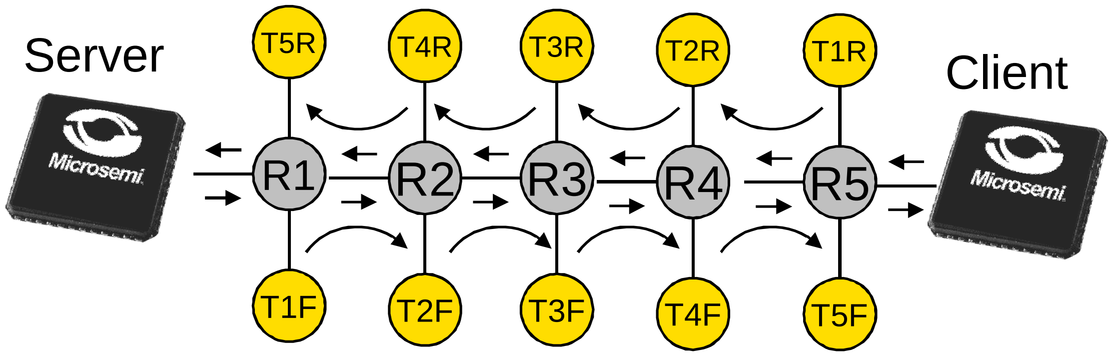


Test results IEEE 1588 V2 only

Test Results

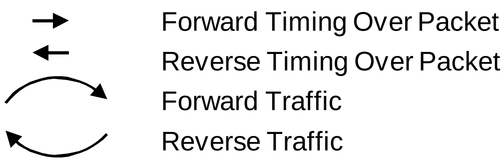
- The following are Time of Day plots for various traffic Test Cases for a 5 node network
  - All nodes are GbE Routers
  - Link Delay asymmetry will be small
- Numerous G.8261 Test Cases have been used
- Many will cause traffic asymmetry
- TDD technologies require less than +/-1us

Network Setup



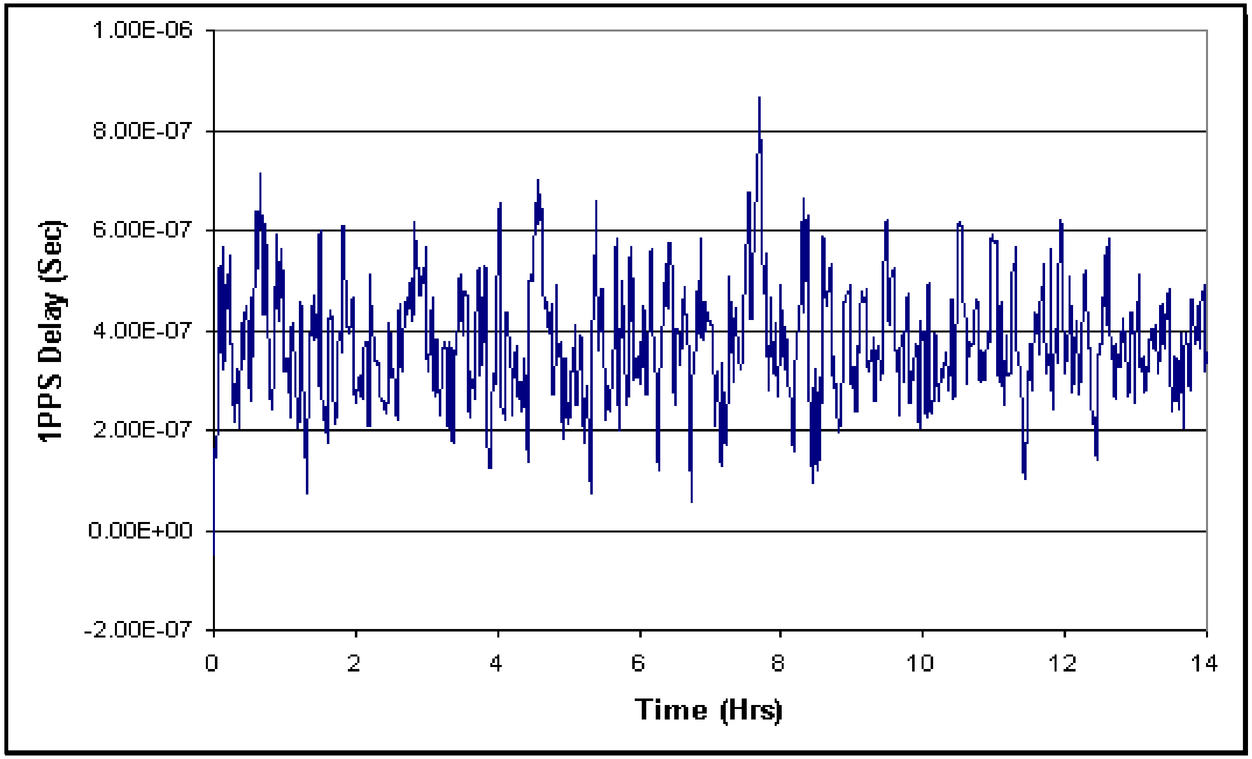
Notes:

