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Phase Delivery in Brownfield World

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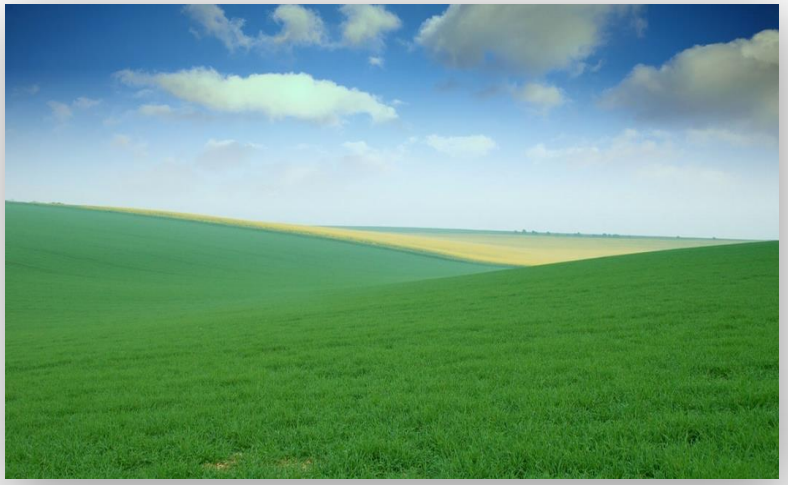
Basics: Brown Vs. Green Field Deployments

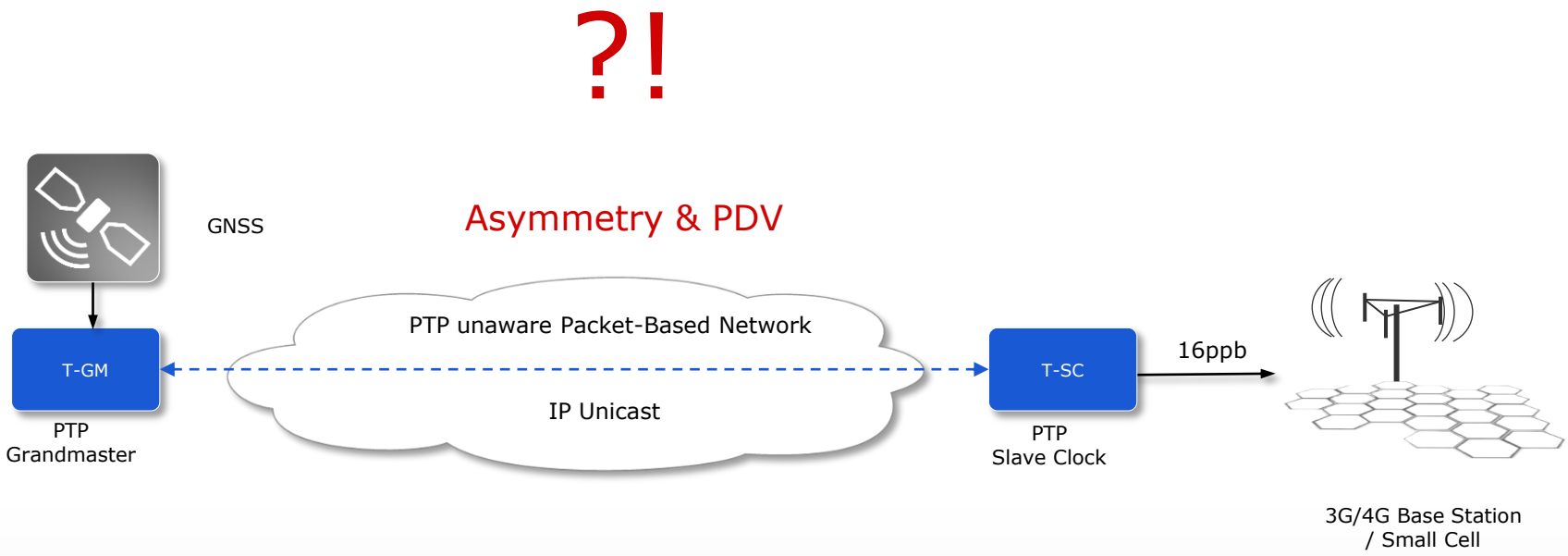
- Green field lacks the constraints imposed by prior work



- However in telecom, brownfield deployments are very common and operators all over the world are facing challenges designing the existing networks for accurate phase delivery

Frequency Synchronization G.8265.1 Centralized Architecture

- End-to-End – IP Unicast



Frequency delivery using centralized End-to-End architecture –
Can we use this architecture for phase delivery?

Why Is Asymmetry an Issue?

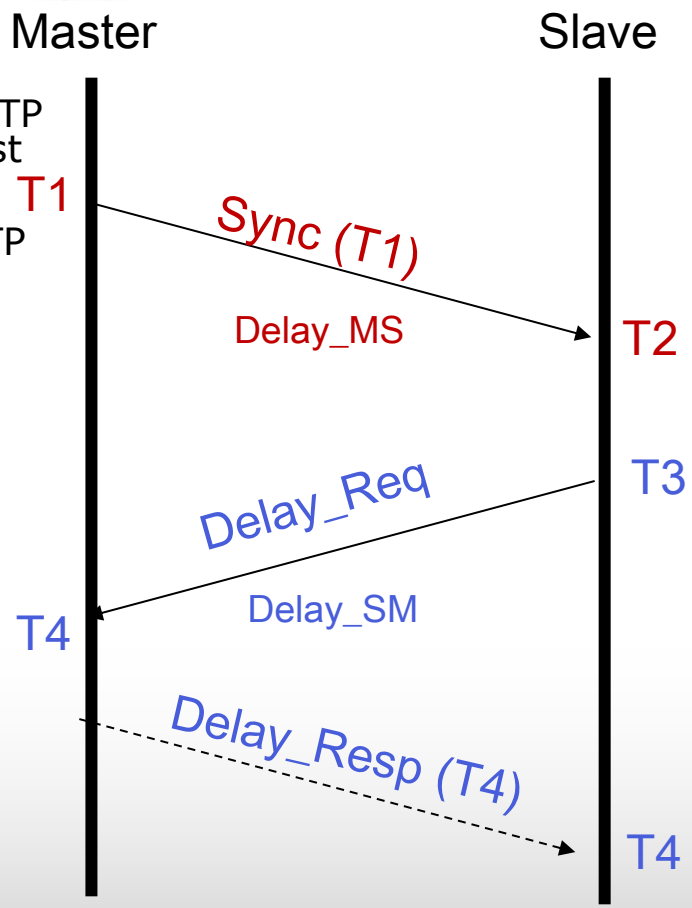
T1 – departure timestamp according to master PTP clock of first message called "sync message".

T2 – arrival timestamp according to slave PTP clock of sync message.

T3 – departure timestamp according to slave PTP clock of second message called "delay request message".

