Cable RPHY deployments – Timing Requirements & Experience

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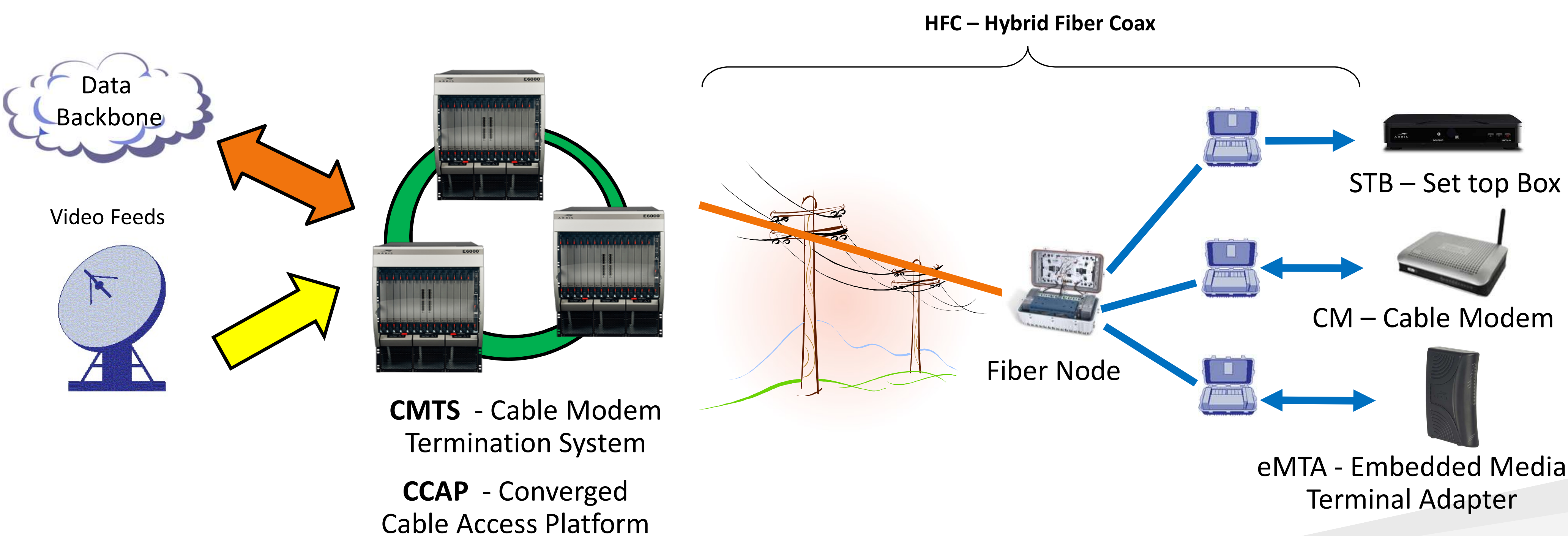
Outline

- Cable Network and Timing
- Distributed Architecture and Timing Requirements
- Deployment Scenarios
- Field Data and Conclusions

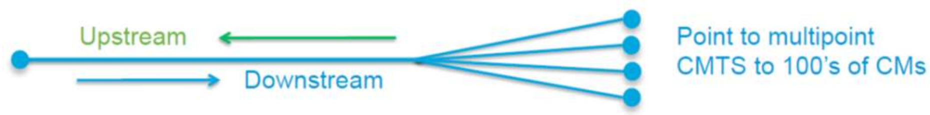
Cable Network Topology

- The HFC network provides the communications link between the CMTS/CCAP and the stations, STBs, CMs and eMTAs.
- HFC plant consists of up to ~160 km of optical fiber, few hundred meters of coaxial cable, RF distributions and Amplifiers.

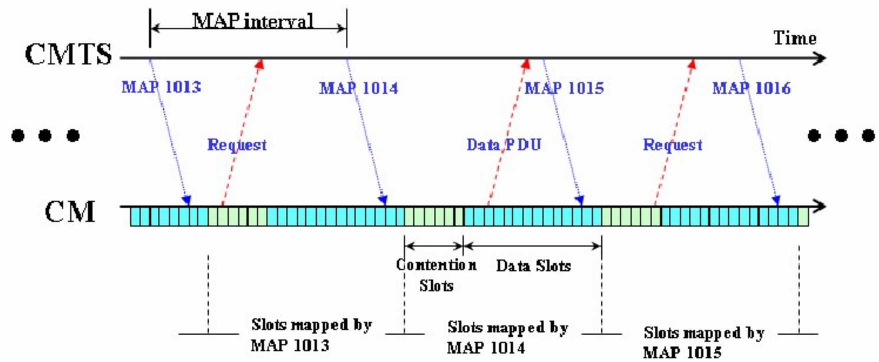


DOCSIS Timing

- DOCSIS transport is Synchronous in nature and uses a common clock derived by the CMTS



