Double Migration

of Packet Clocks

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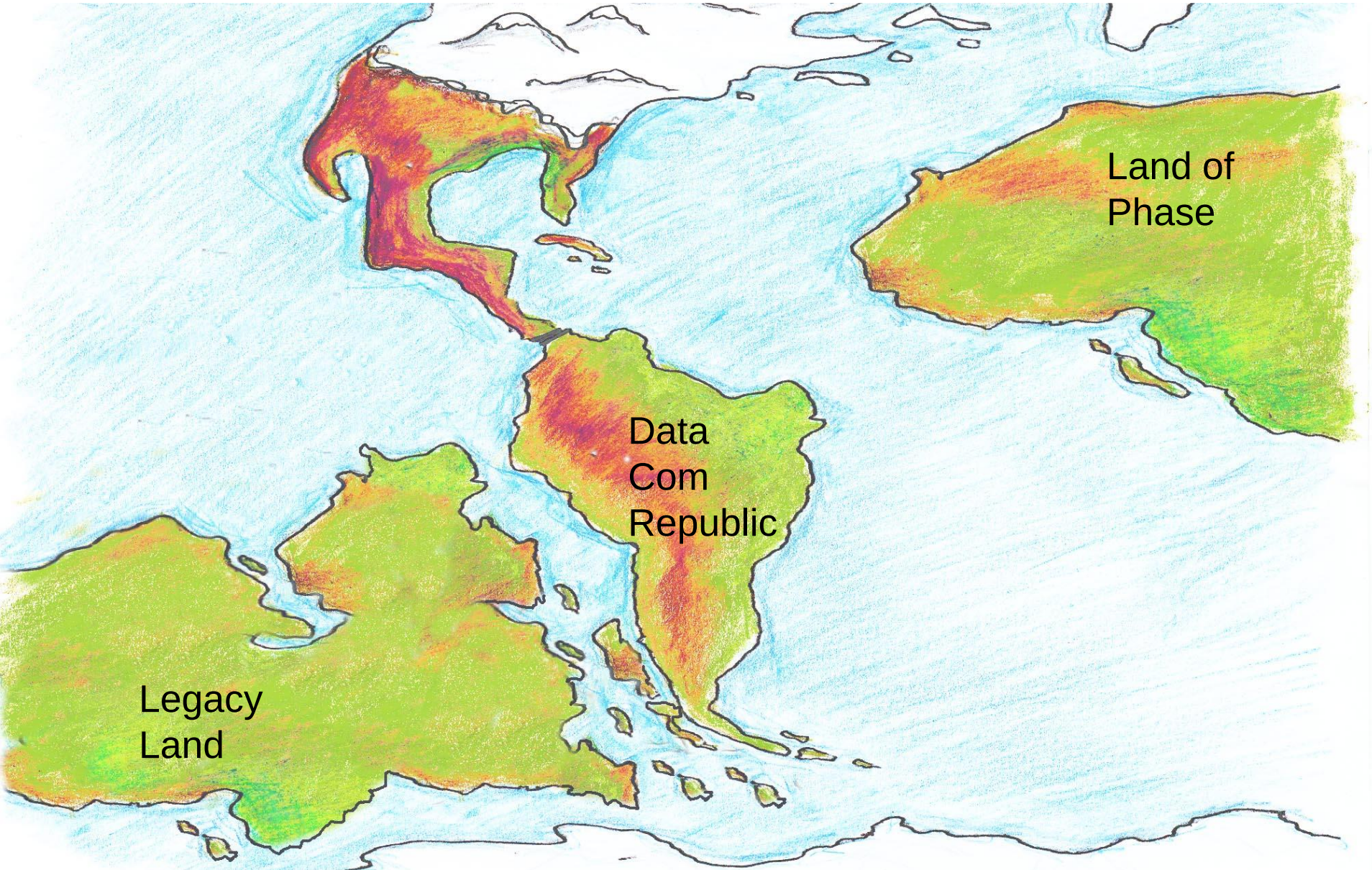
Artwork:Tanja Hann

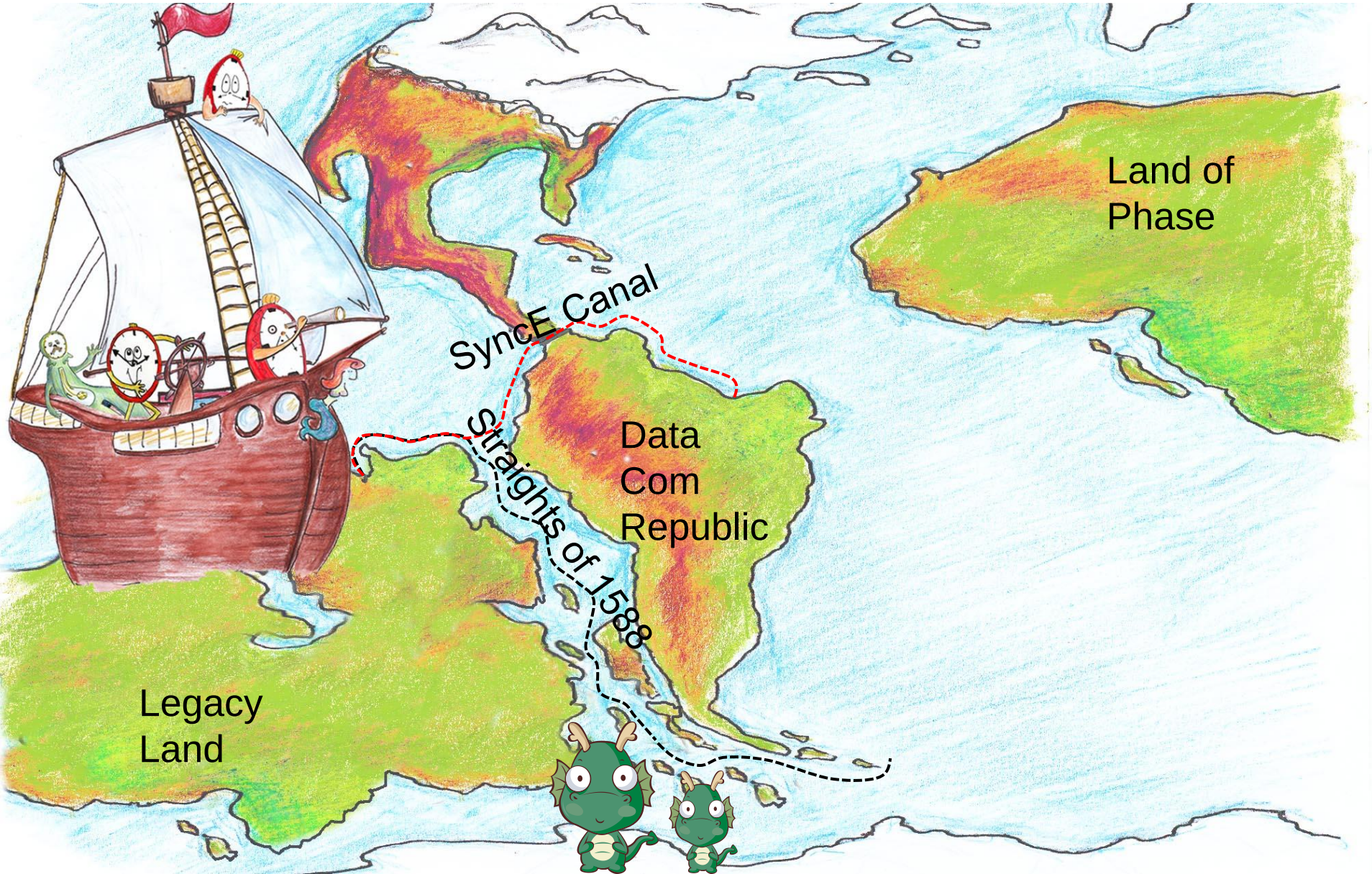
Packet Clocks...