1. R - GE (1 Gbps) Gigabit Routers
2. T - Traffic Generator (R is reverse path, F is forward path)
3. ToP protocol is IPV4 UDP Port 319
4. Traffic Generators are GE (1 Gbps); IXIA 1600 or similar



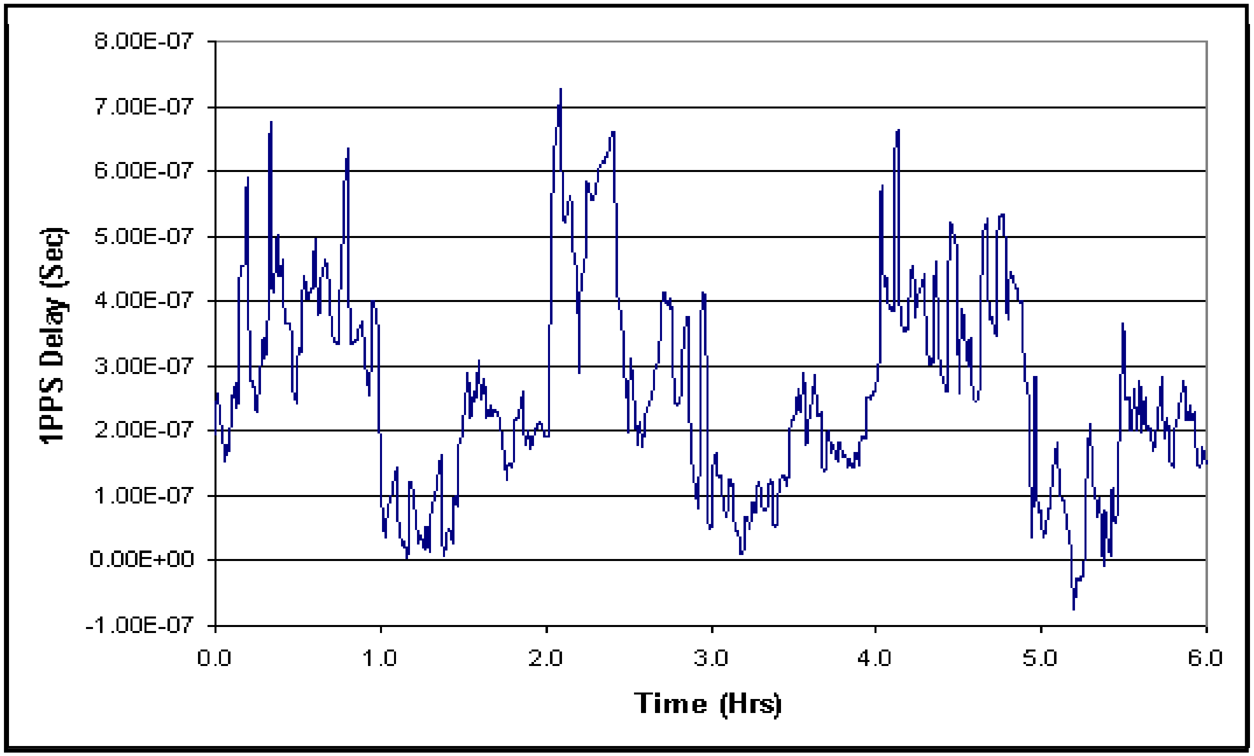