- DOCSIS upstream is TDMA in nature. Each CM is given transmit opportunities.
- The CMTS delivers MAC management messages on the downstream to sync the CMs with its time and communicate transmit opportunities



- The CM derives its frequency from the RF QAM symbol clock and “time reference” from the DOCSIS timestamps

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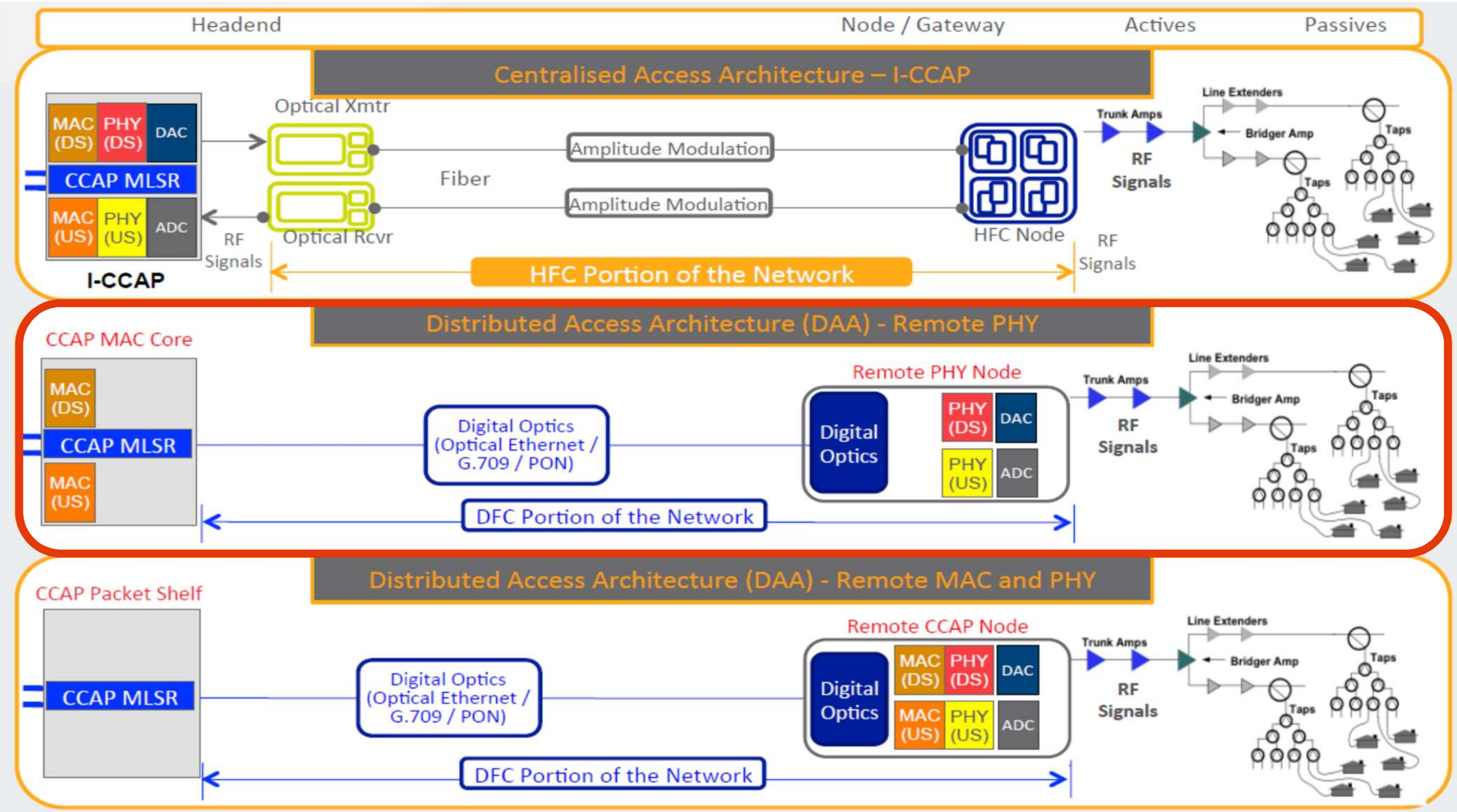
Distributed Access Architectures