T4 – arrival timestamp according to master PTP clock of delay request message.

Offset from Master



$T2 = T1 + Delay\_MS + Offset$

$T4 = T3 + Delay\_SM - Offset$

Symmetry: $Delay\_MS = Delay\_SM = Delay$

$Offset = ((T2-T1)-(T4-T3))/2$

Asymmetry: $Delay\_MS \neq Delay\_SM$:

$Offset+(Delay\_MS-Delay\_SM)/2=(T2-T1)-(T4-T3))/2$

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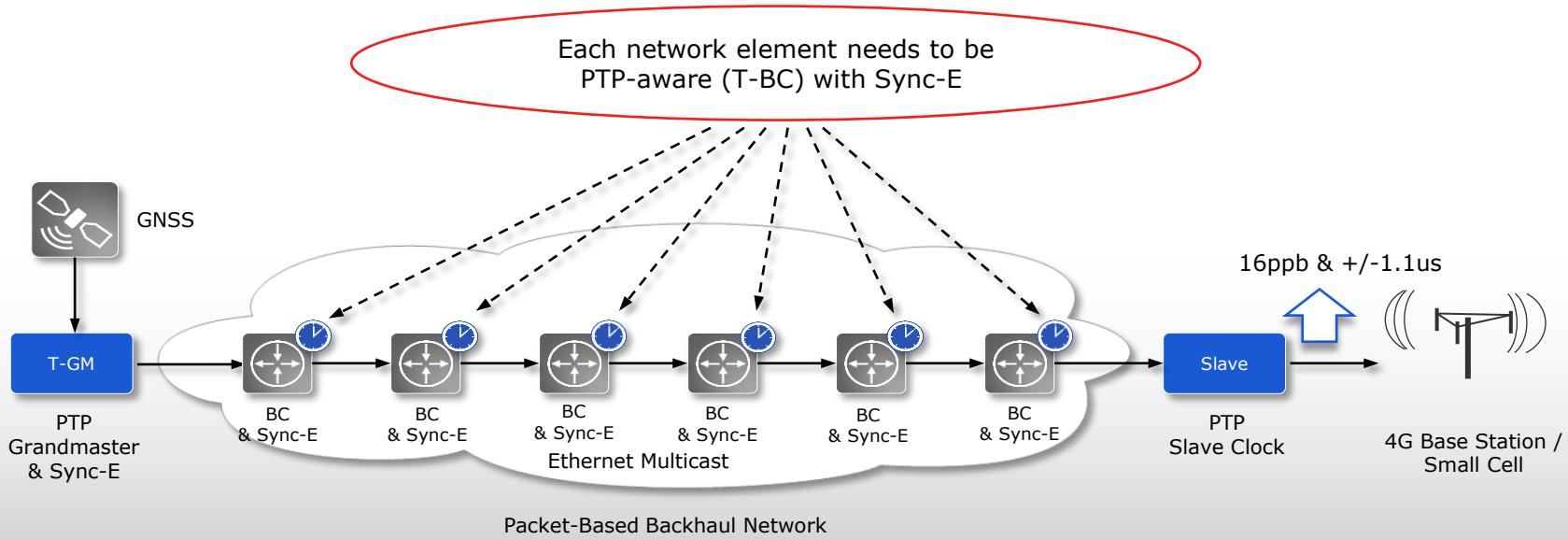
Green Field Deployments – G.8275.1

- Full on Path Support
- Solving PDV and asymmetry uncertainties using full PTP on path support
- All Boundary clocks based on G.8275.1 – PTP + Sync-E
- Point to Point , Ethernet multicast



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G.8275.1 – Full On Path Support

Advantages:

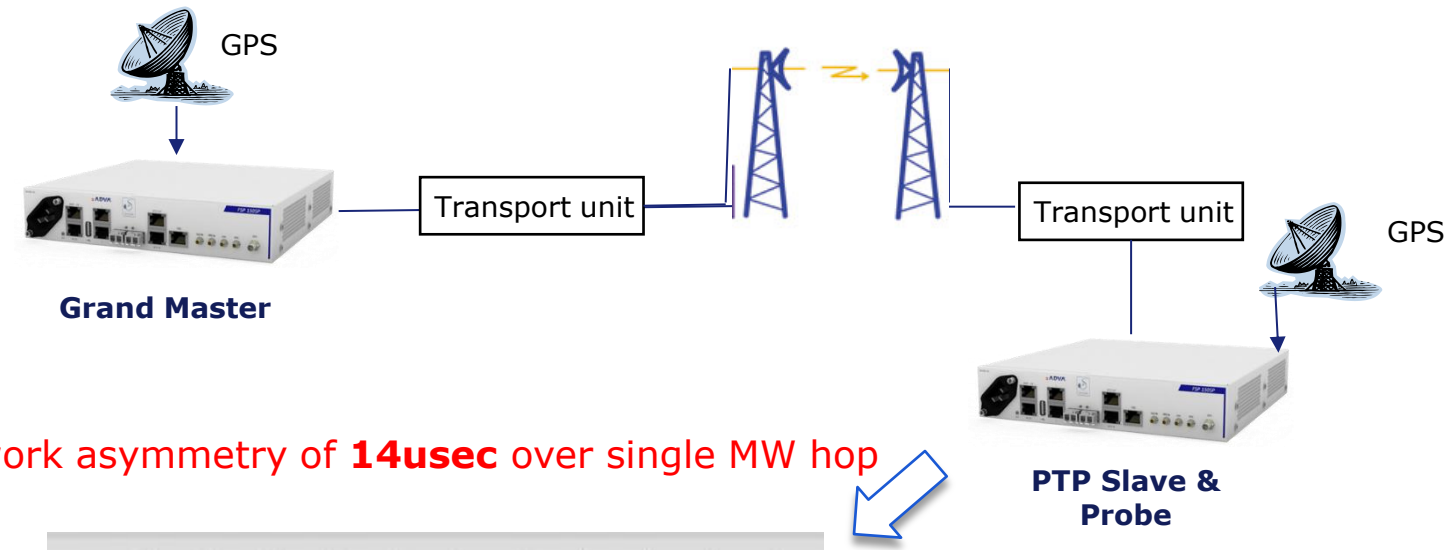
- Fully standardized
- Guaranteed performance – the PDV and asymmetry are controlled

Disadvantages:

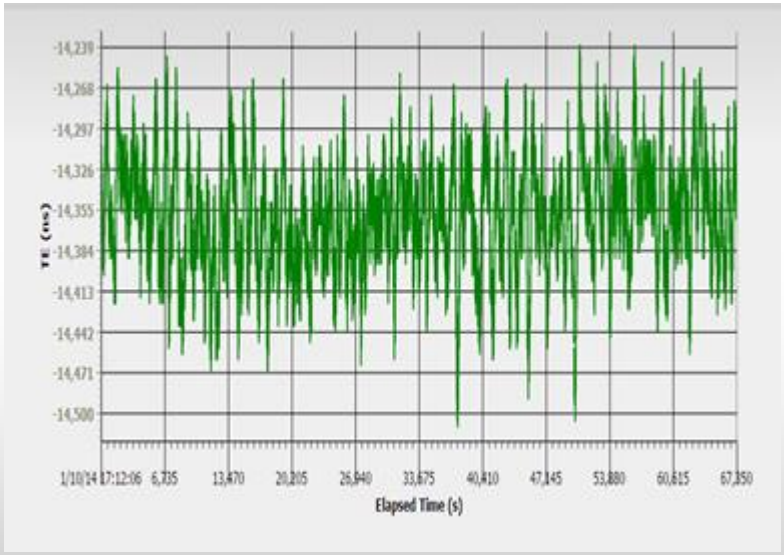
- Costly – require Sync-E and Boundary Clock in each NE
- Standardized for 1G/10G Ethernet interfaces but not for other commonly used technologies (OTN/MW/MPLS/PON)

Can’t fully solve the phase delivery challenges in brownfield world!

Example #1



Network asymmetry of **14usec** over single MW hop



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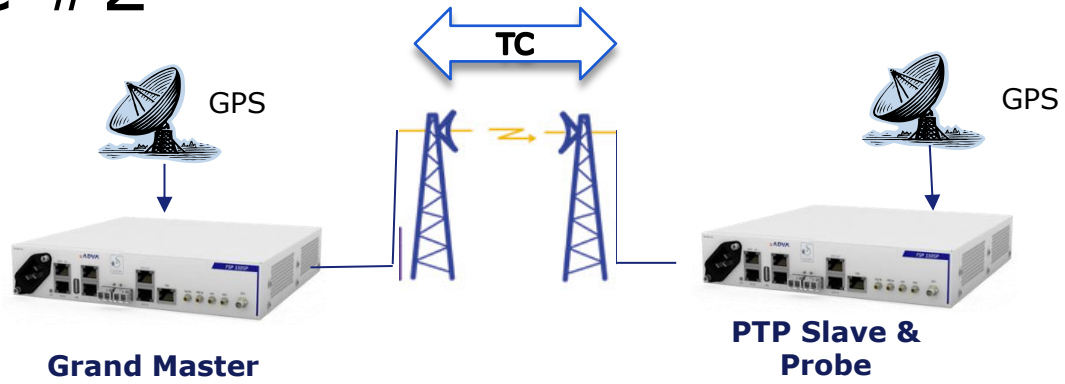
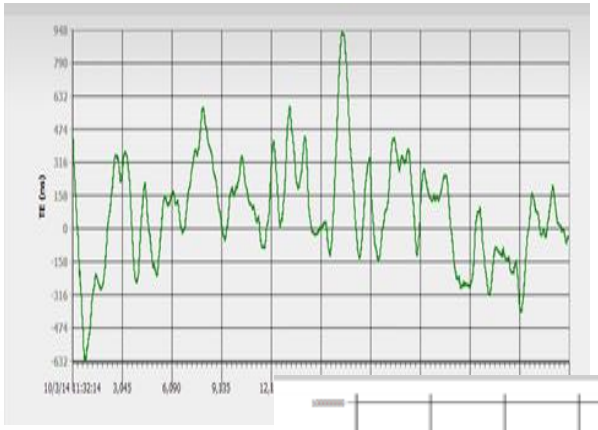
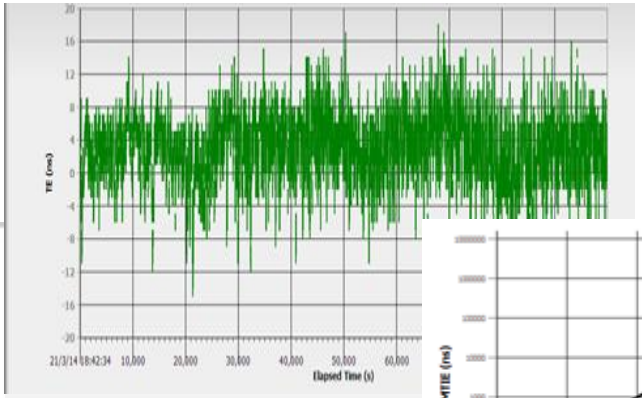
Example #2

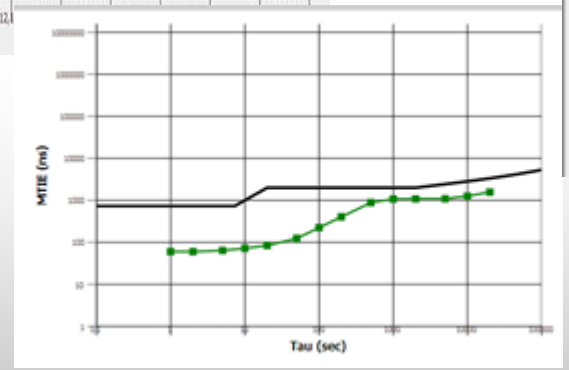


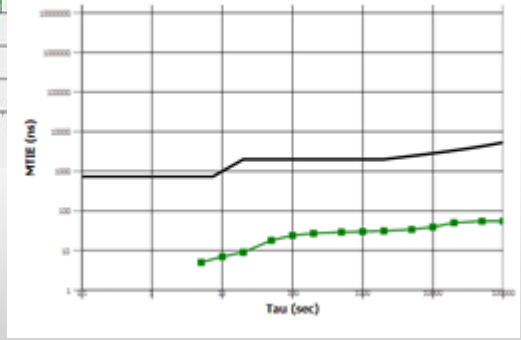
Slave recovered clock without Transparent Clock (TC) enabled – **1500 nsec pk2pk**



Slave recovered clock **with** TC enabled – **55 nsec pk2pk**







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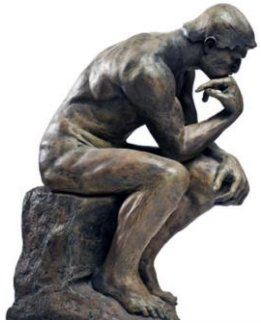
Phase Delivery Challenges in Brownfield Deployments