the first migration



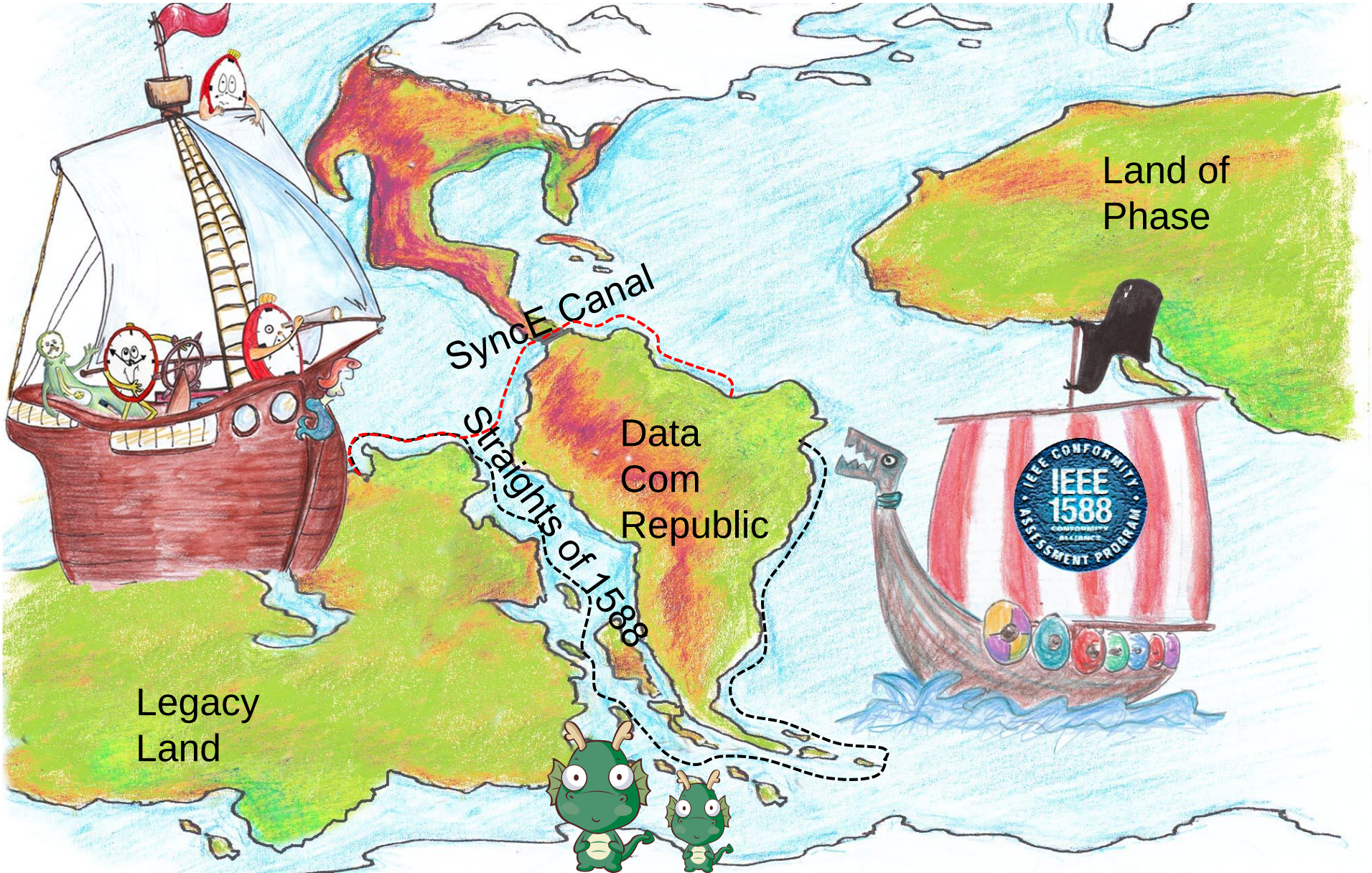
Packet Clocks...

the first migration



Packet Clocks...

the first migration



Agenda

1. From “here”...
2. Timely progress
3. Supporting PTP migration

4. To Phase (eventually)

5. Conclusions

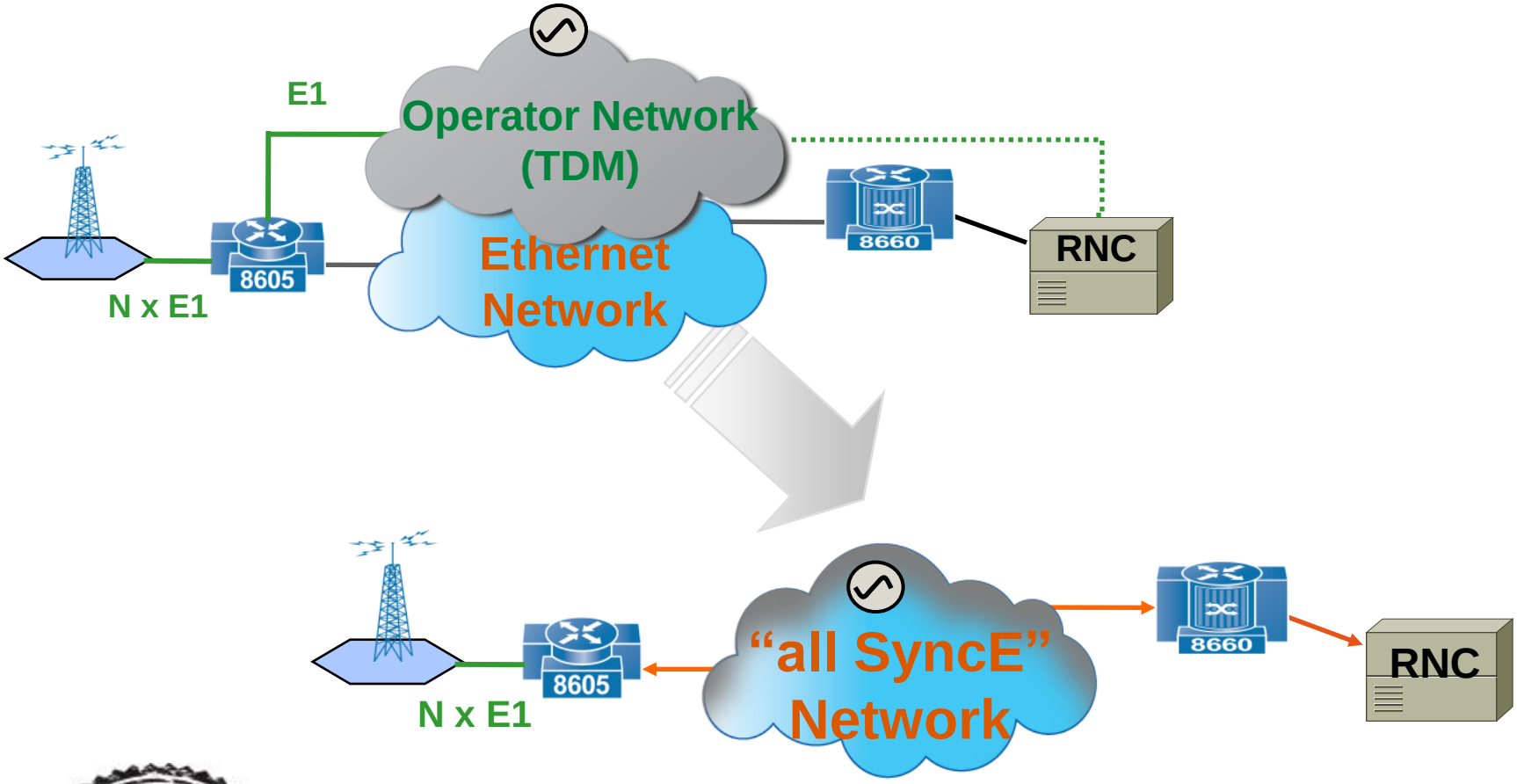
1st Migration | 2nd Migration

1. From “here”:

- *mobile FDD*
- *Ethernet backhaul*
- *that “last E1”*

From Legacy Sync ...

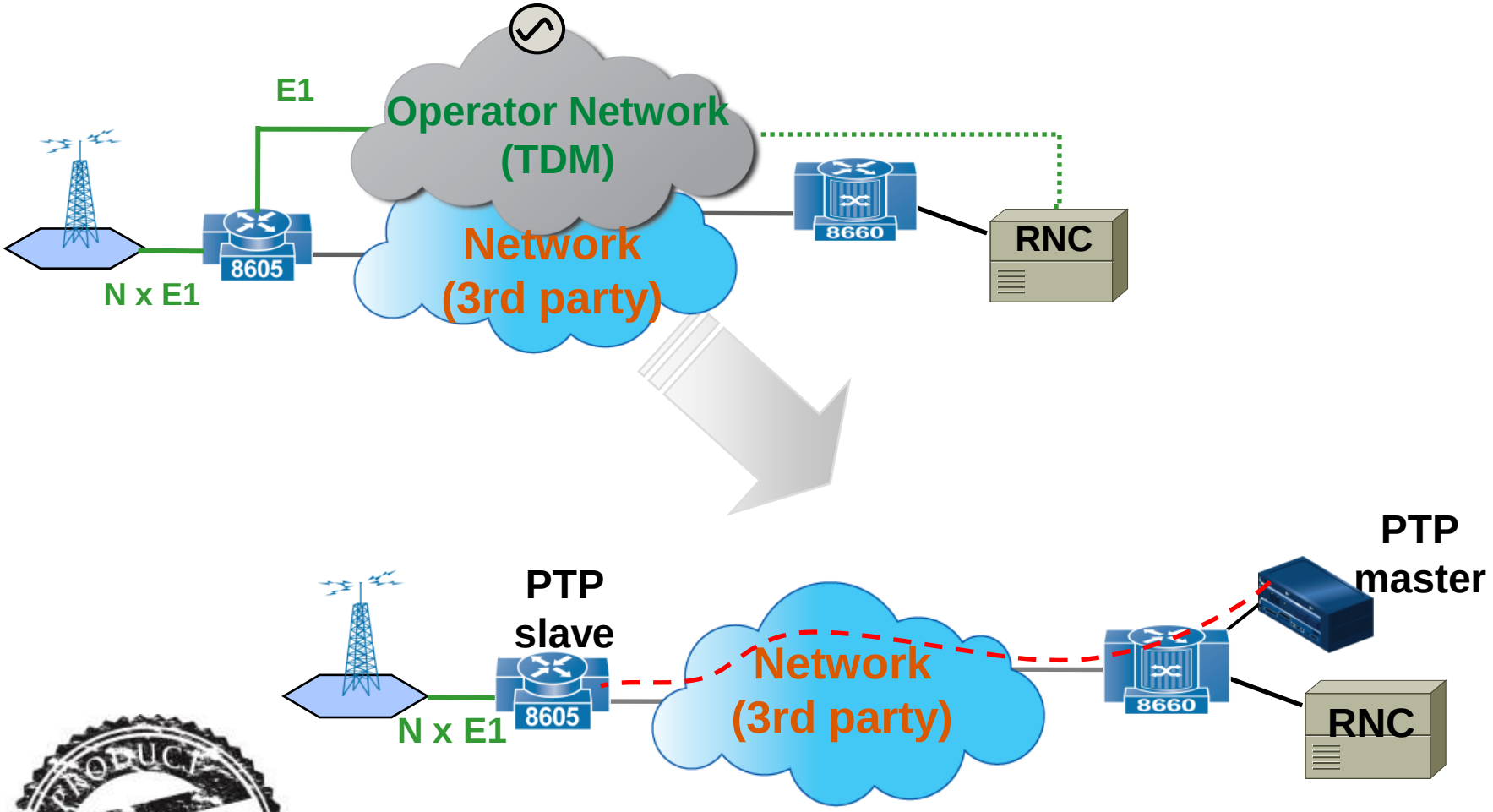
to SyncE



SyncE flow

From Legacy Sync ...