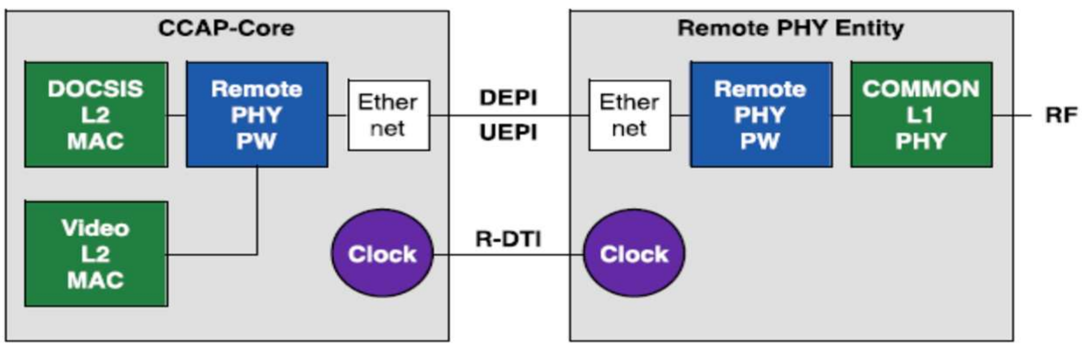
Slide 6

LT11 I downsized it a bit because it looked "streched"

Laufer, Tal, 3/18/2017

Remote PHY and Timing

- Separating the MAC and the PHY into 2 boxes with 160 -2000 km distance between them requires timing synchronization between the MAC and the PHY
- The CCAP Core maintains the MAC functionality and is responsible of the transmit opportunities allocation
- The R-PHY is responsible for providing the timestamps to the CM
- **The Core and R-PHY must be synced in phase**
- CableLabs Remote DTI spec (R-DTI) specifies the timing requirements for R-PHY architecture:



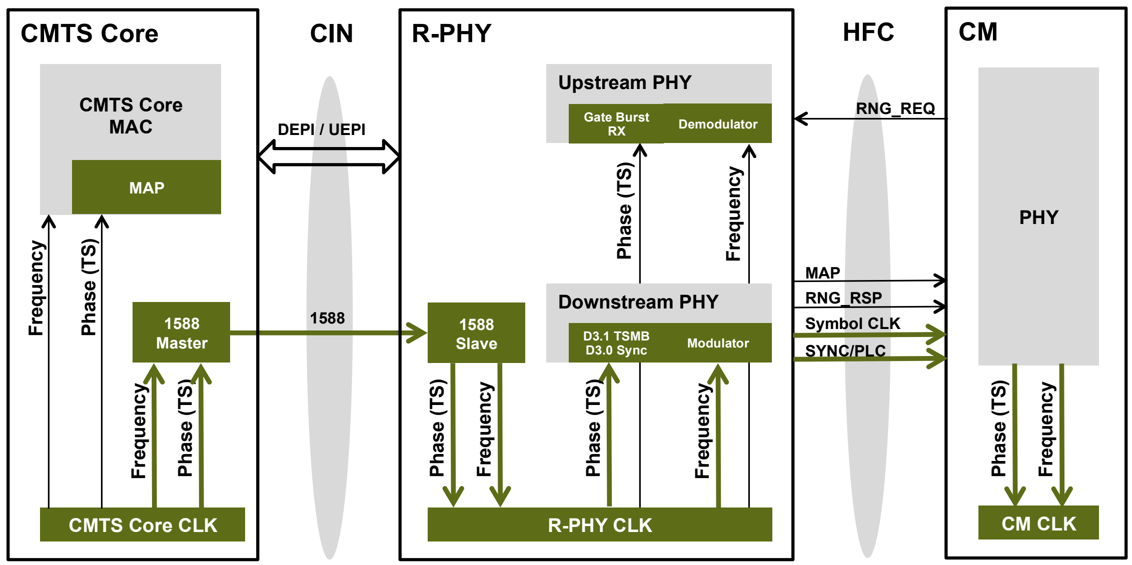
R-PHY Timing Requirements and Challenges

- The Precision Time Protocol (PTP) was chosen for Core and R-PHY synchronization
- G.8275.2 PTP profile selected
- SyncE is optional
- Frequency accuracy of 0.5 - 5 ppm500 (depends on specific use cases and applications)
- Time Error <= (0.5ms) depends on timing topology
- Fast convergence from boot-up till phase lock (1-2 minutes)
- Large PDV on network (up to the ms level)
- 1588 unaware or partially aware networks
- Frequency drift (slew rate when CM are locked) is <= 10 ppb/sec
- No phase steps are allowed when CMs are locked
- Scale (each Core could have hundreds of Remote PHY devices that should be synced)