G.8261 TC12 Constant Traffic

- 1pps Delay 870ns/-50ns



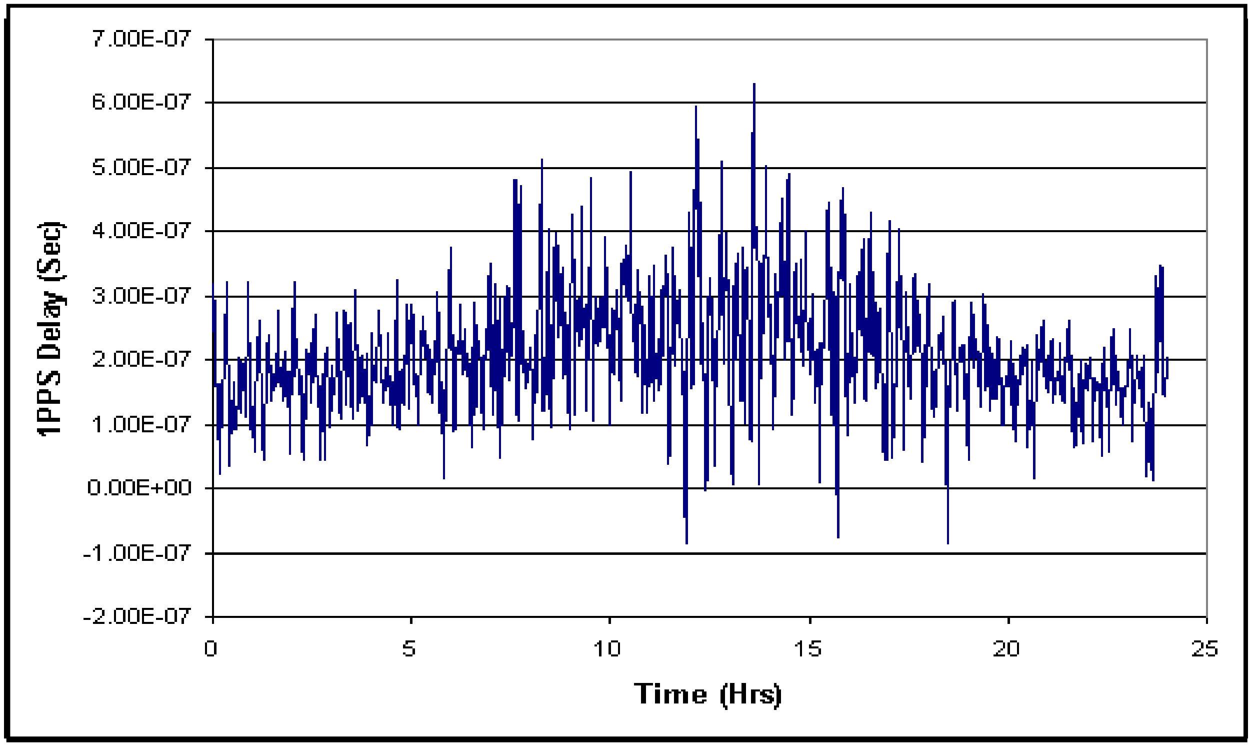
G.8261 TC13 Square

- 1pps Delay 730 ns/-75ns



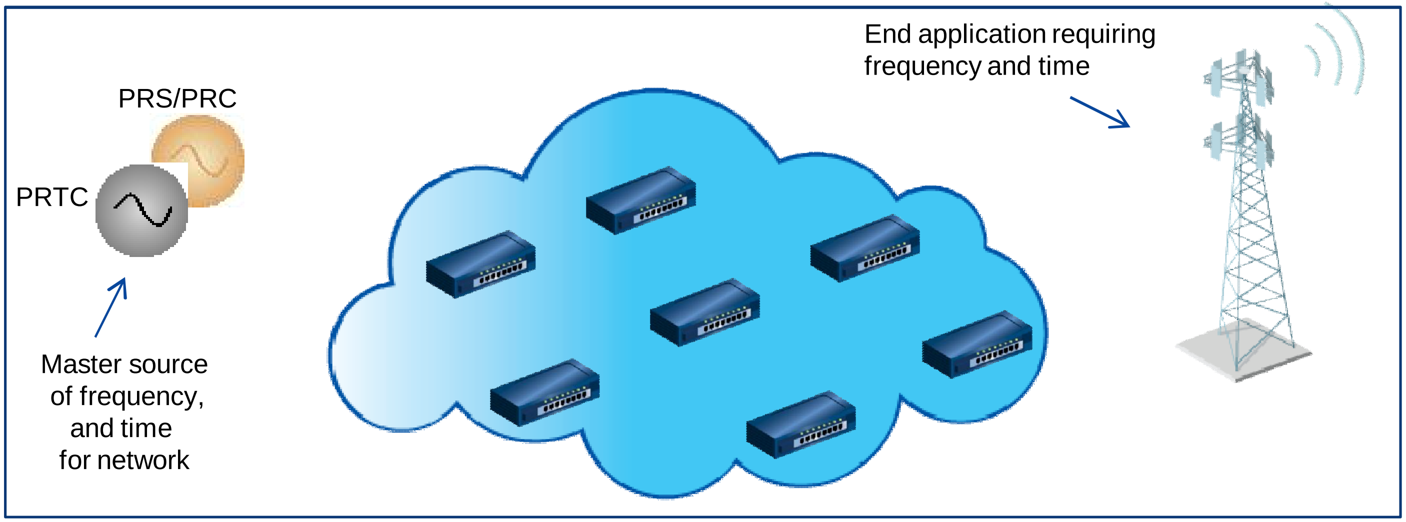
G.8261 TC14 Ramp