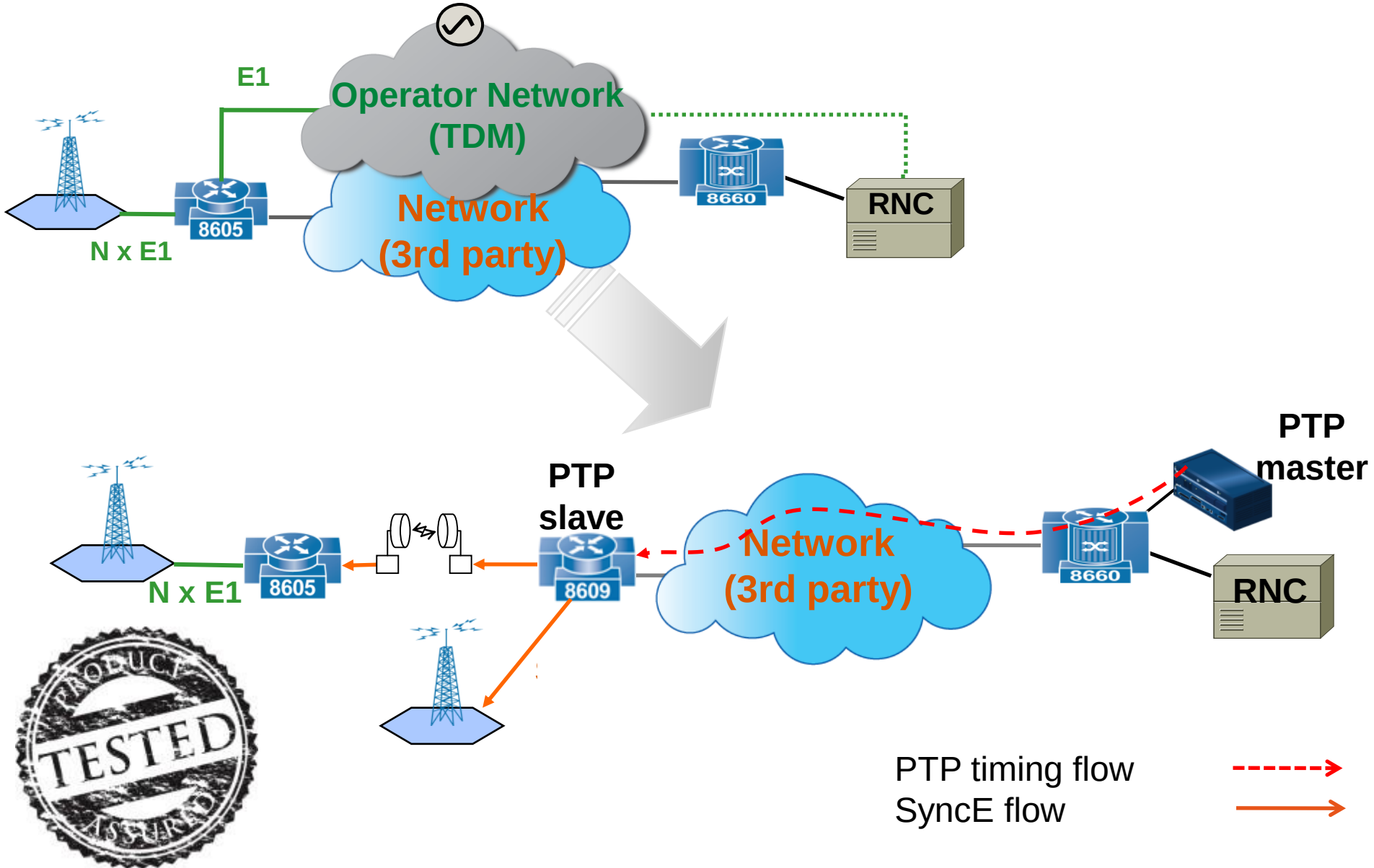
to PTP



PTP timing flow
(G.8265.1)

From Legacy Sync ...

to Hybrid networks



2. Timely Progress

- *Network limits G.8261.1*
- *Packet Equipment Clock model G.8263*
- *PEC "knowledge base" G.8260*

Output limits for a packet Clock (frequency / FDD applications)

G.8261.1 Sneak Preview

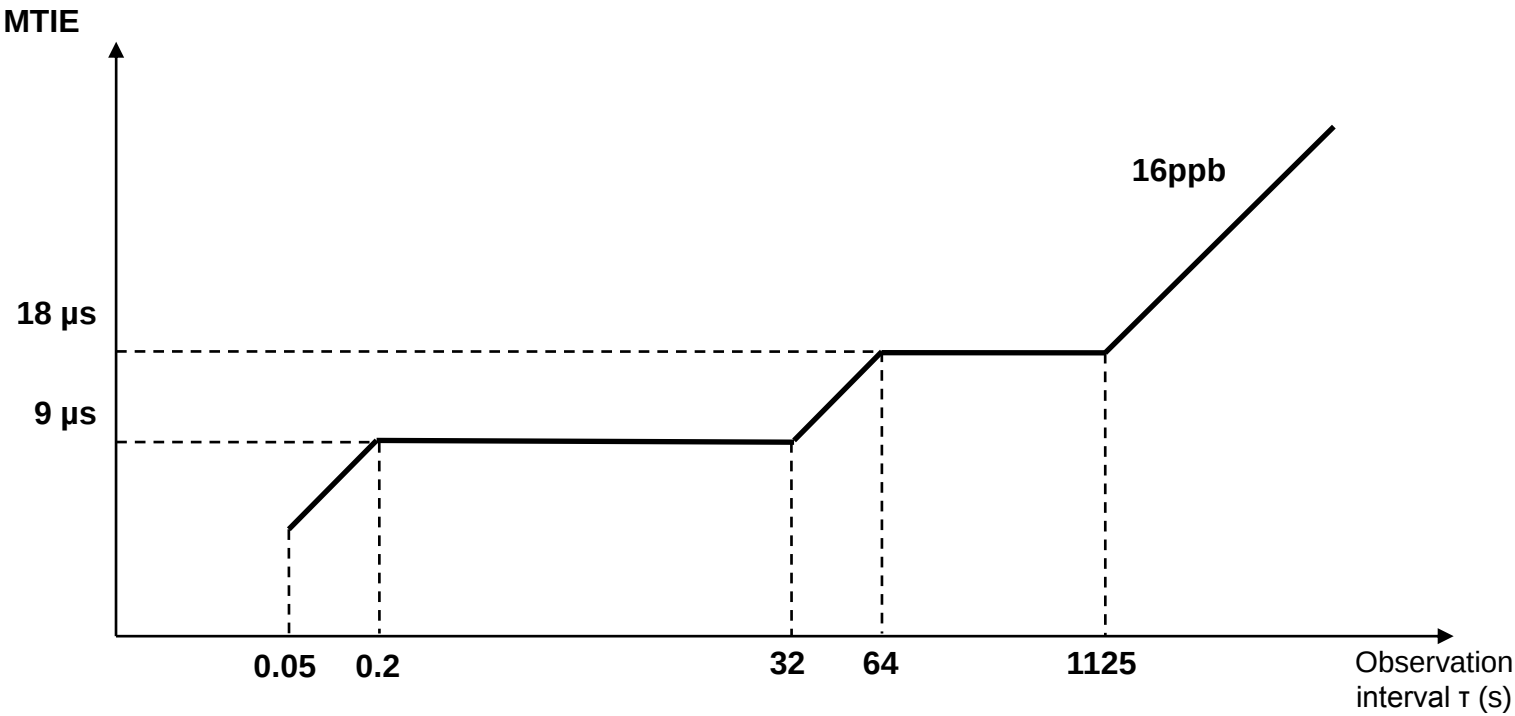
50ppb

2us
18us
MTIE

2us +16ppb
18us + 50ppb

Or...