Remote PHY Deployment Scenarios – Node Slave

- Will probably be the most common scenario.
  Two main use cases:

  A. CMTS Core is the Grand Master (GM) and the Remote Phy Device (RPD) is the Slave:

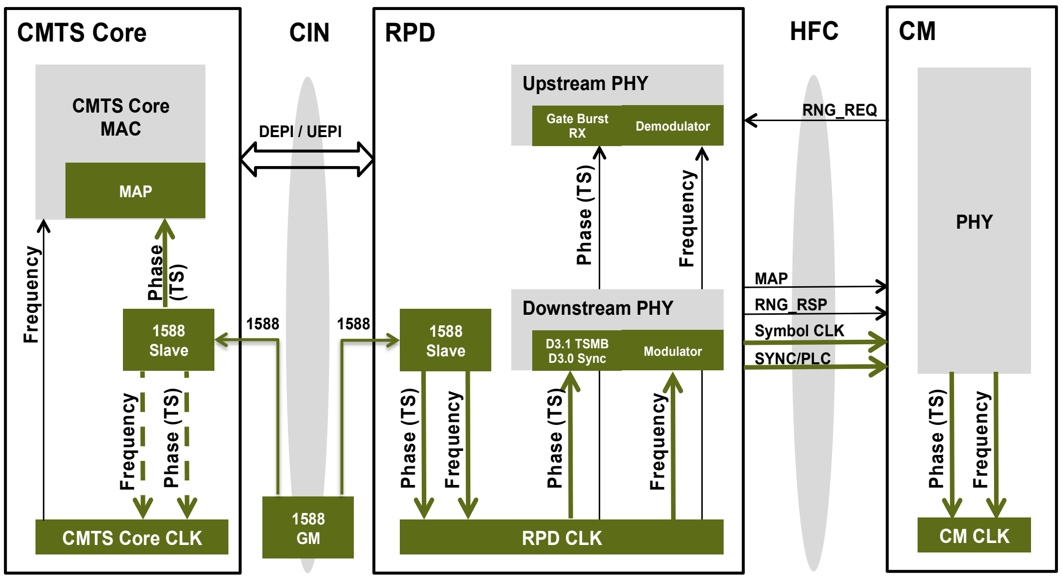


– Main Advantage:
  - No need for an external Grand Master

– Main Disadvantage:
  - The CMTS Core will need to distribute timing information via PTP to hundreds or thousands of RPDs

Remote PHY Deployment Scenarios – Node Slave

B. CMTS Core and the RPD are Slaves to an external Grand Master:



– <u>Main Advantages:</u>
- CMTS Core is only a slave. PTP performance requirements are on the Grand Master
- Accurate ToD

– <u>Main Disadvantage:</u>
- A need for external GM (costly, Interop required)

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Deployment characteristics and challenges

- Currently all deployments (we know have) are using unaware networks. Some routers are BC capable but that functionality is not yet used…

- where to place the GM is a key decision:
  - Closer to RPDs → less PDV, low scale, need more GMs…
  - Further up the network → more PDV, high scale, less GMs…
  - Usually between 1-5 between the GM and RPD

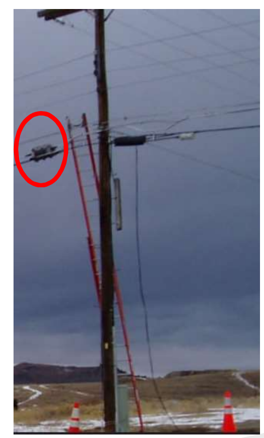
- Whether the GM needs to be connected to a GNSS? Some customers want the GM to free run… (track to UTC is not mandatory)…

- GM redundancy approach:
  - PTP module redundancy inside the GM
  - Geo redundancy of GMs