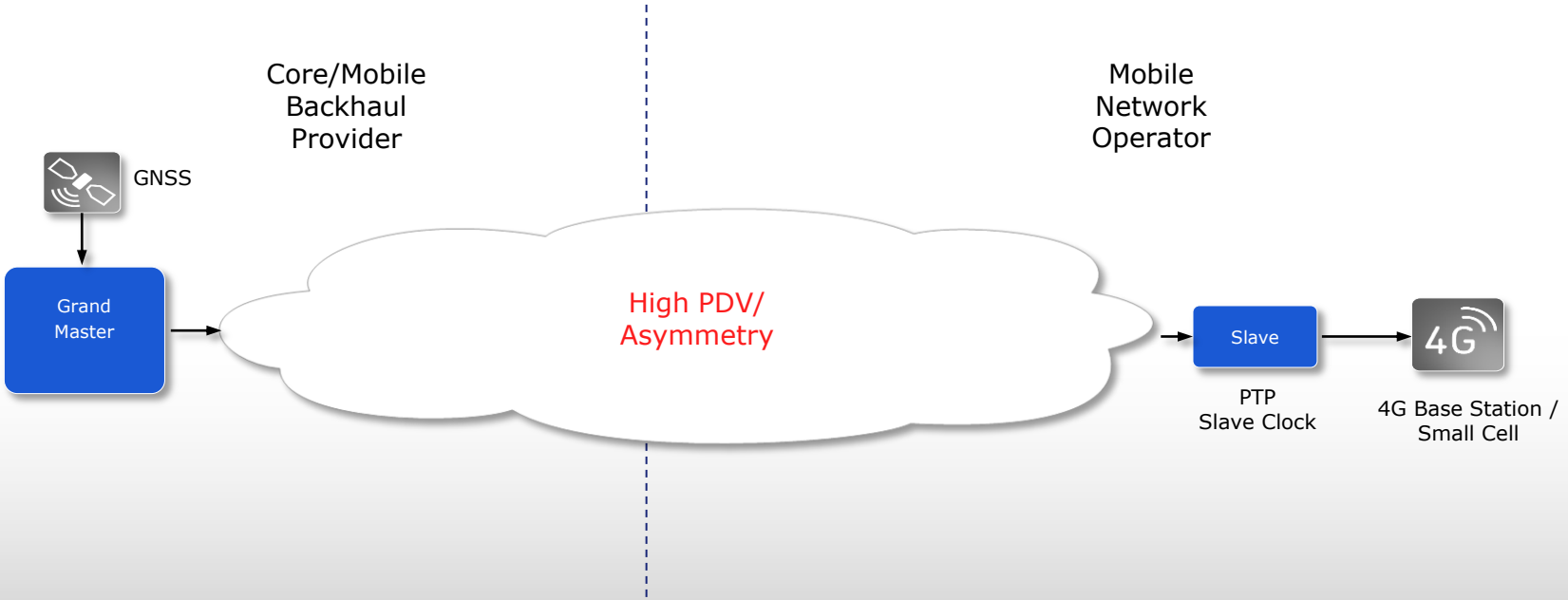
- Existing network introduce high level of asymmetry and PDV
- The asymmetry and PDV varies over time
- Existing networks include different transport technologies
- Upgrading/forklifting the existing NE to Sync-E/BC is very costly



Do we really need frequency and phase in the core network?

The Solution

Bypass the problem:
Get the Grand Master closer to the Slave
Use full on path support (if need) in the last mile



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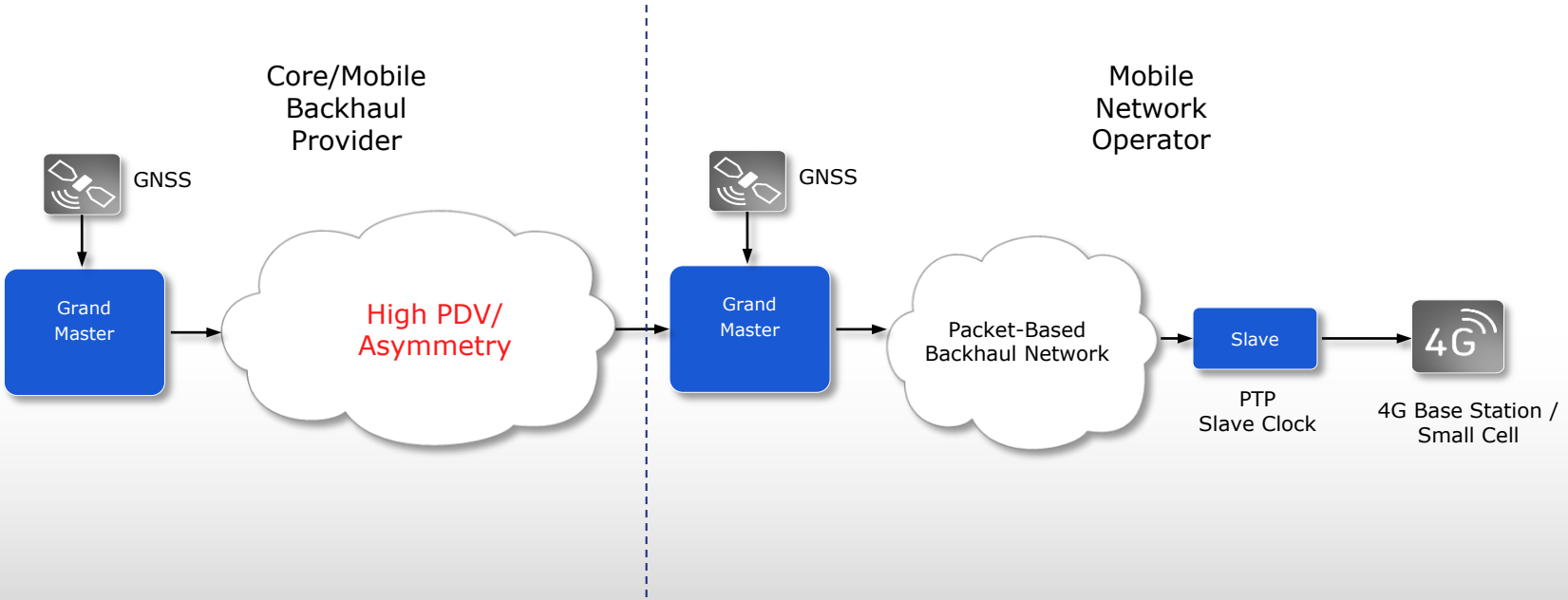