18us + 16ppb



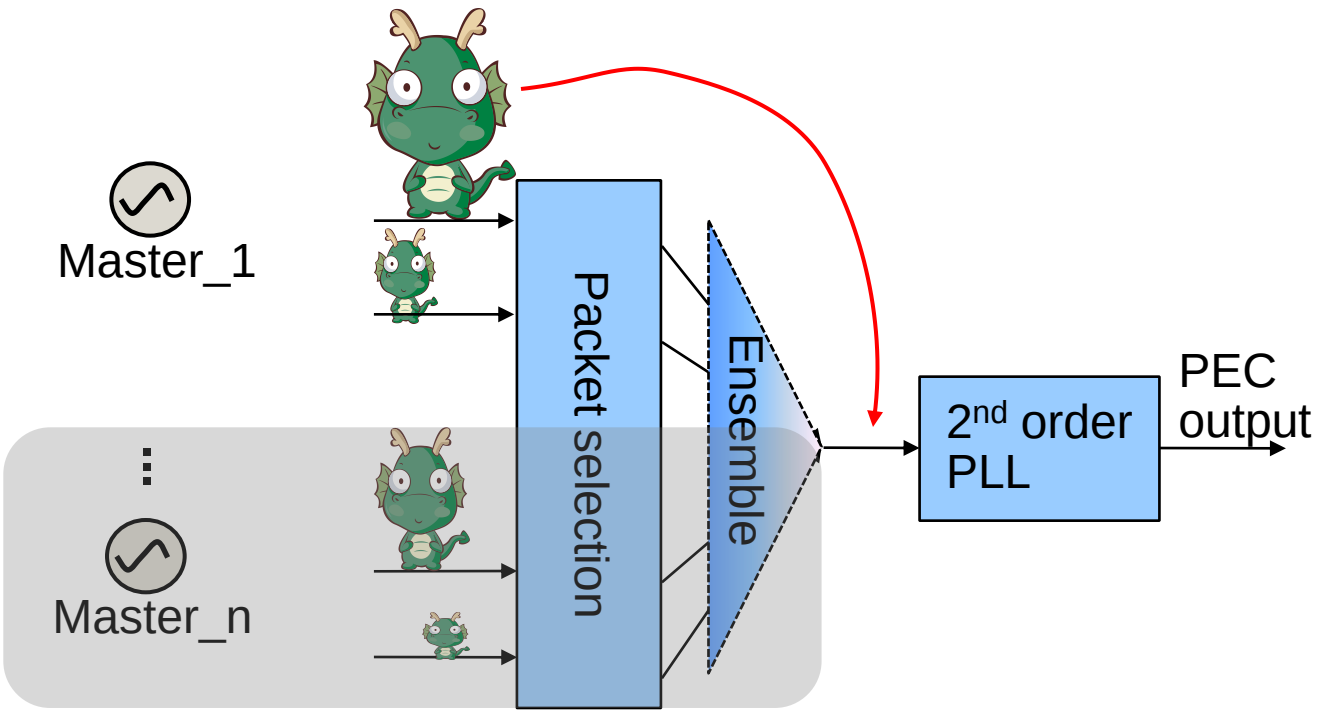
2G / 3G / LTE mobile requires **50ppb frequency stability**

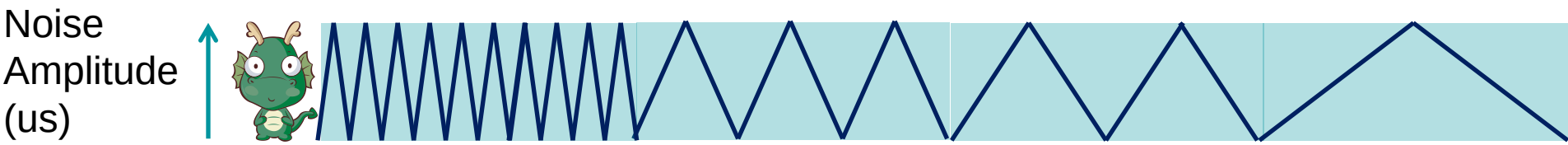
Factors impacting Packet clock "performance":

- Local oscillator stability
- Accuracy of timestamps
- Sync rate
- PDV characteristics of the network
- PDV filtering in the packet clock — 2011
- Packet selection algorithm
- Number of synchronization flows in Ensemble
- Ensemble combining algorithm — 2010
- Adaptive clock recovery algorithm

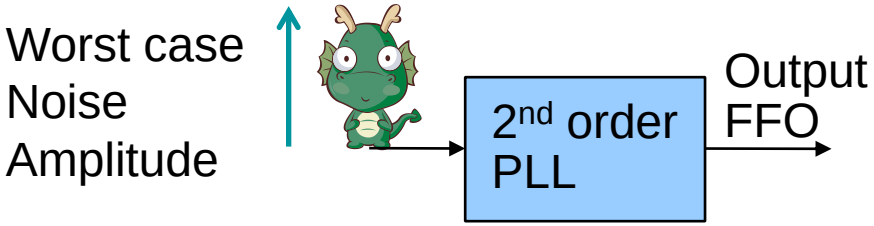
~~None~~ Some of above being standardized

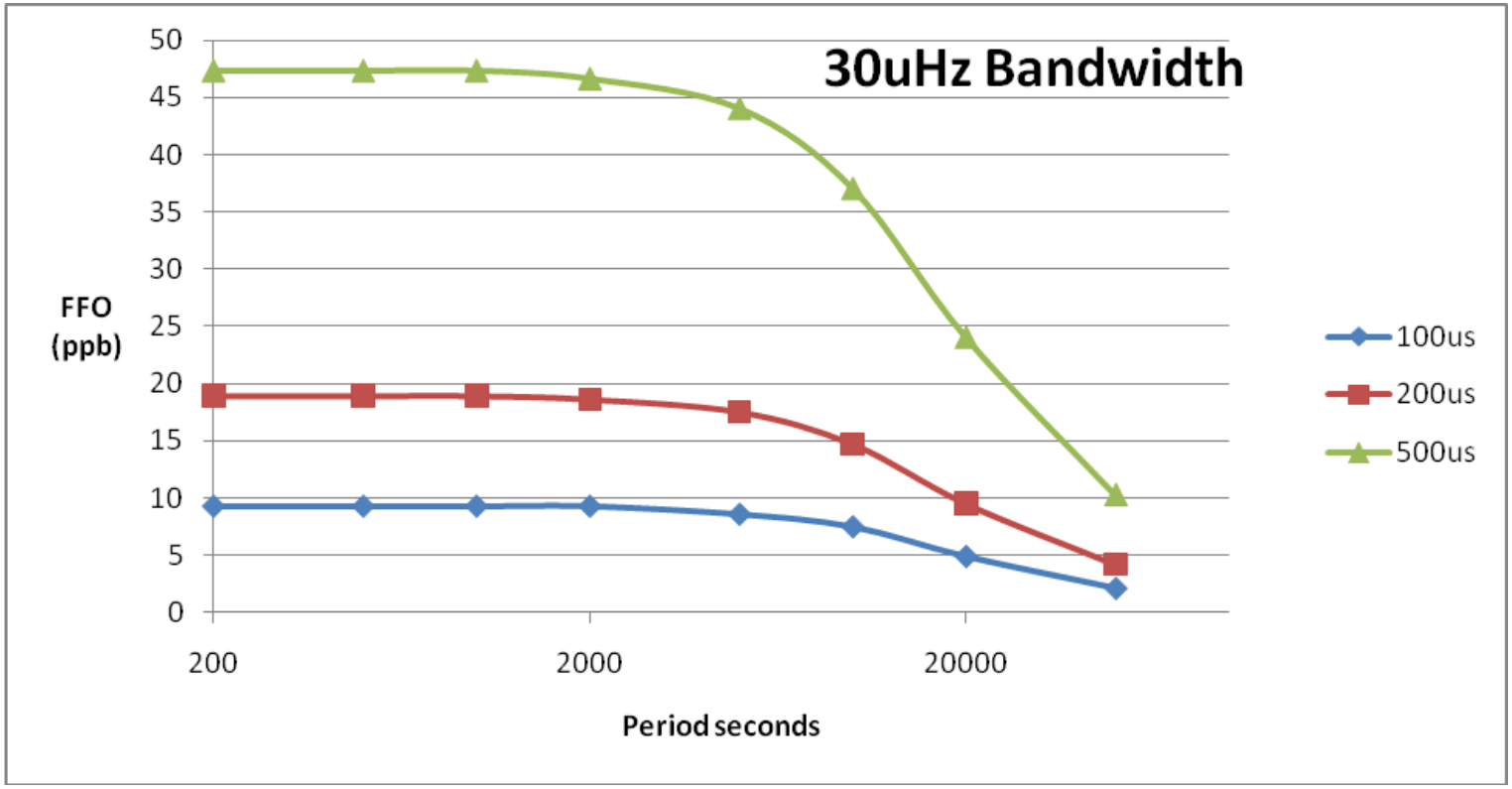
Model of a frequency PEC (G.8263)