Deployment characteristics and challenges

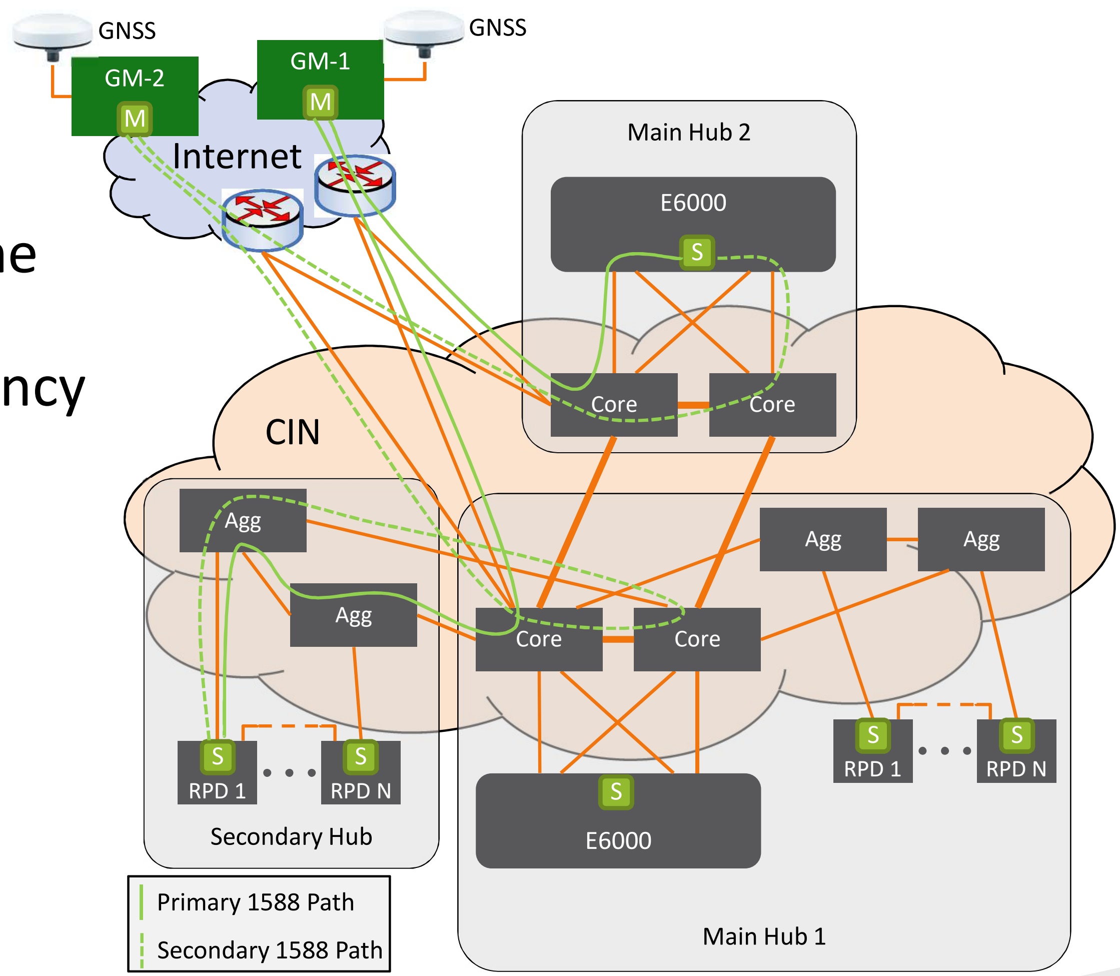
- Holdover performance:
  - Some RPDs only support a connection to a single GM
  - Usually low quality/cost oscillators.
  - How long would RPDs hold accurate phase under temperature changes?

- How to monitor RPD time?
  - RPDs are usually either on poles or in cabinets not easily accessible
  - Many won't have 1 pps port.
  - Many will have only 1 Eth interface (no mirroring capability)