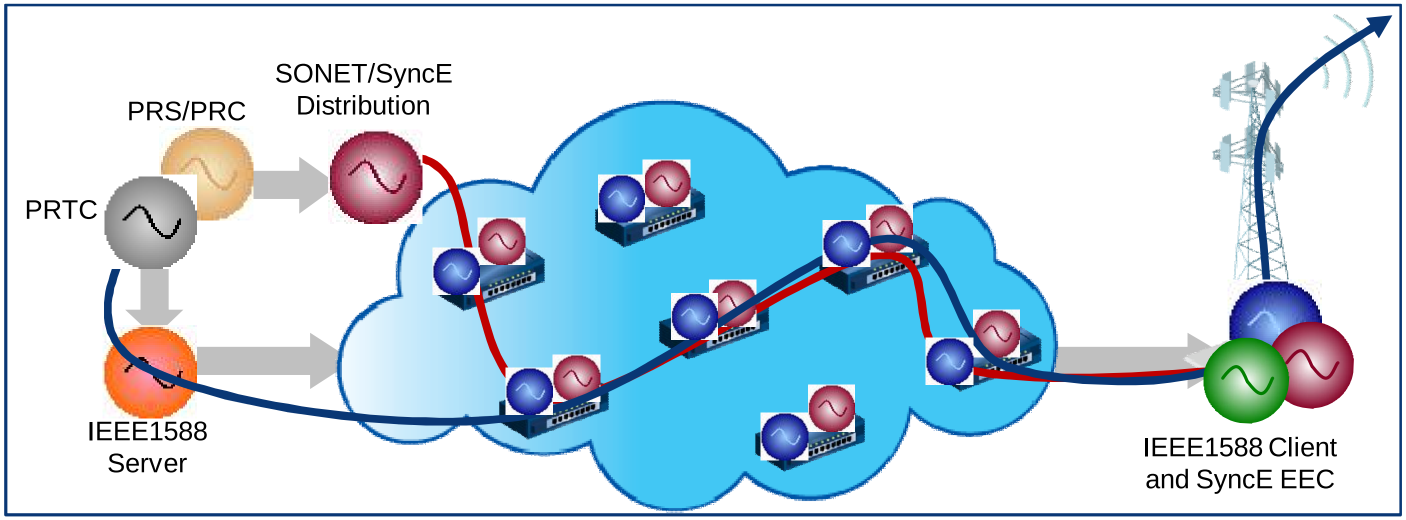
- 1pps Delay 630ns/-90ns



Option 3:
Convergence of SyncE & IEEE 1588

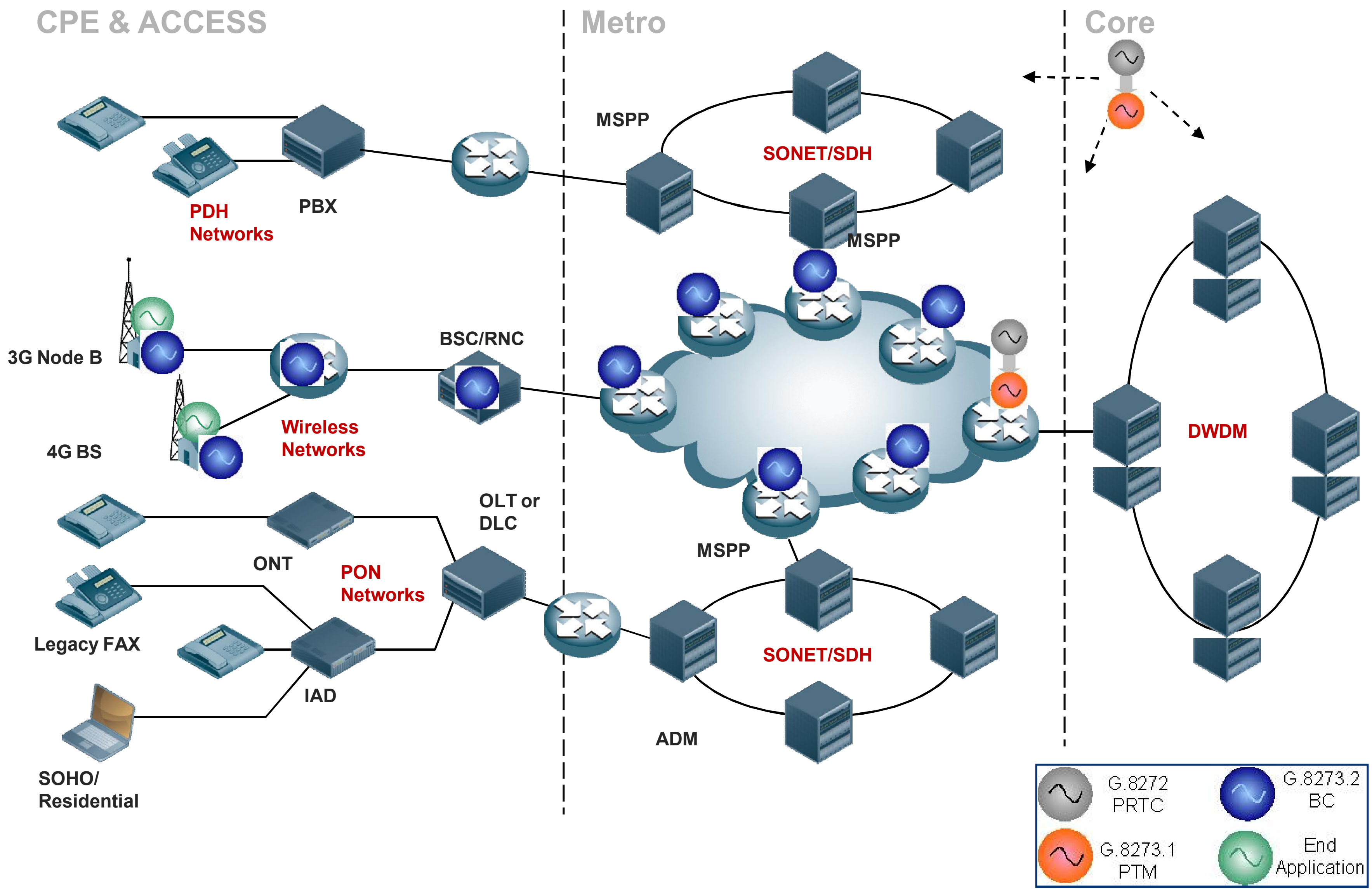
Combine Physical Layer & Protocol Layer Synchronization into a Single View