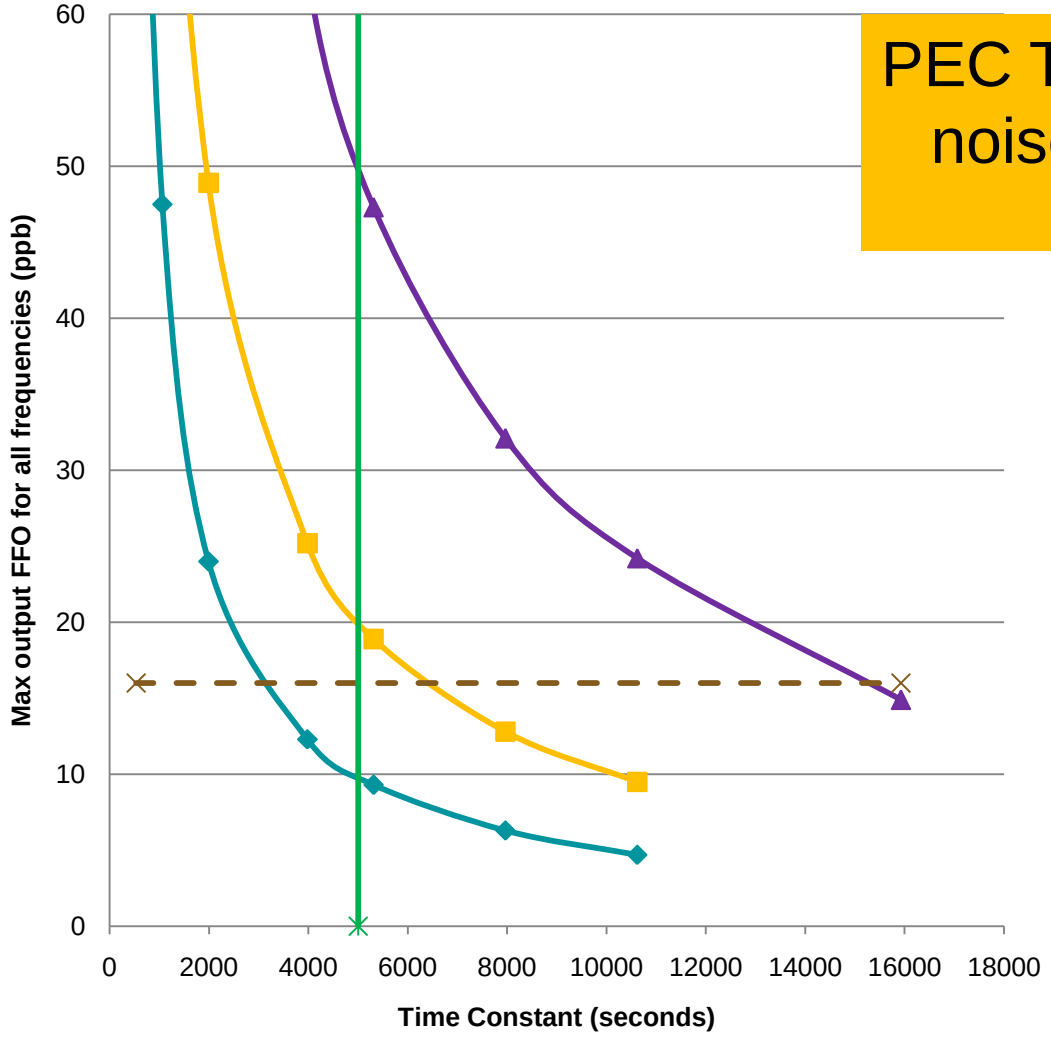


PEC output for worst case input





Packet Equipment Clock model – not just ”secret plans and clever tricks”



PEC Time constant guarentees a noise tolerance

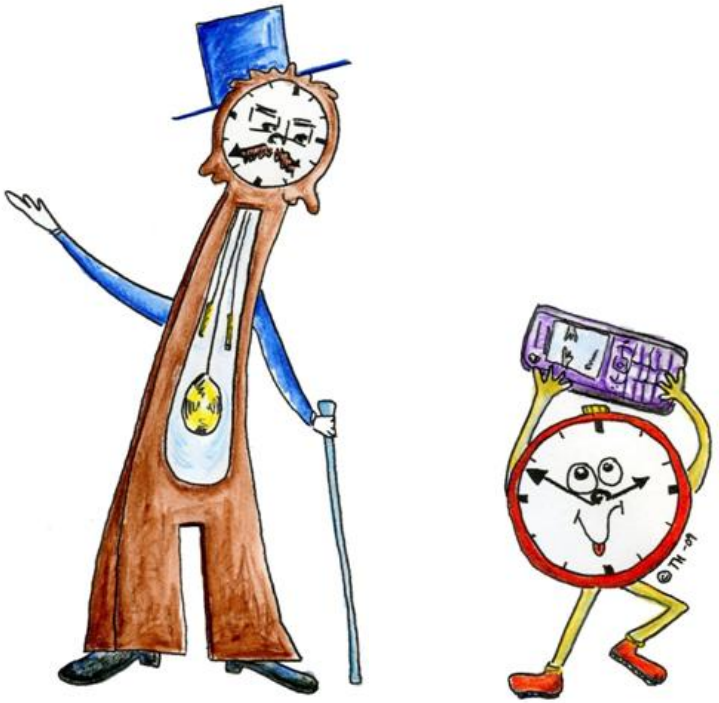
$$FFO_{max} = \frac{Noise\ Amplitude}{2 \times Time\ Constant}$$

3. Supporting PTP migration (Frequency FDD)

- *PDV metrics*
- *Clock output monitoring*
- *Live network deployments*

Monitoring of the Synchronization network

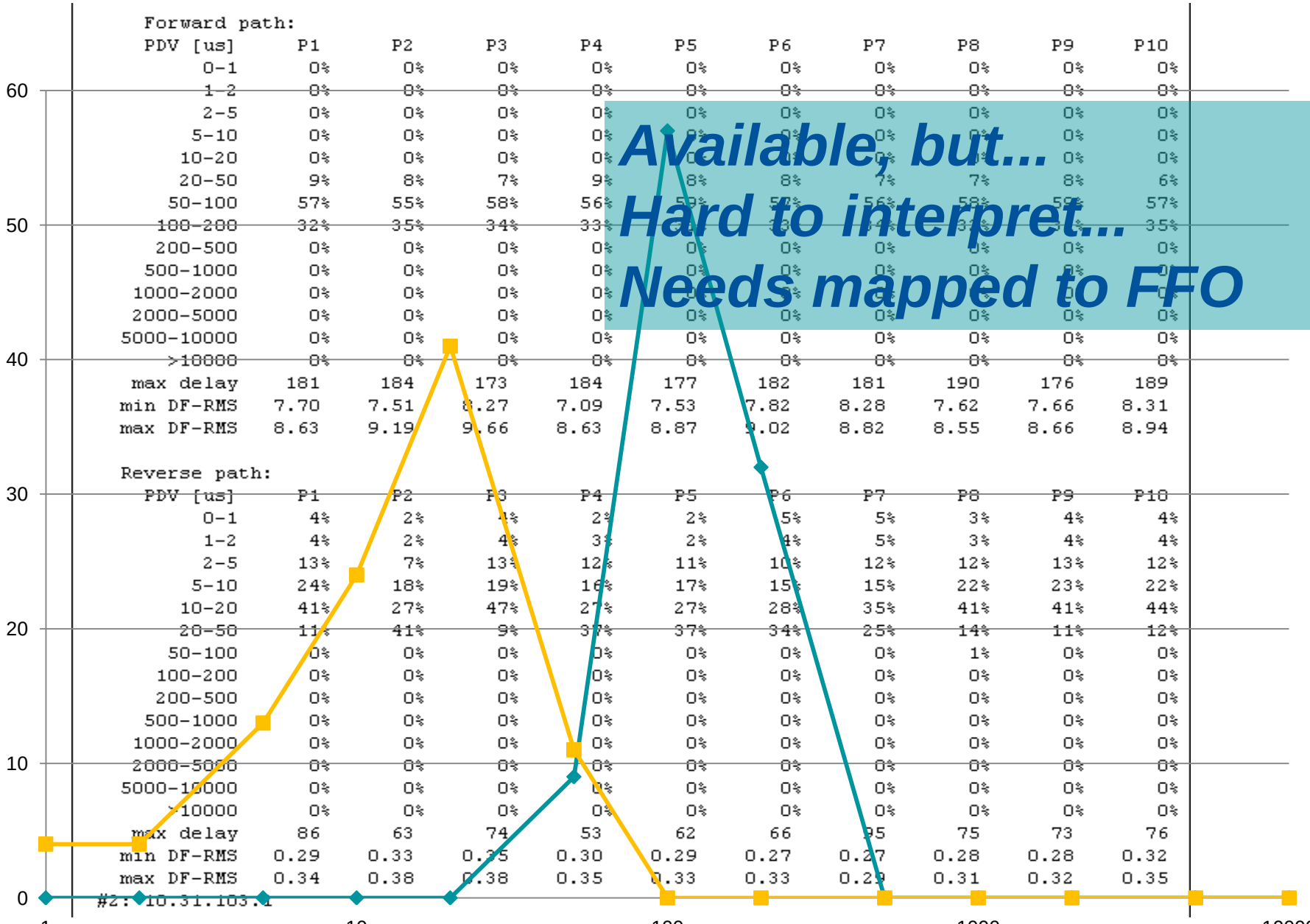
- Mobile networks:
  - need synchronization <50ppb
  - May be >10,000 nodes
  - Some must migrate to IEEE1588



- PECs viewed with suspicion
  - Are fairly new
  - Telecom standards still evolving
  - Performance partially dependent on network conditions

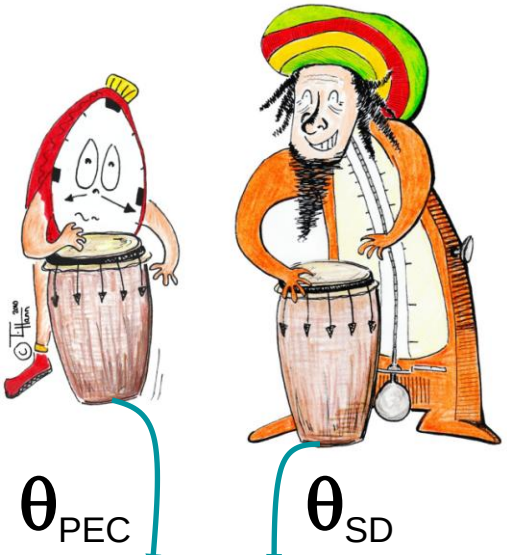
Operators need to be conservative

Packet Metrics – work in progress ...