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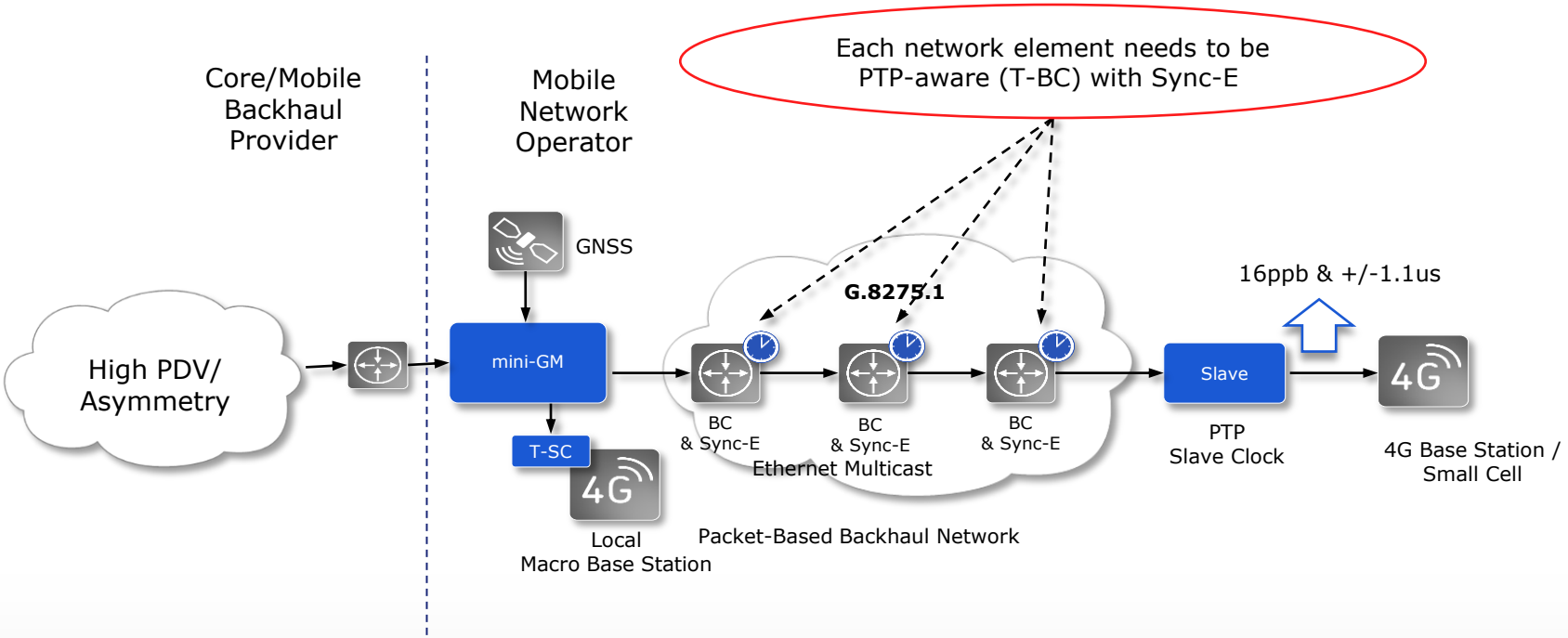
Phase Delivery:
Small Scale GM & G.8275.1 – Last Mile

- G.8275.1 – Uses hop by hop , Ethernet multicast



Last mile full on path support
Small Scale GM as a head of G.8275.1 chain

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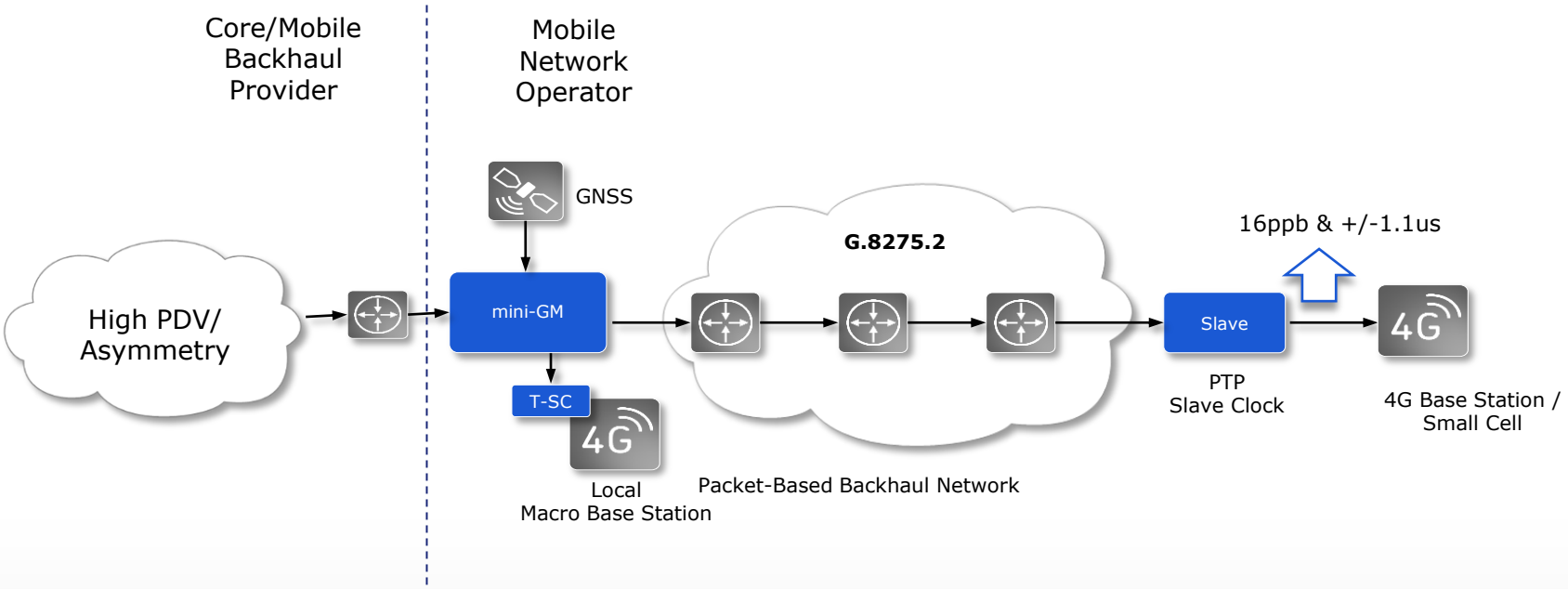
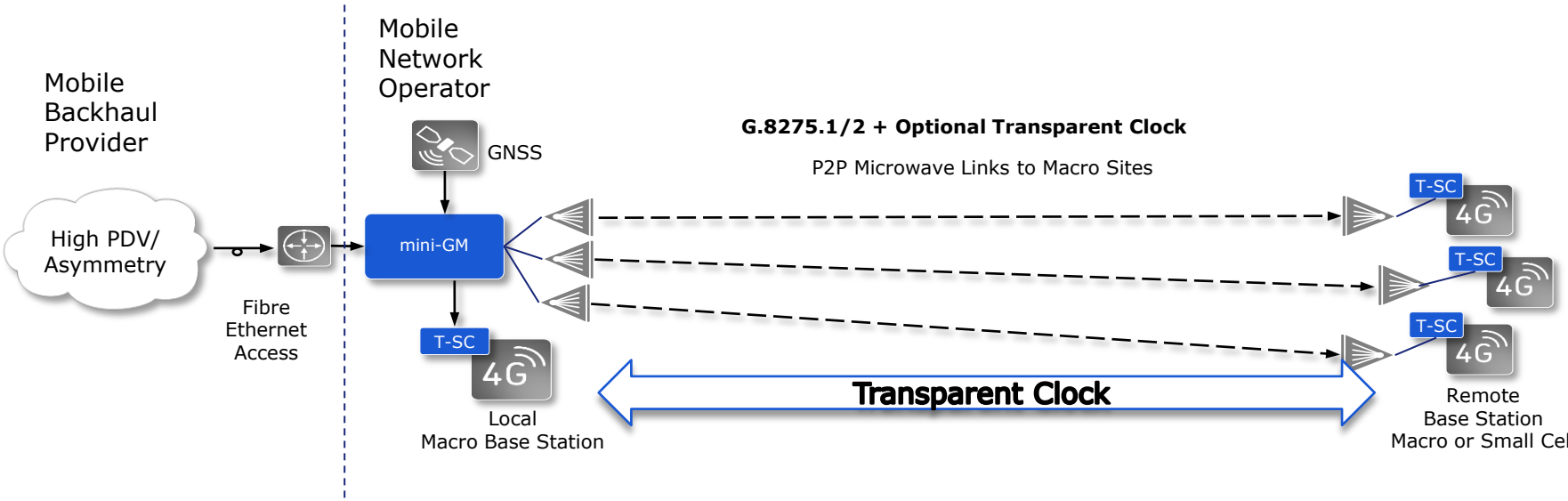
Phase Delivery:
Small Scale GM & G.8275.2 – Last Mile