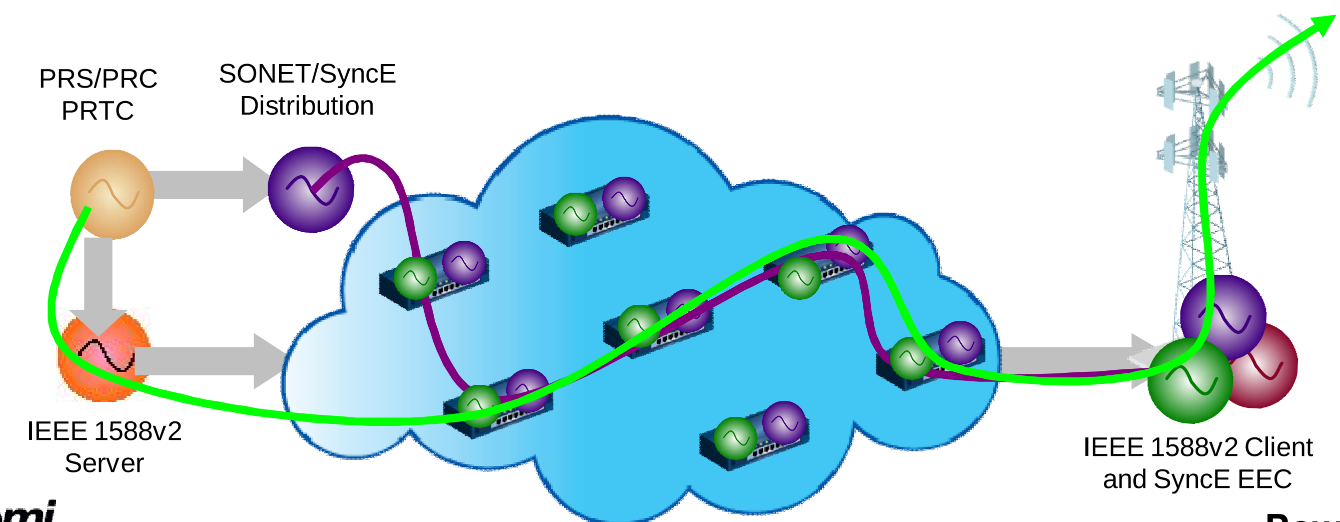
	G.811 PRC		G.8262 Option 2
	G.8272 PRTC		G.8273.2 BC
	G.8273.1 PTM		End Application