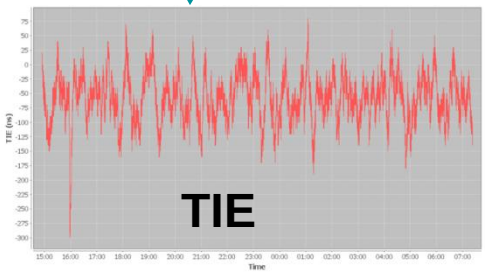
Available, but...
Hard to interpret...
Needs mapped to FFO

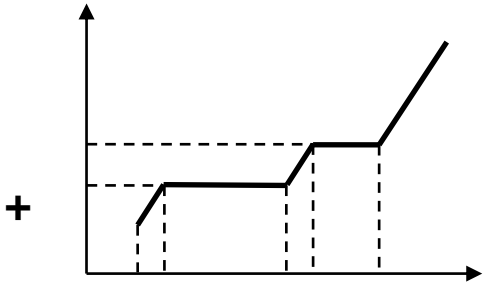
IEEE1588 Clock Monitoring



θ_{PEC} θ_{SD}

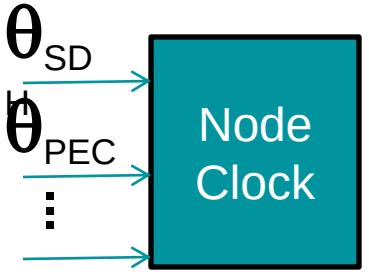
Phase comparitor



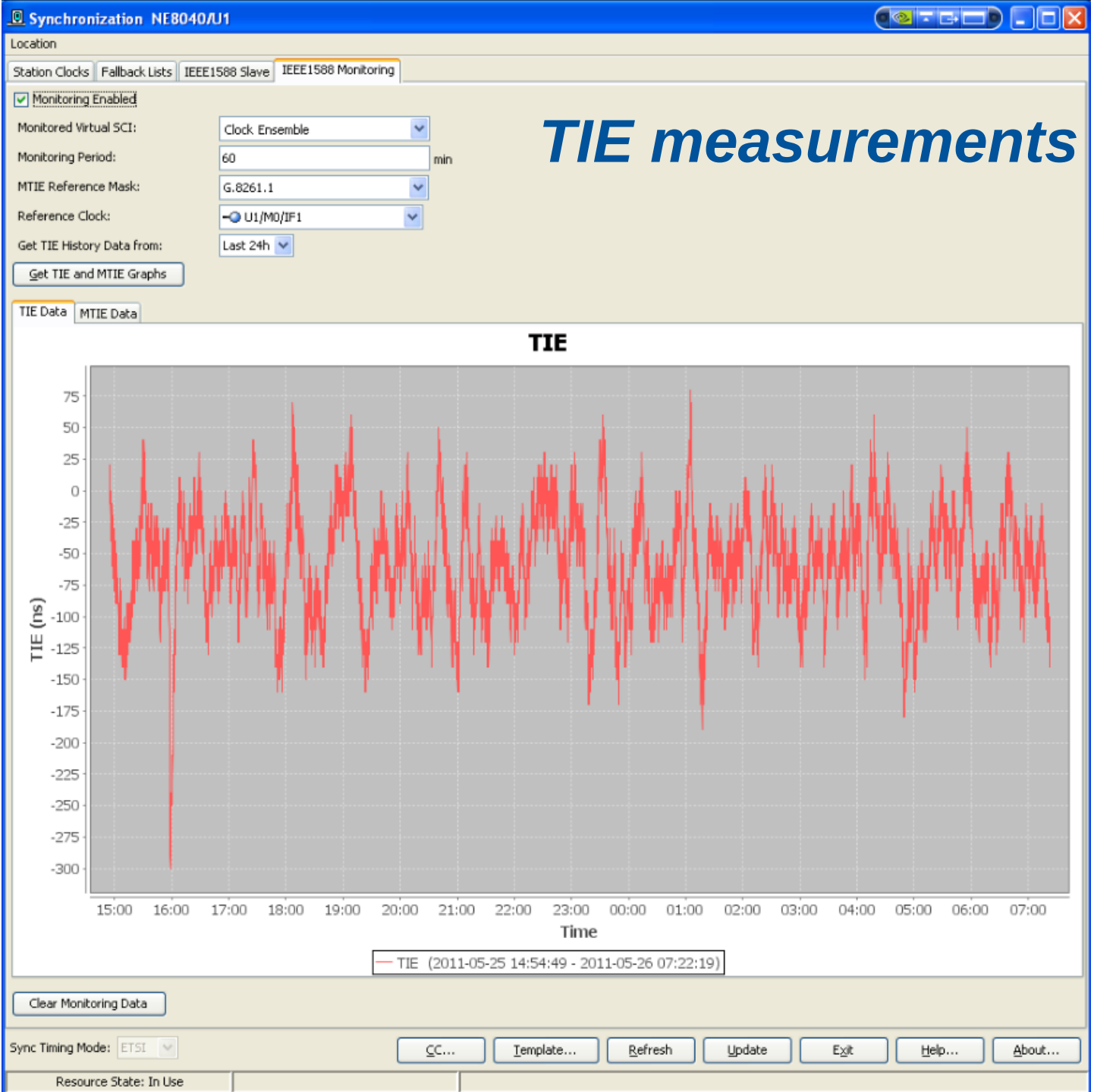


MTIE > Mask → Alarm

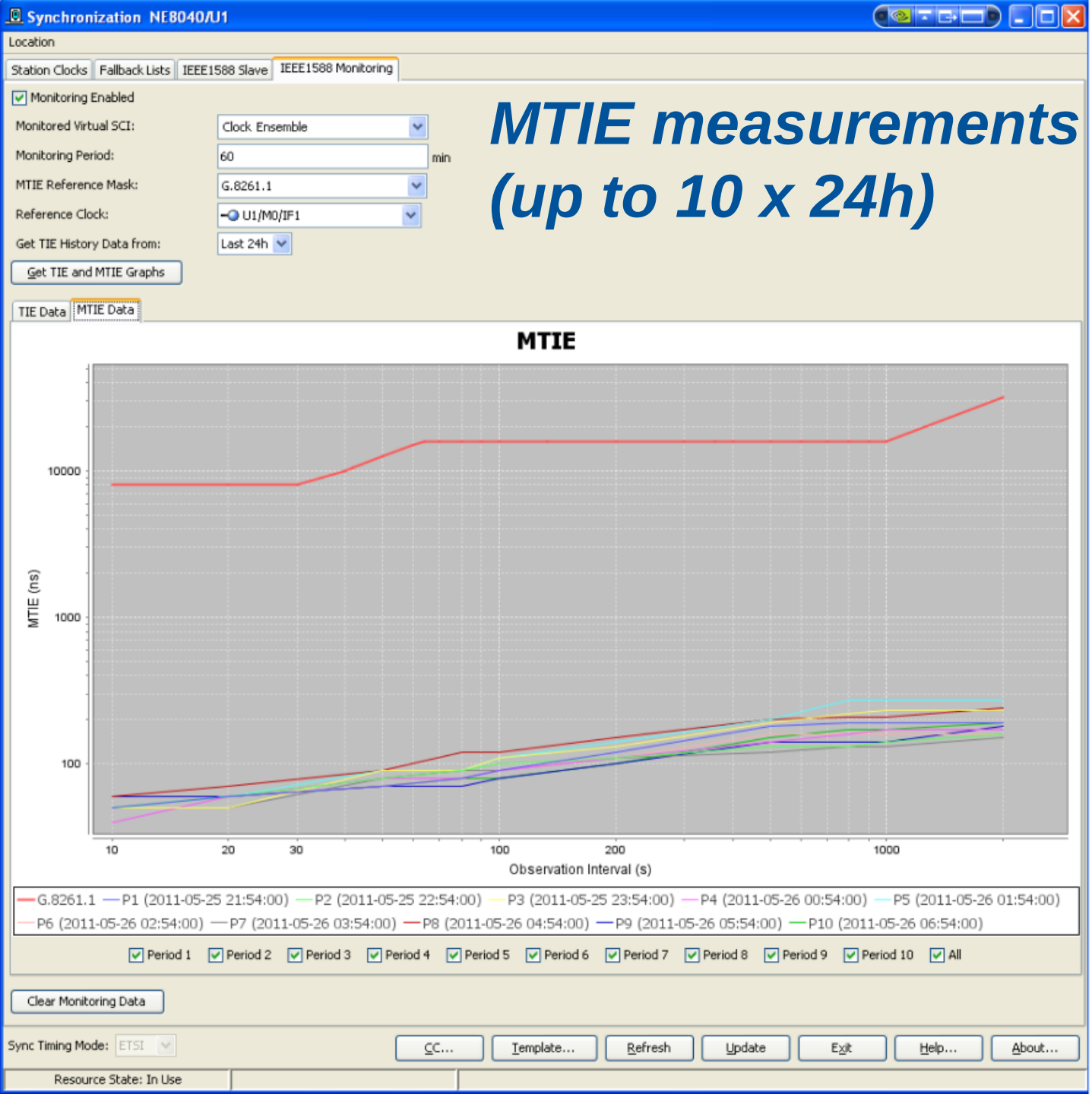
- True PEC output monitoring (Built-in wander meter)
- Needs a reference, but...
- Fortunately legacy provides the reference (temporarily).