- G.8275.2 – Uses IP unicast for phase delivery over last mile



Small Scale GM as a head of G.8275.2 chain

Small Scale GM at Fibre Macro Site Extension over Microwave to Remote Site



Small Scale GM as a head of G.8275.1/2 chain
Optional Last mile full on path support using Transparent Clock

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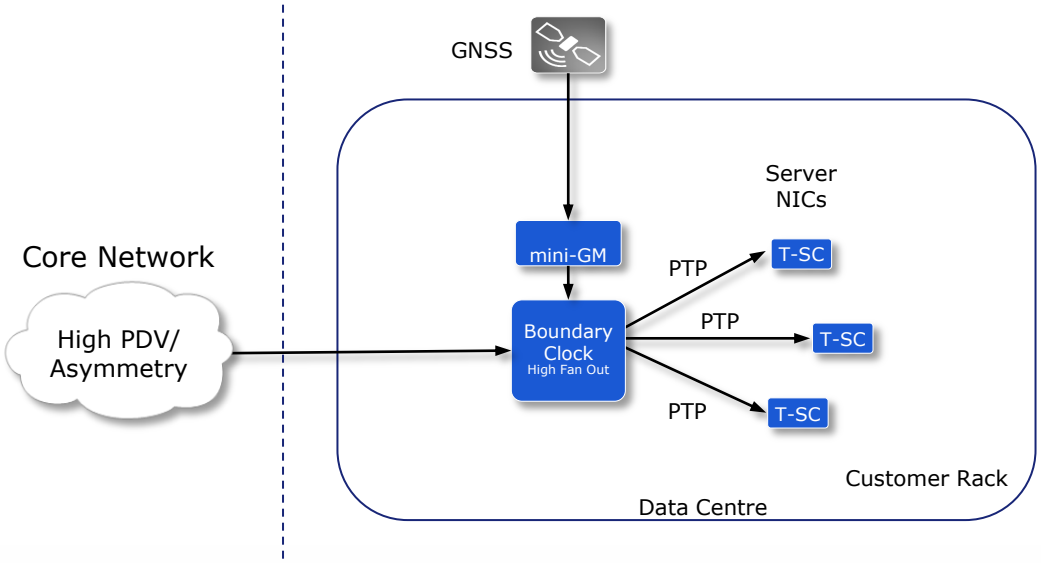
Time as a Service into Data Centre Financial Markets, Health, Media



Bring accurate time and frequency synchronization into data centers

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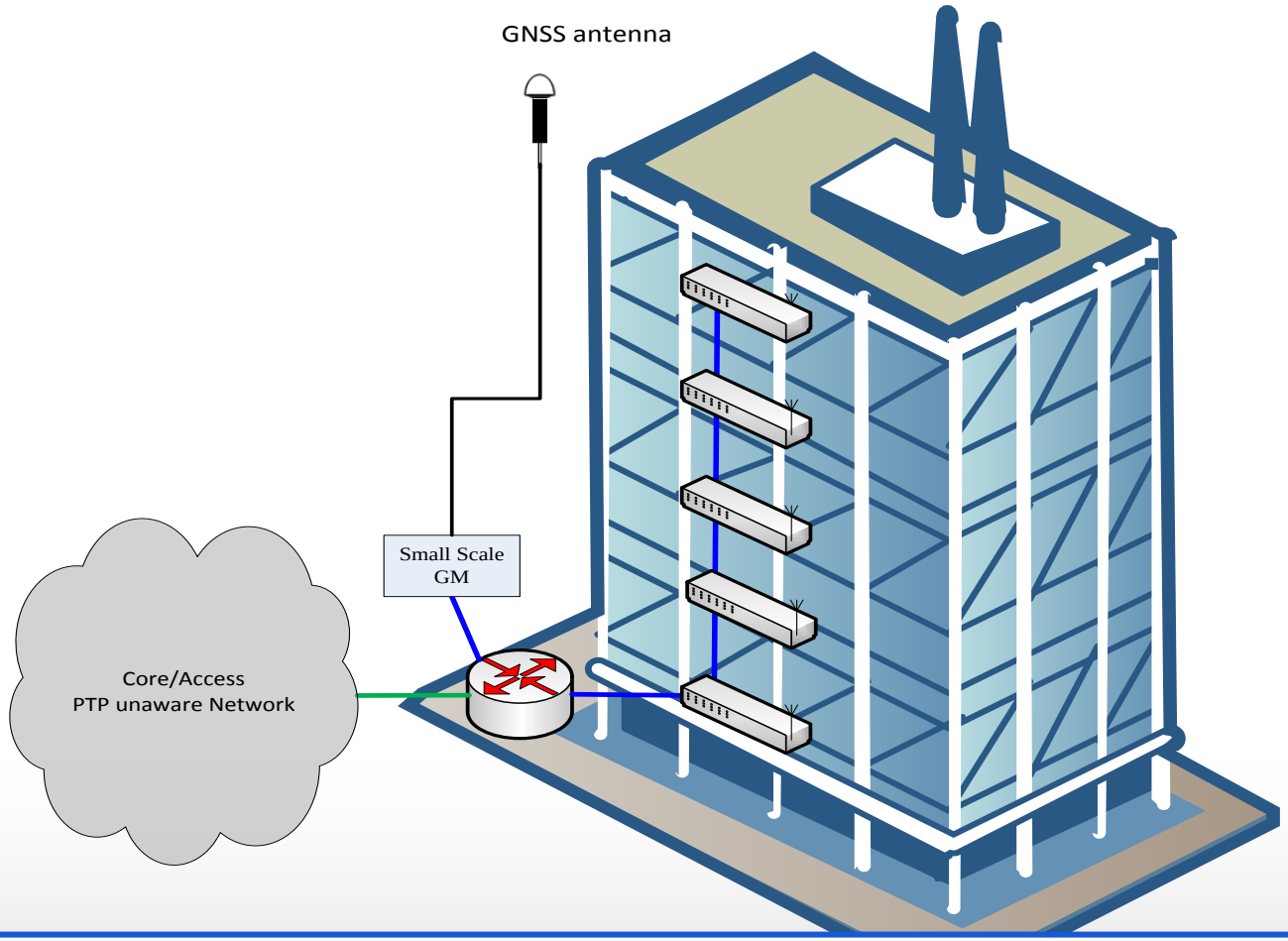
Phase Delivery: Indoor Small Cells