Generic Packet Switched Network - Deployment of Boundary Clock



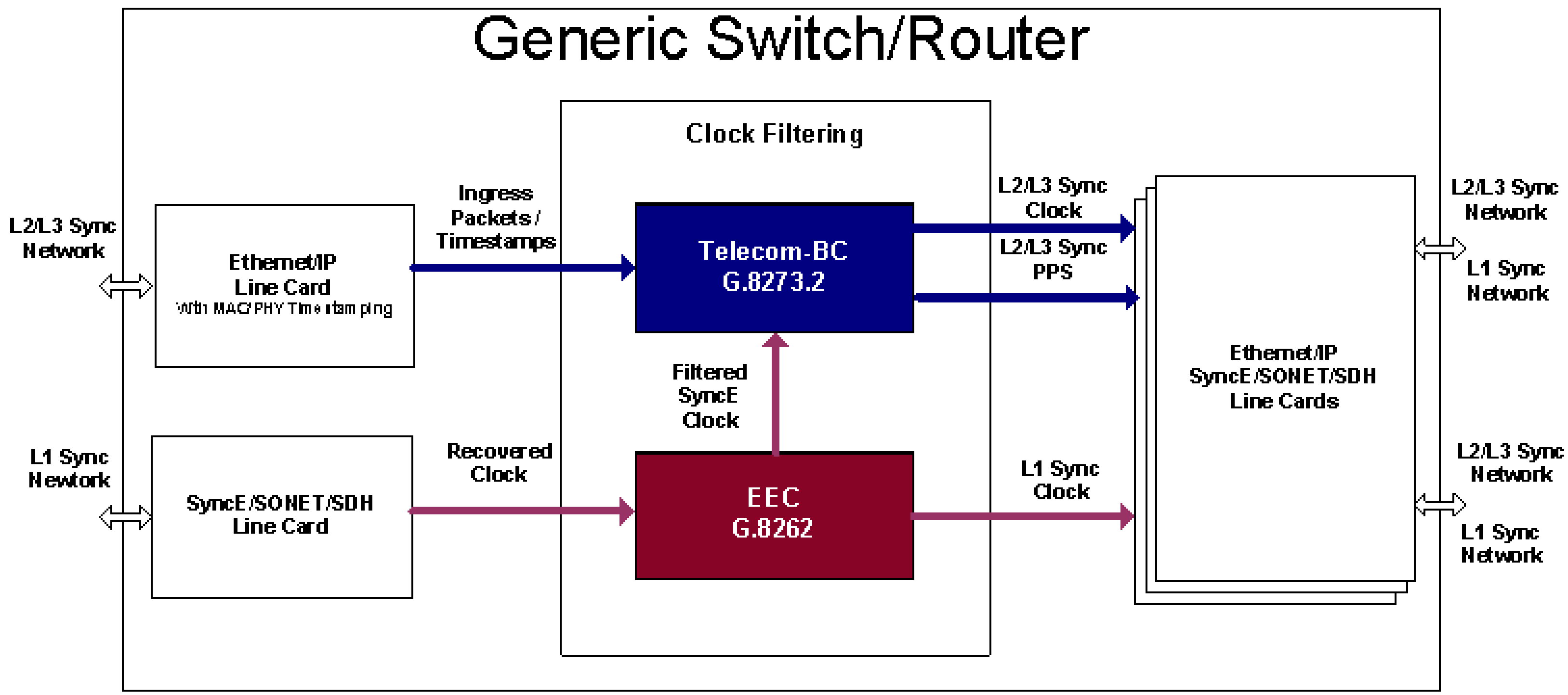
Convergence of IEEE 1588 and SyncE

- MEN with SyncE-enabled and 1588-aware switches/routers
  - Å The technologies work together, as SyncE provides syntonization for IEEE 1588v2
  - Å All nodes in the MEN support IEEE 1588 protocol phase & time synchronization implementing Boundary Clock
  - Å All nodes in the MEN support SyncE/SONET Layer 1 frequency synchronization
  - Å Supports high performance synchronization - Frequency accuracy, phase and time alignment
  - Å ITU-T working on specifications where every node is 1588-aware for time synchronization
    - ï Likely every node will also have SyncE/SONET synchronization/syntonization
    - ï Likely will be IEEE 1588v2 Boundary Clock
  - Å Note there is only one time domain and time does not drift between operators
    - ï e.g. everyone is using GPS today



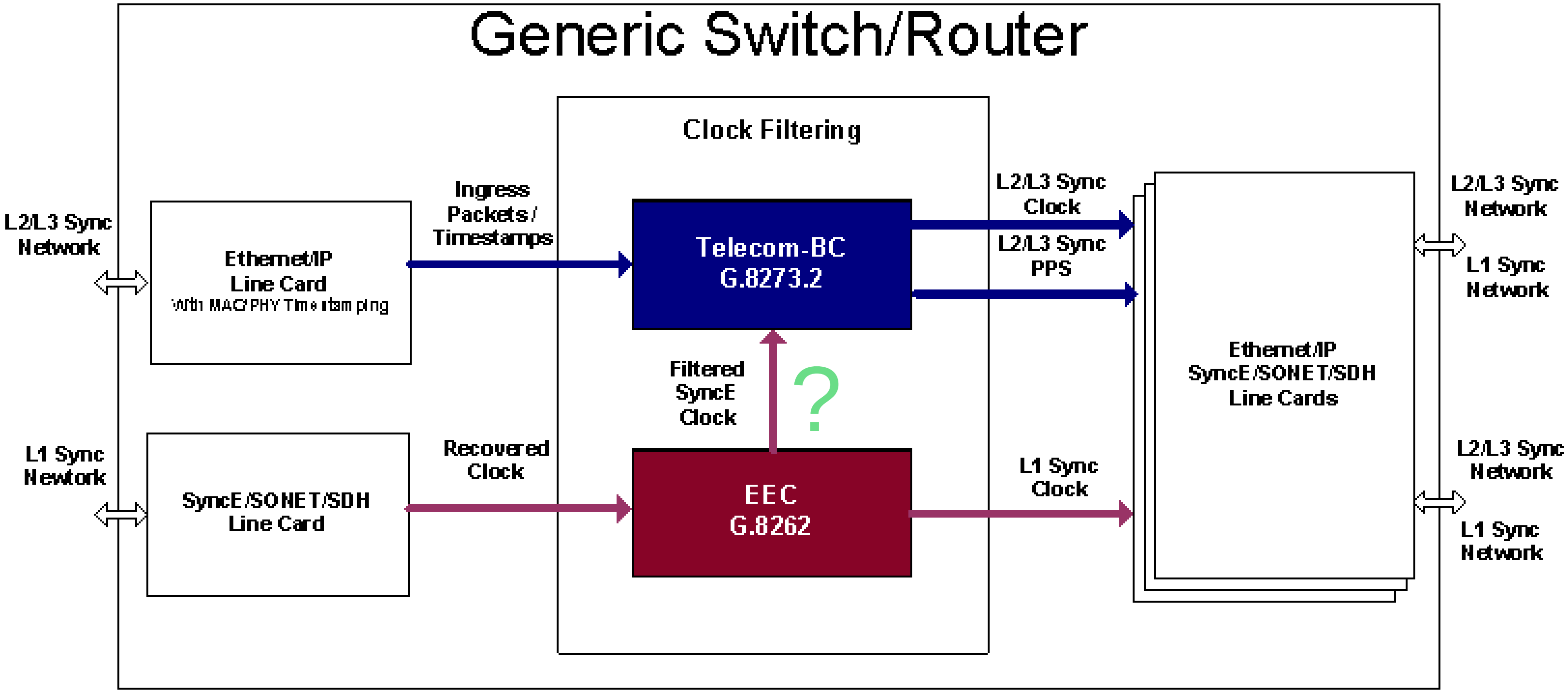
Zoom Inside a Generic Switch/Router with Multiple Line Cards & Timing Cards