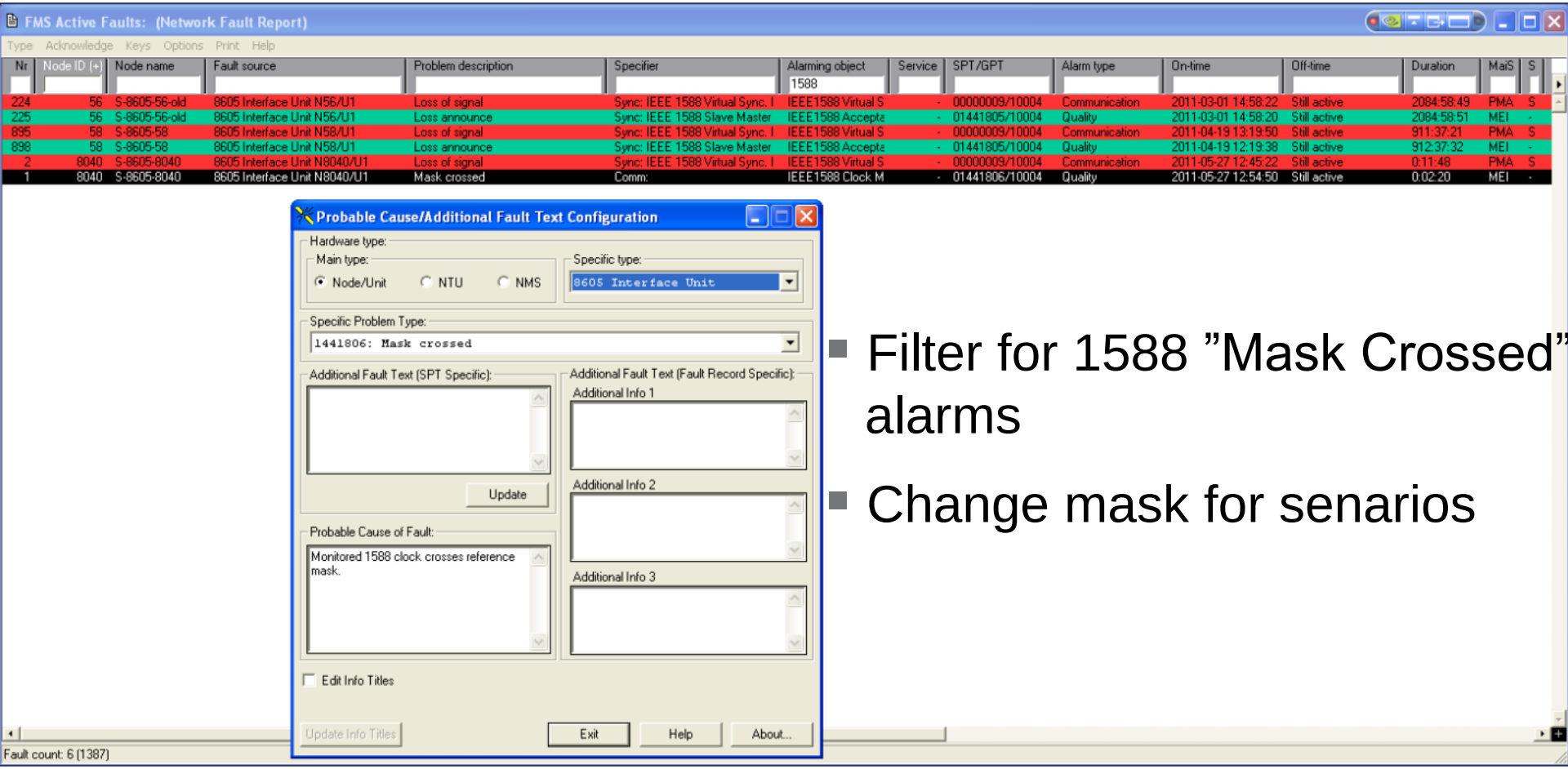
TIE measurements



MTIE measurements (up to 10 x 24h)



Which of my 10,000 nodes should I monitor?

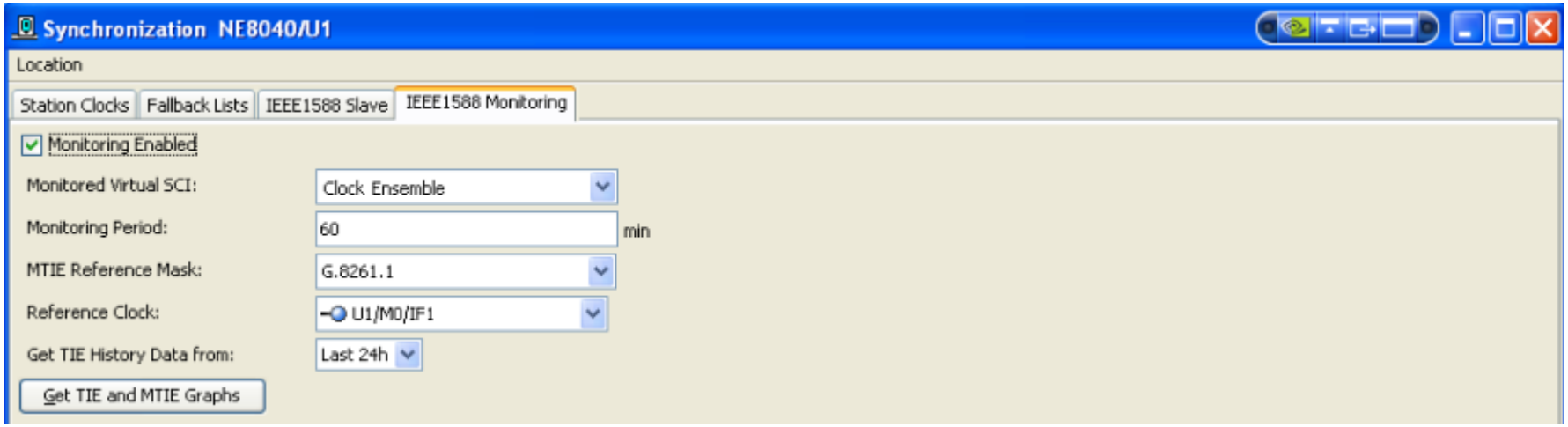


- Filter for 1588 ”Mask Crossed” alarms
- Change mask for senarios

Why not monitor all 10,000?

Network management Supports 1588 clock monitoring

- Select reference (for Migration use ”last E1”).
- Configure MTIE mask and monitoring period



- Set Fall Back List priorities (determines node clock)
  - E.g. Initially E1 then switch to PTP

Automate configuration using tools; rules and macros

Large scale evaluation of IEEE1588 performance (TDM to IEEE1588 migration)

Work flow:

1. Configure clock monitoring (Node clock = E1)
2. Periodically during migration
   - filter faults to show synchronization “trouble spots”
   - launch clock monitoring on selected node
   - optionally “tighten MTIE mask” for scenarios
3. Preference PTP over E1 (Node clock = PTP)

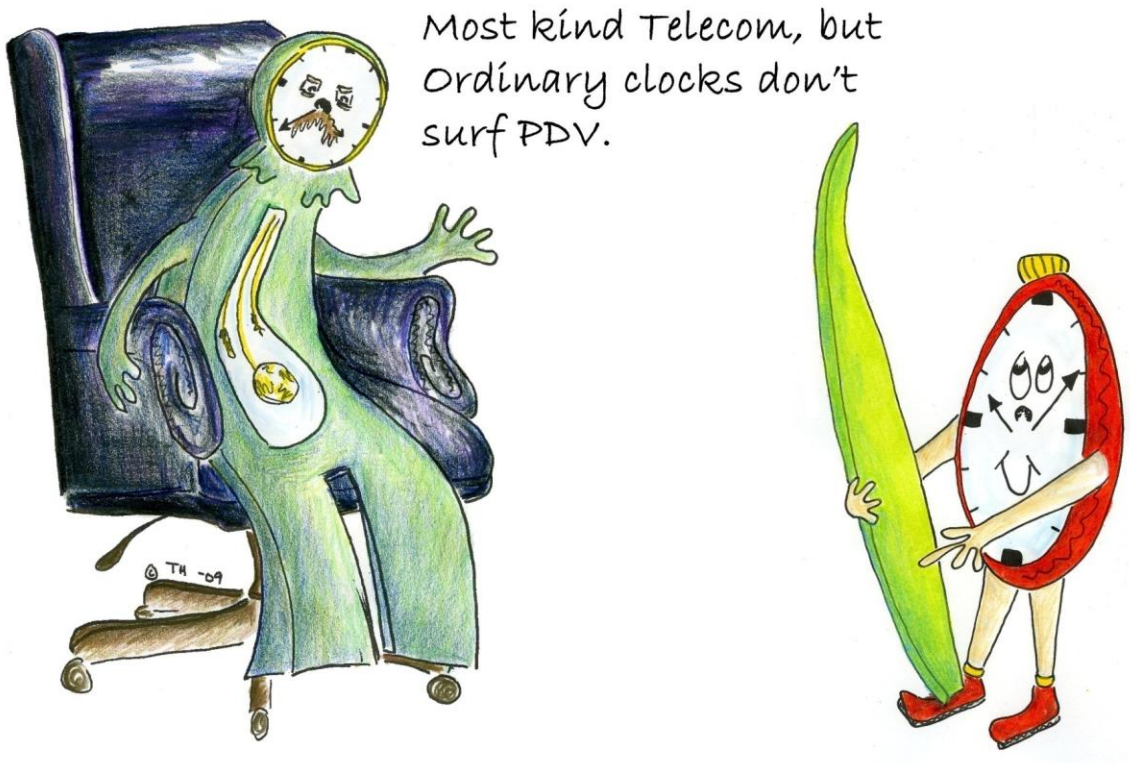
   (clock selection process does the “switchover)
4. Decommission the “last E1” from nodes

Perhaps leave a few measurements points...