GNSS antenna on the roof, Indoor Sync distribution using G.8275.1/2

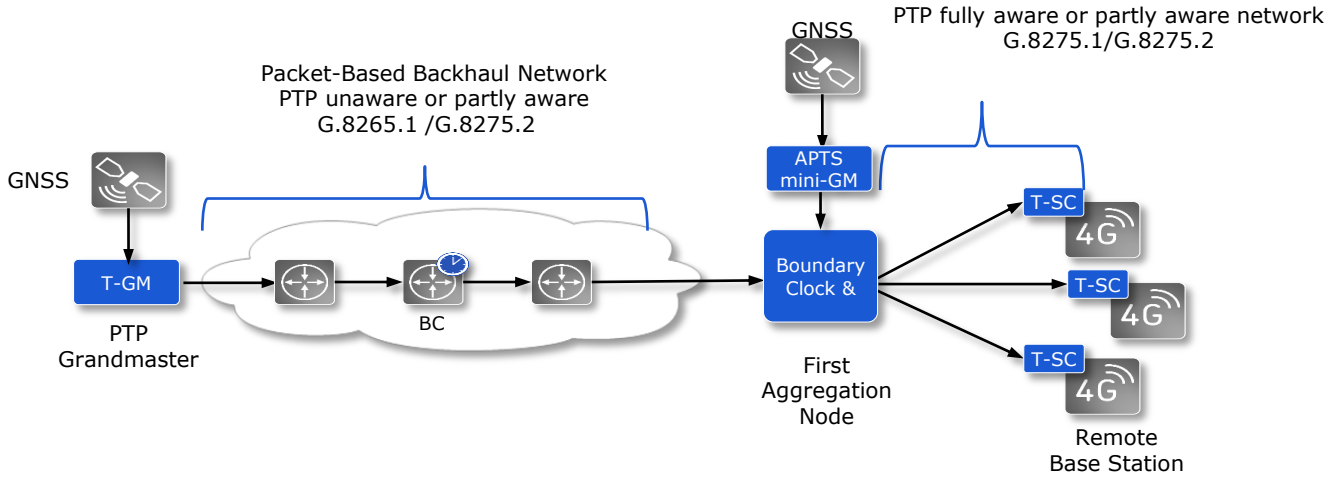
Small Scale GM Protection

How can the Small Scale GM be protected against local GNSS outage?

→ Secondary sources

1) Sync-E (time holdover) for core network or adjacent PTP GM
2) PTP input (Slave) locked to core or adjacent PTP GM (APTS)
   - Can be used as secondary frequency and/or time source

Small Scale GM with APTS in Aggregation Node – Core GM Protection



GNSS only at first aggregation site
1588v2 with Full/Partial On Path Support to Cell Sites
APTS in case of GNSS failure

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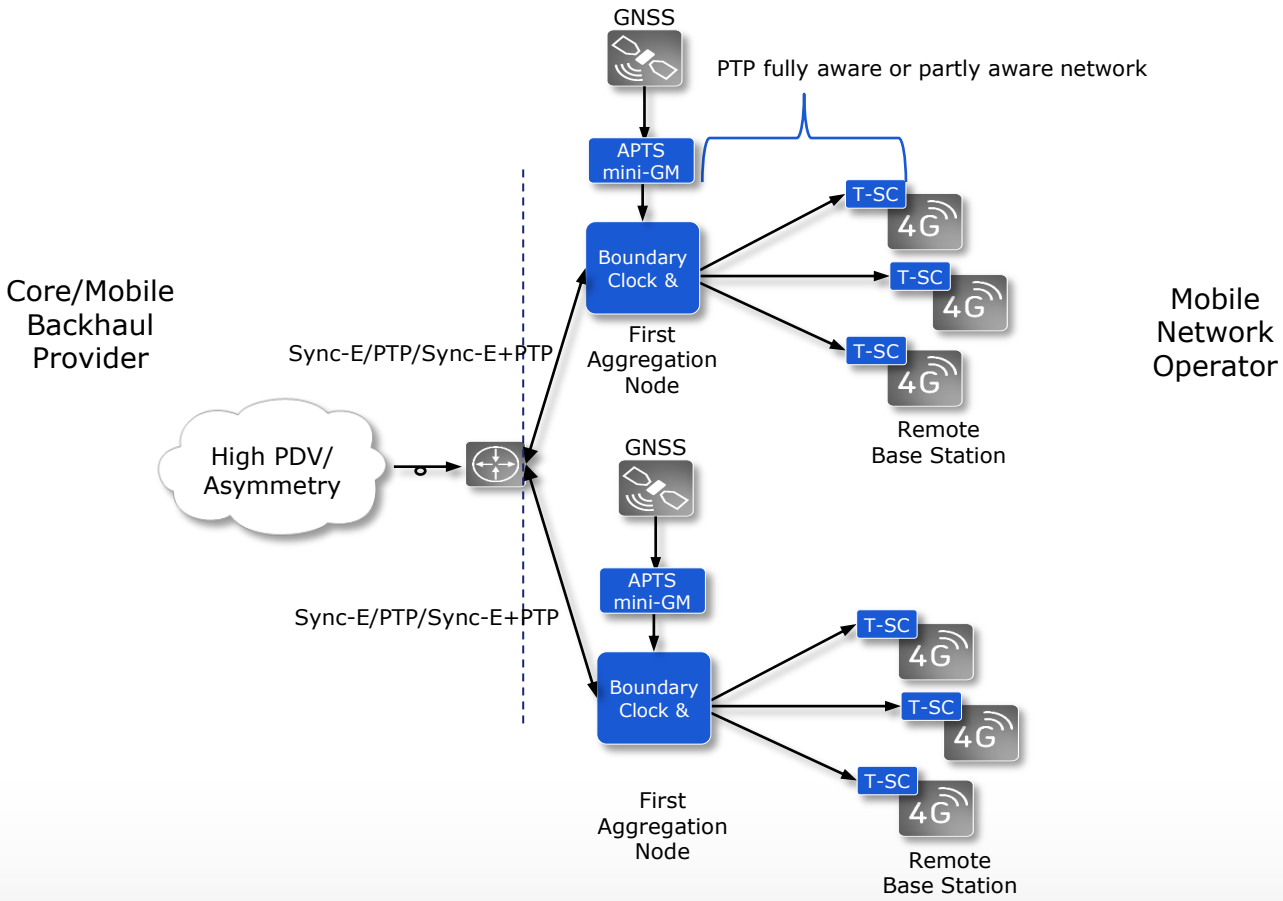
Small Scale GM with APTS in Aggregation Node – Adjacent GM Protection