- Physical layer synchronization path implements G.8262 EEC functionality
  - Option 1 Europe/China/India, Option 2 USA/Japan
  - Unaffected by protocol layer synchronization path ï the IEEE 1588 BC does not impact the SyncE/SDH reference chain
  - This path exists today in the SyncE, SONET/SDH, PDH reference chain
- Protocol layer synchronization path implements G.8273.2 Telecom Boundary Clock
  - Uses the filtered physical layer synchronization clock from the EEC



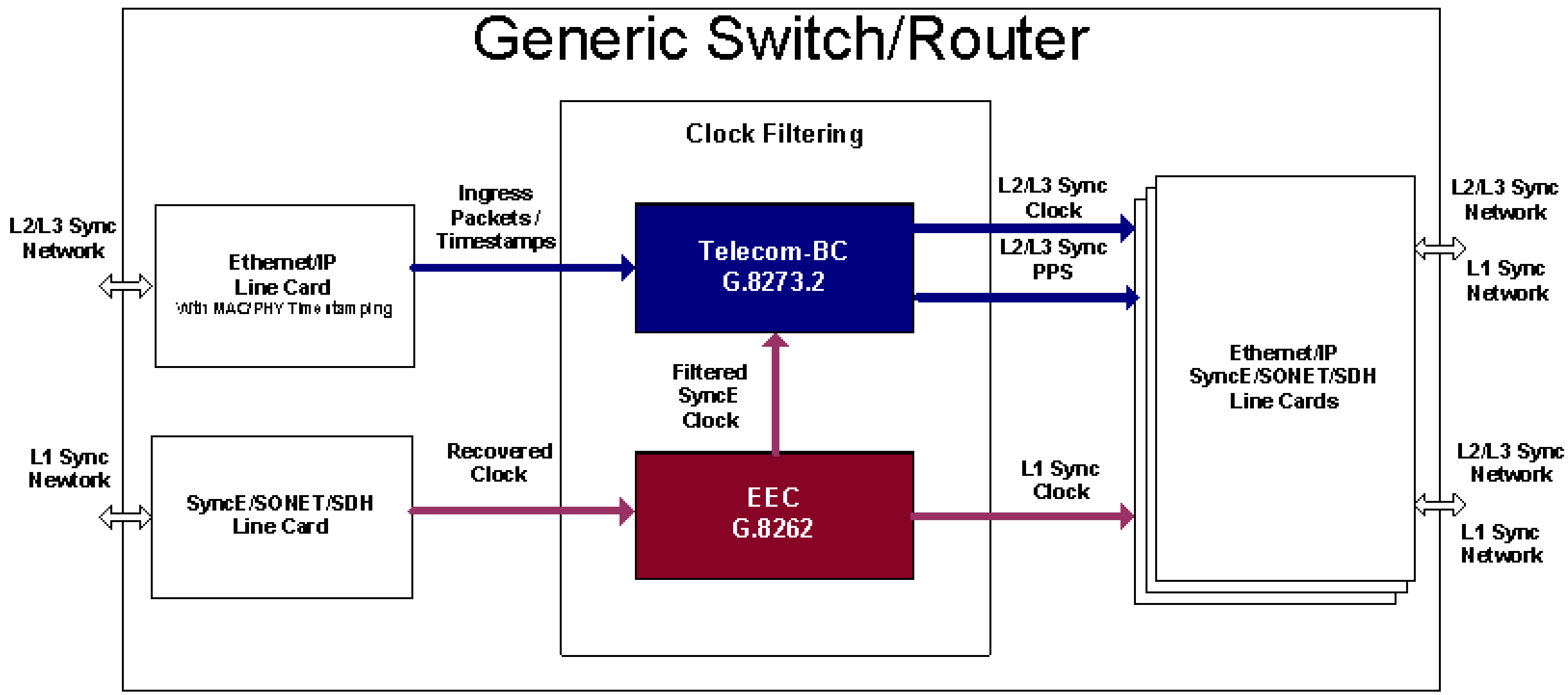
What's that line between the EEC and T-BC?

- Telecom Boundary clock uses the SyncE clock from the EEC for syntonization
- If a highly reliable physical layer clock (SyncE, SONET/SDH, PDH) is not present, then the Telecom-BC can operate without physical layer syntonization