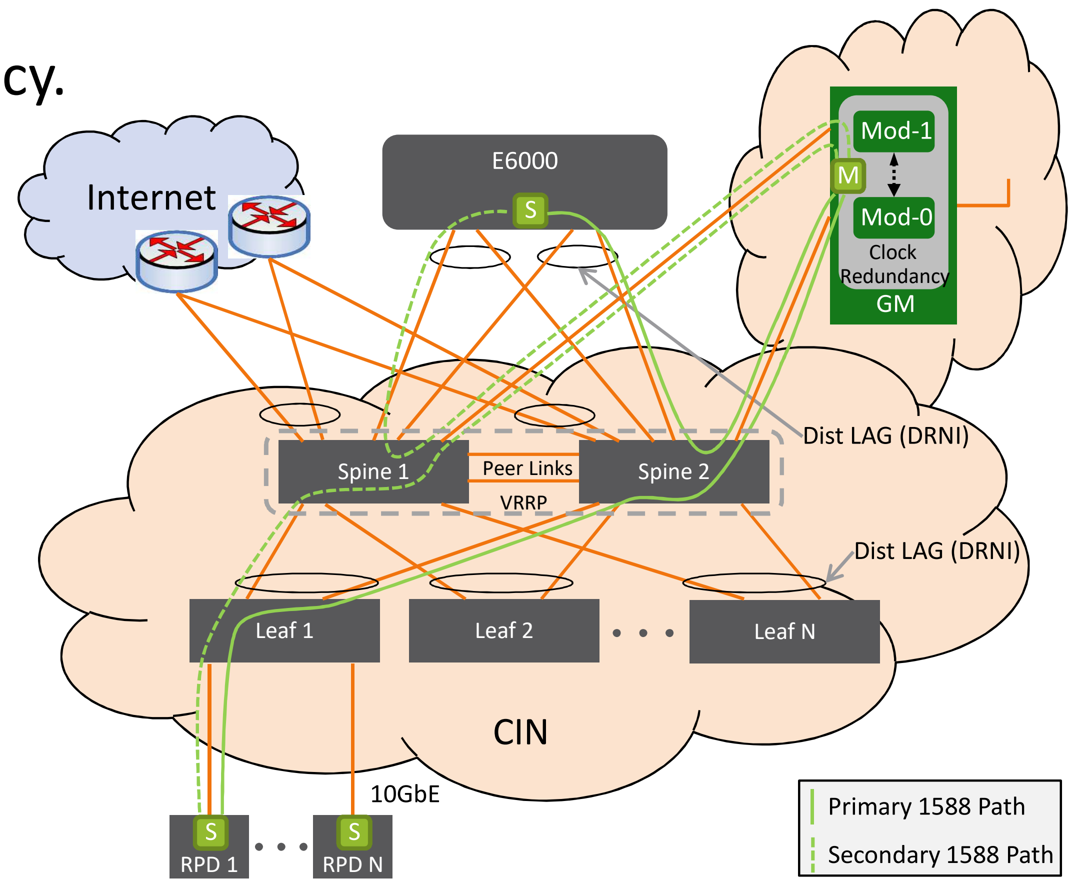
Deployment scenario - A

- GMs are located high in the network
- Multiple GMs for redundancy



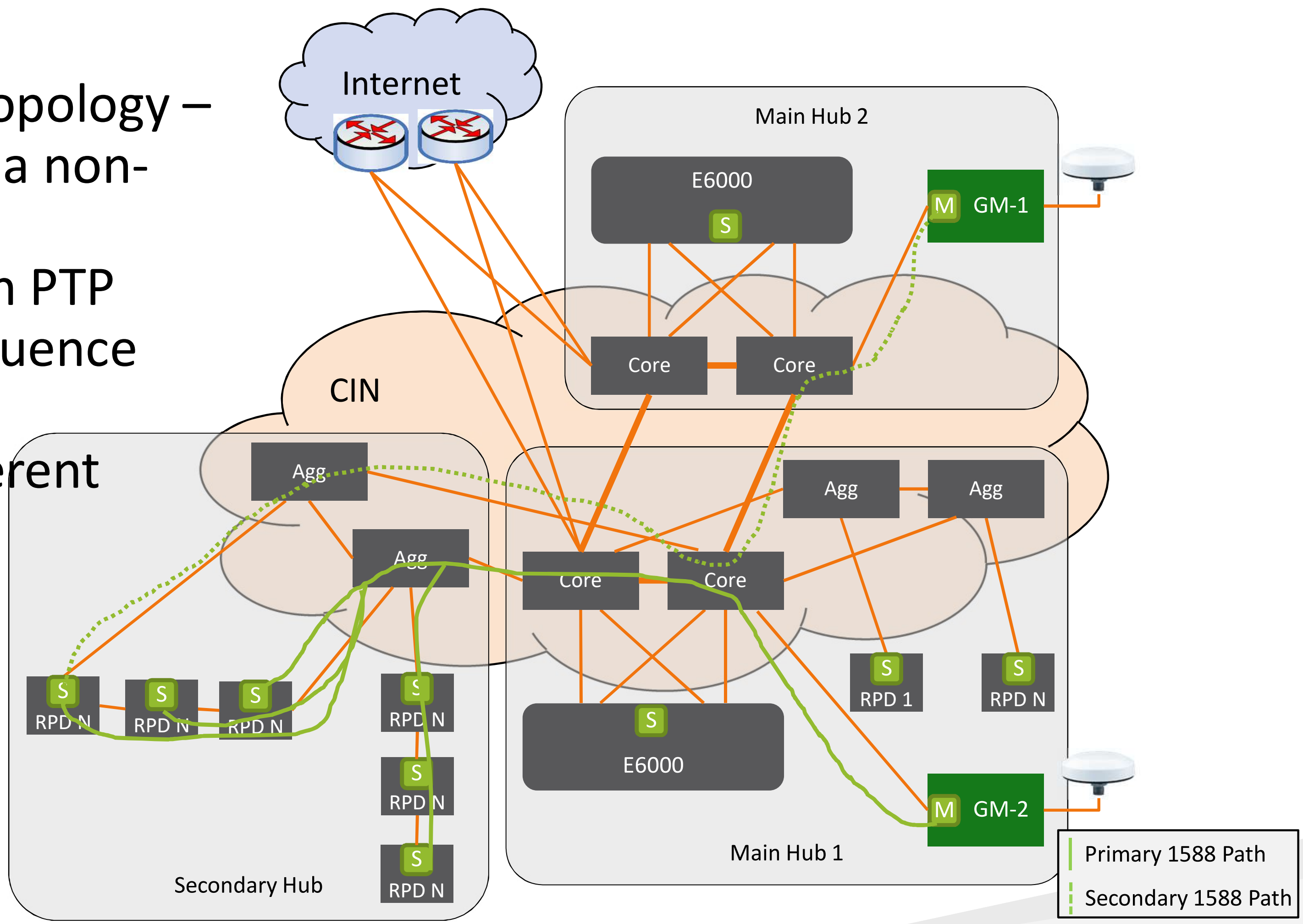
Deployment scenario - B

- GMs have internal redundancy.
- GMs are located in Hubs relatively close to the RPDs



Deployment scenario - C

- RPD Ring/Daisy Chain topology – each RPD is a slave and a non-participant clock…
- DHCP is used for QoS on PTP
- Change in path may influence the BMCA
- GMs are located in different Hubs for redundancy