Adjacent Small Scale GM protect one anther

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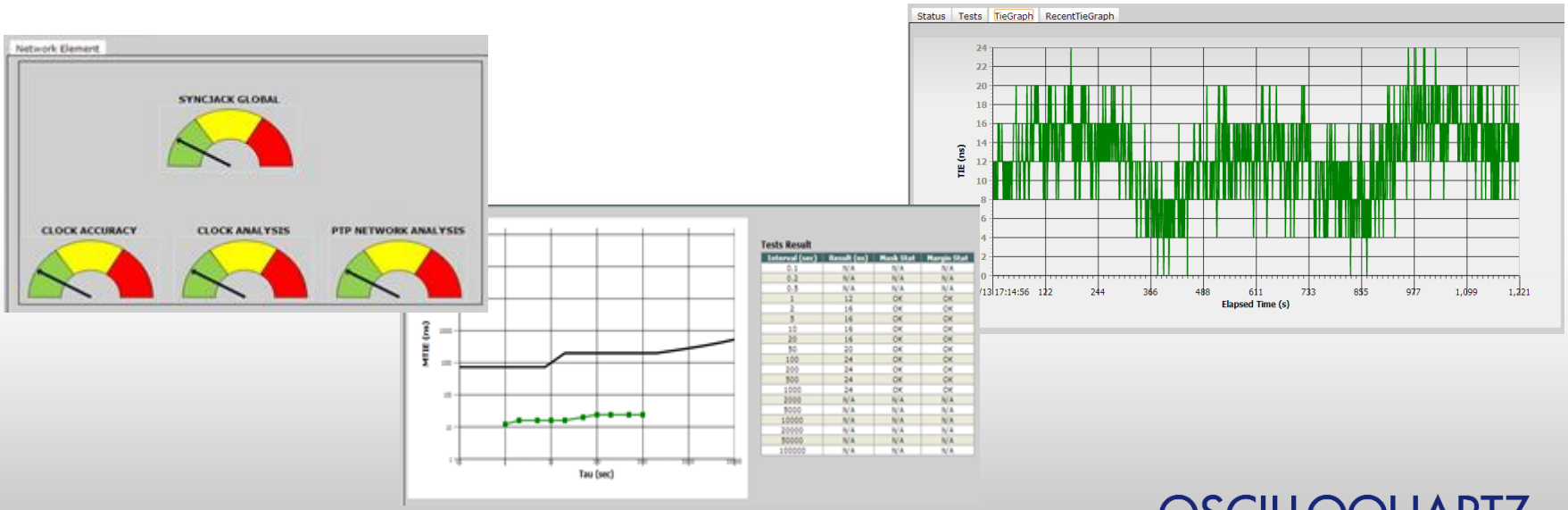
APTS KPIs and SLA

- Low Scale GM includes Primary Reference Time Clock (PRTC) which filter the GNSS input
- The PRTC is very accurate time reference – time error within +/- 100nsec from UTC (G.8272)
- This accurate reference can be used for the validation of the secondary references:

- **PRTC Vs. PTP Slave recovered clock** (PTP Input)
  - Total/Constant/Dynamic Time Error (TE) Vs predefined threshold
  - MTIE Vs predefined mask
  - Network asymmetry and PDV
- **PRTC Vs. Sync-E**
  - MTIE Vs predefined mask

- The results and failure alarms should be collected by the NMS.
- **APTS KPI's and SLA will be part of OSA demos scheduled during WSTS**



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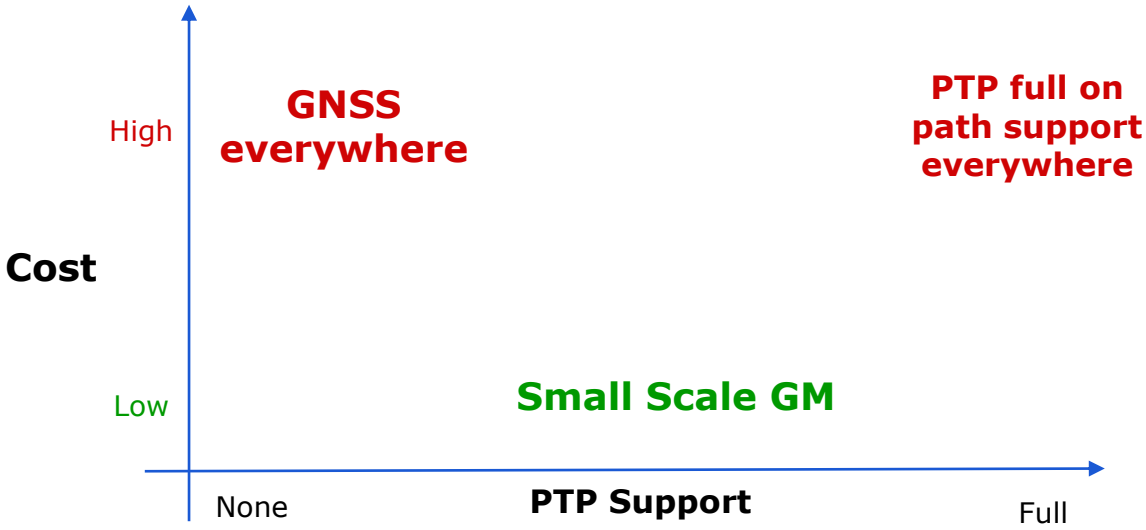
Requirements for Small Scale GM + APTS

- Low cost solution is needed in order to deliver cost effective solution in large scale deployment
- Integrated GNSS, Sync-E, PTP GM/BC/Slave , Probe in one box
- Support PTP GM ,Slave and Sync-E simultaneously
- Sync Probing and assurance of Sync inputs for synchronization protection validation

Business Case: Small Scale GM vs. GNSS Everywhere



- Only one GNSS antenna is needed every N base stations (I.e. N=4..64)
- (Cost of small scale GM divided by N + one antenna installation) << (N x Cost of GNSS antenna installation)

Summary – Brownfield Deployments

Meeting the stringent Phase synchronization requirements is possible in brownfield deployments!

- Get the master closer to the slave!
  - Lower PDV
  - Lower asymmetry
- If needed use Full on path support BC/TC only in last mile
- APTS - Improve Robustness & Protection by use Sync-E/PTP/PTP+Sync-E from core GM or adjacent small scale GM to protect GNSS outages
- Use the GNSS while available to monitor and assure the quality of the secondary synchronization source (i.e. Sync-E , PTP input)

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Questions? Thank you!

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