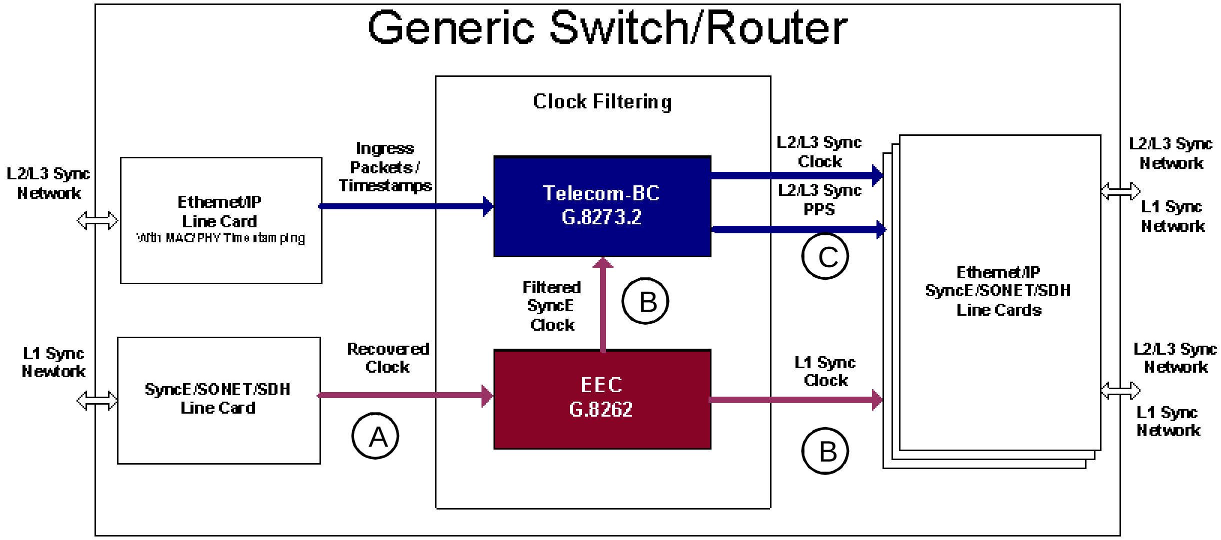
Telecom Boundary Clock using SyncE

- The SyncE clock is traceable to 10^-11 accuracy (0.01 ppb) or better, whereas IEEE 1588 is normally traceable to a GNSS (e.g. GPS)
- The SyncE clock stability far exceeds a replacement oscillator for this type of application
  - Generic TCXO for 100 mHz bandwidth (e.g. Stratum 3) specs about ~ 320 ppb/day movement



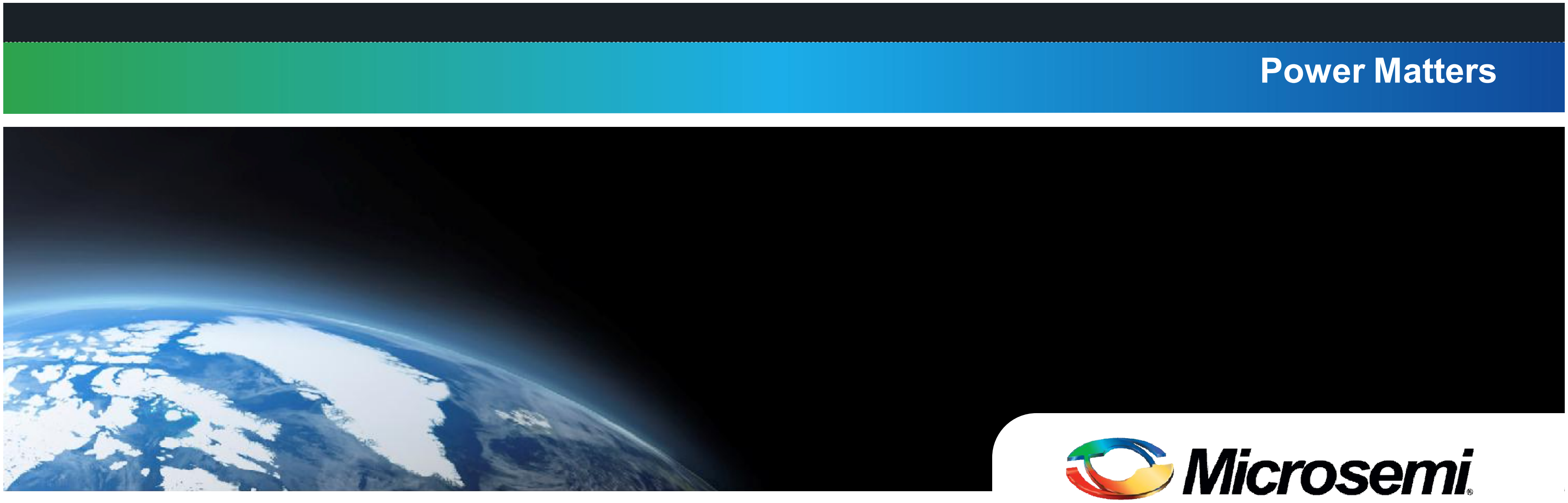
Telecom Boundary Clock using SyncE

- Disturbances on the physical layer clock may be handled with two-stage approach
  - These may be the result of an upstream reference switch
  - Modern PLL reference switching is 'hitless', meaning no noticeable impact on TIE
- The input disturbance that must be tolerated (but is not necessarily present) by the EEC is at point A
- The EEC minimizes the impact of this disturbance according to specific criteria in G.813/G.8262, based on bandwidth, gain peaking and phase slope limiting. The output after such handling is seen at point B
- The Telecom-BC then acts as a second stage transient suppressant. The output clock at point C is produced by combining the phase information from IEEE 1588 with the frequency traceability from SyncE.



Conclusion

- Migration to Packet Switched transport for Basestations is accelerating
- Synchronization is key to allowing this migration
- 3G & 4G technologies are increasingly requiring Time of Day Synchronization
- IEEE 1588 offers both Phase and Frequency synchronization
  - But SyncE offers better performance Frequency synchronization
- Combined 1588 and SyncE can offer better performance than 1588 alone
- Further improvement can be achieved with the use Telecom Boundary Clock which mitigates network PDV



Thank You