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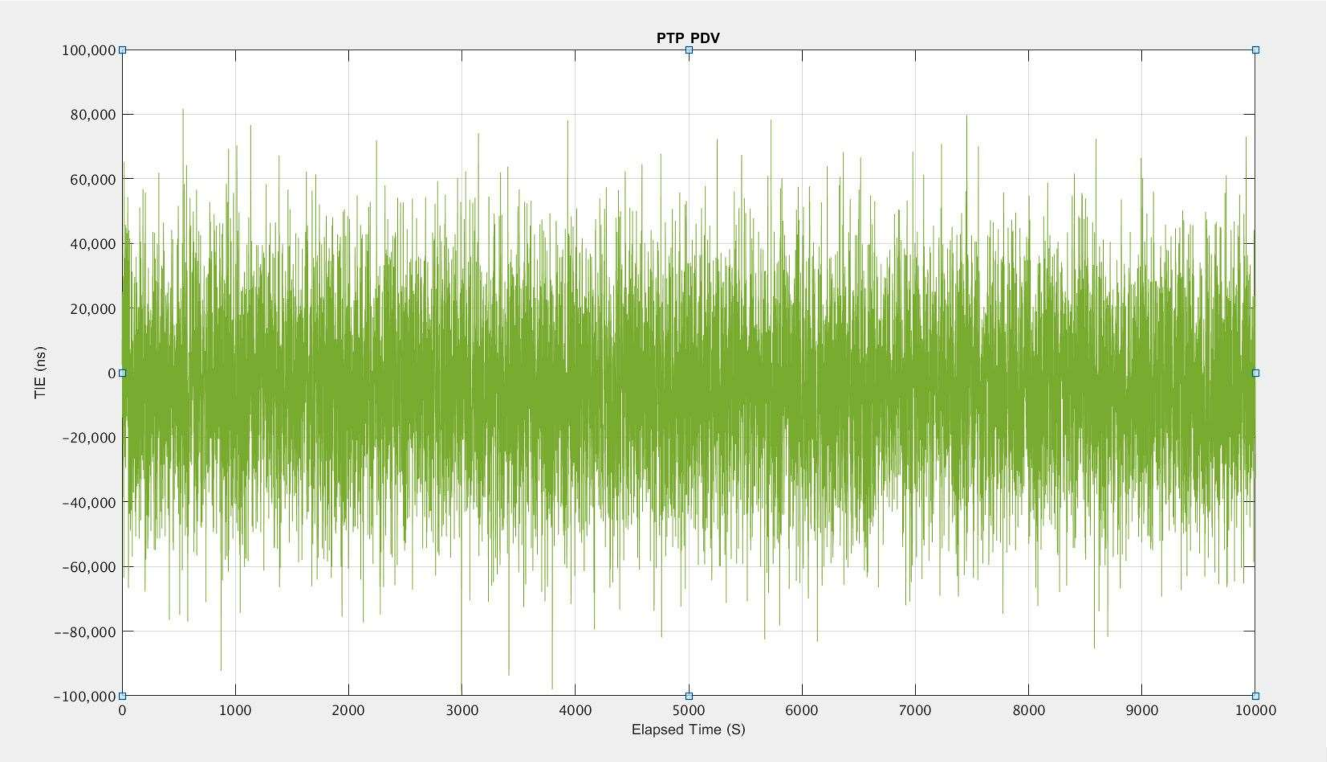
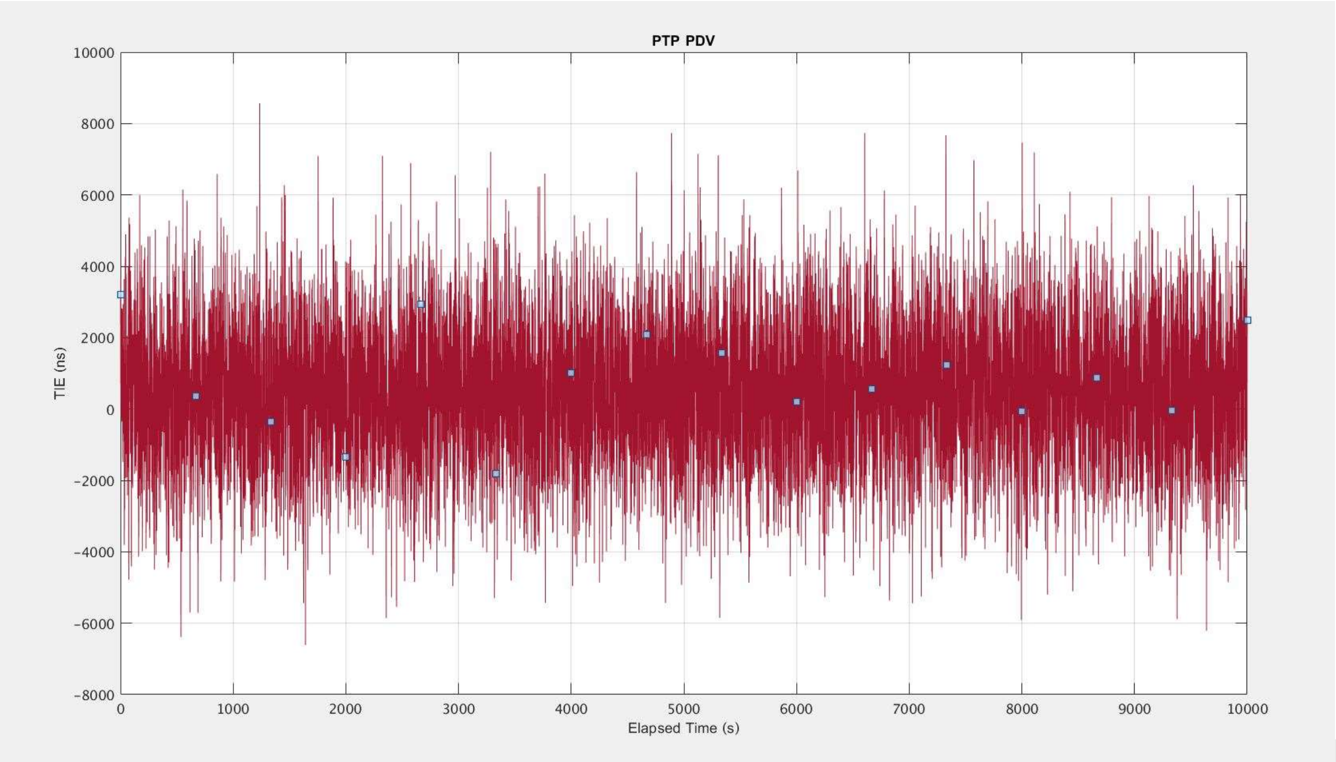
Deployment PDV stats

- GM located ~7 hops from RPD.
- Unaware network
- PDV ~ 150 microsec Peak to Peak.



Deployment PDV stats - Cont

- GM located ~1-2 hops from RPD.
- Unaware network
- PDV ~ 12 microsec Peak to Peak.



Conclusion

- RPHY Timing performance is usually easy to achieve.
- In most cases no need for BC support in the network unless there is a need for load balancing the amount of Slave in a GM centralized approach.
- From field data → PDV is << 1 ms even with many unaware hops.
- SyncE is not required. RPD could usually keep phase and frequency for few hours.
- Phase accuracy is << 100 microsec in Steady State. No need to compensate for line rate asymmetries.
- Remote monitoring of RPDs clock is a challenge..