4. Future Directions
(phase synchronization TDD/LTE adv.)

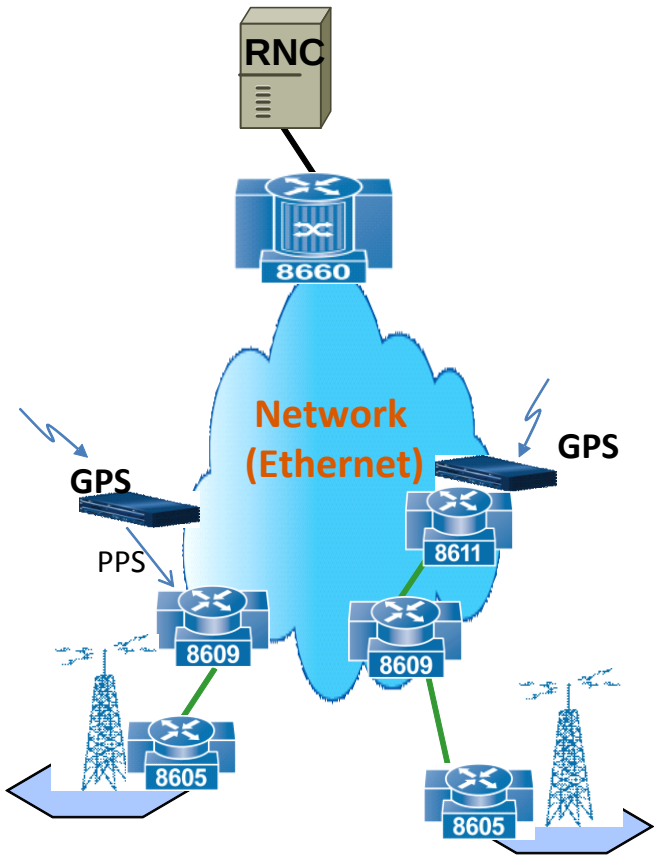
- ***Phase requirements (new network)***
- ***Telecoms boundary clock***
- ***Network phase & service phase***

Telecom Phase and frequency solutions are very different...



... but same management (SSM) for both

Prepare for the ”phase migration”

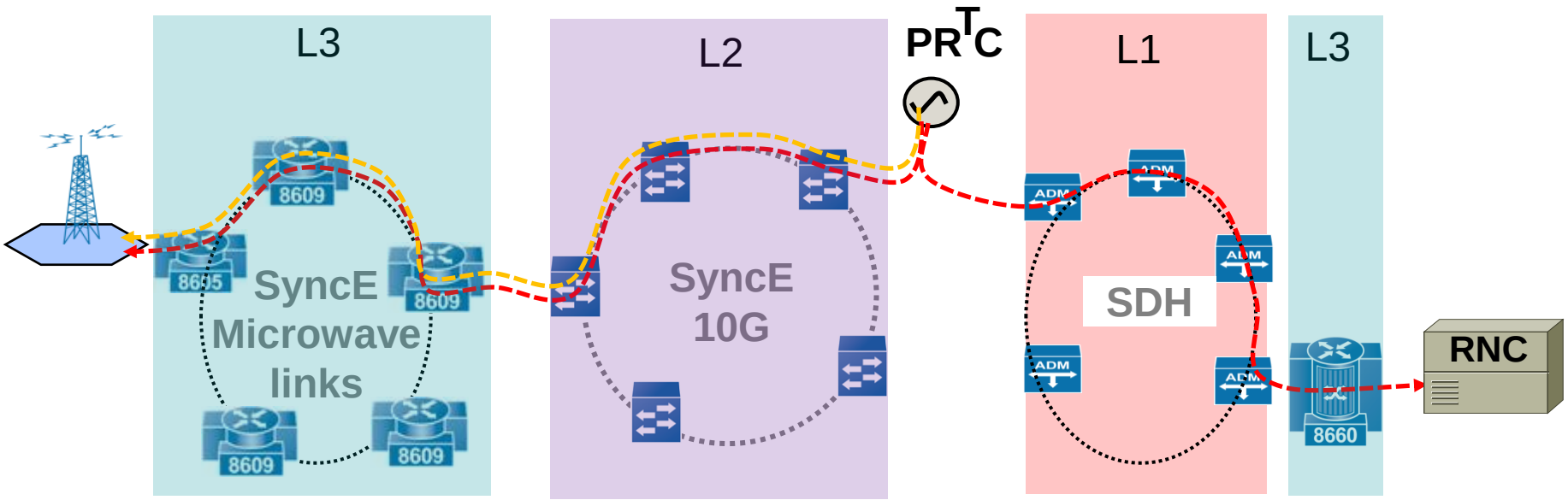


- LTE-TDD and LTE-advanced
  - Require phase synchronization
  - 1us or better accuracy
- GPS extension using IEEE1588
  - Standardization work ongoing
  - Nodes ”T-BC Hardware Ready”

Initially islands around GPS

Synchronization Topology

Provisioned, uses ”SSM” for ring protection



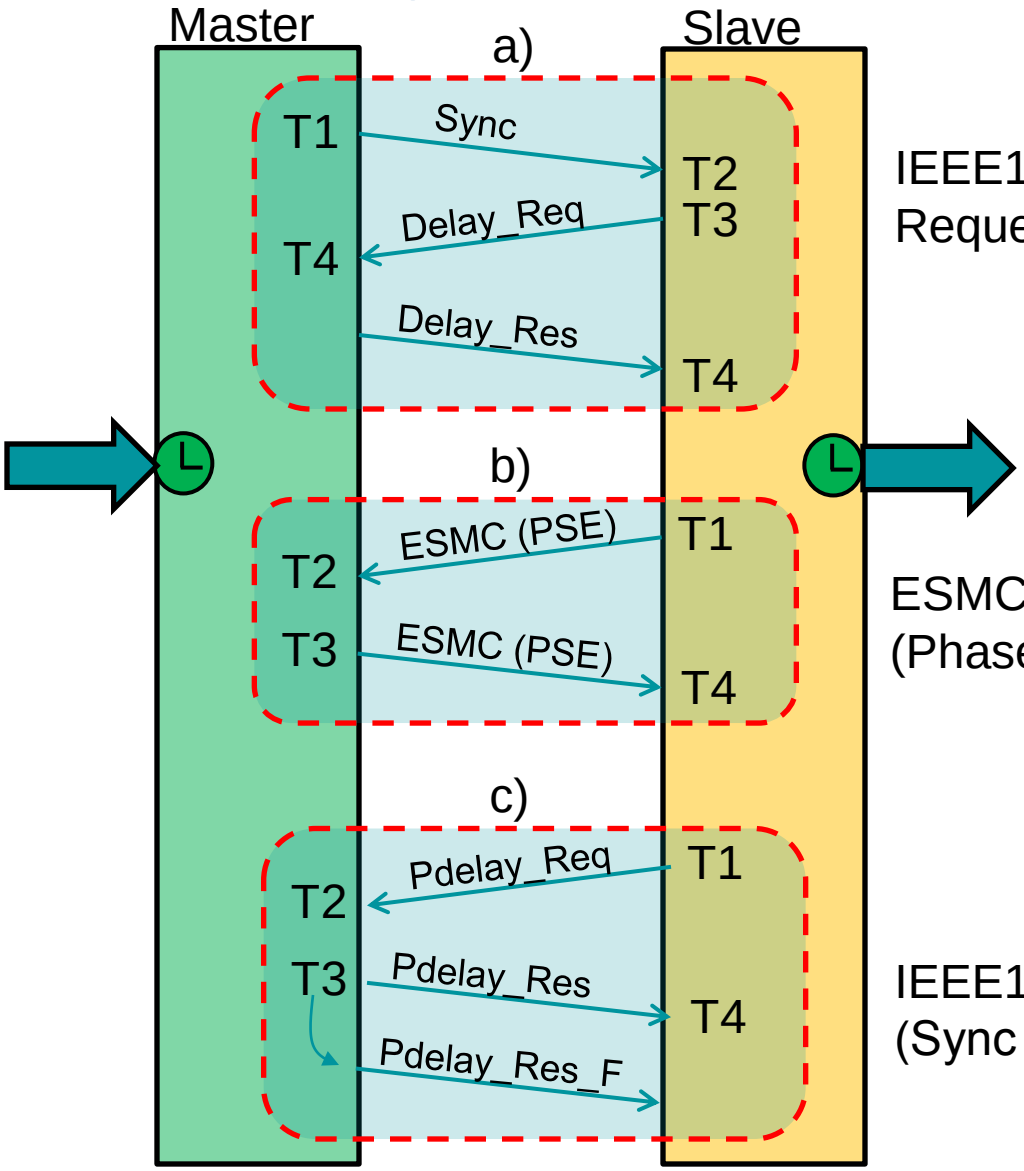
- Migration to support phase means
  - Upgrading PRC to PRTC
  - Upgrading EEC’s to T-BC’s

Network timing flow

Network phase flow

Topology management is the same for phase

Phase sync needs 4 timestamps
Delivery mechanisms differ...



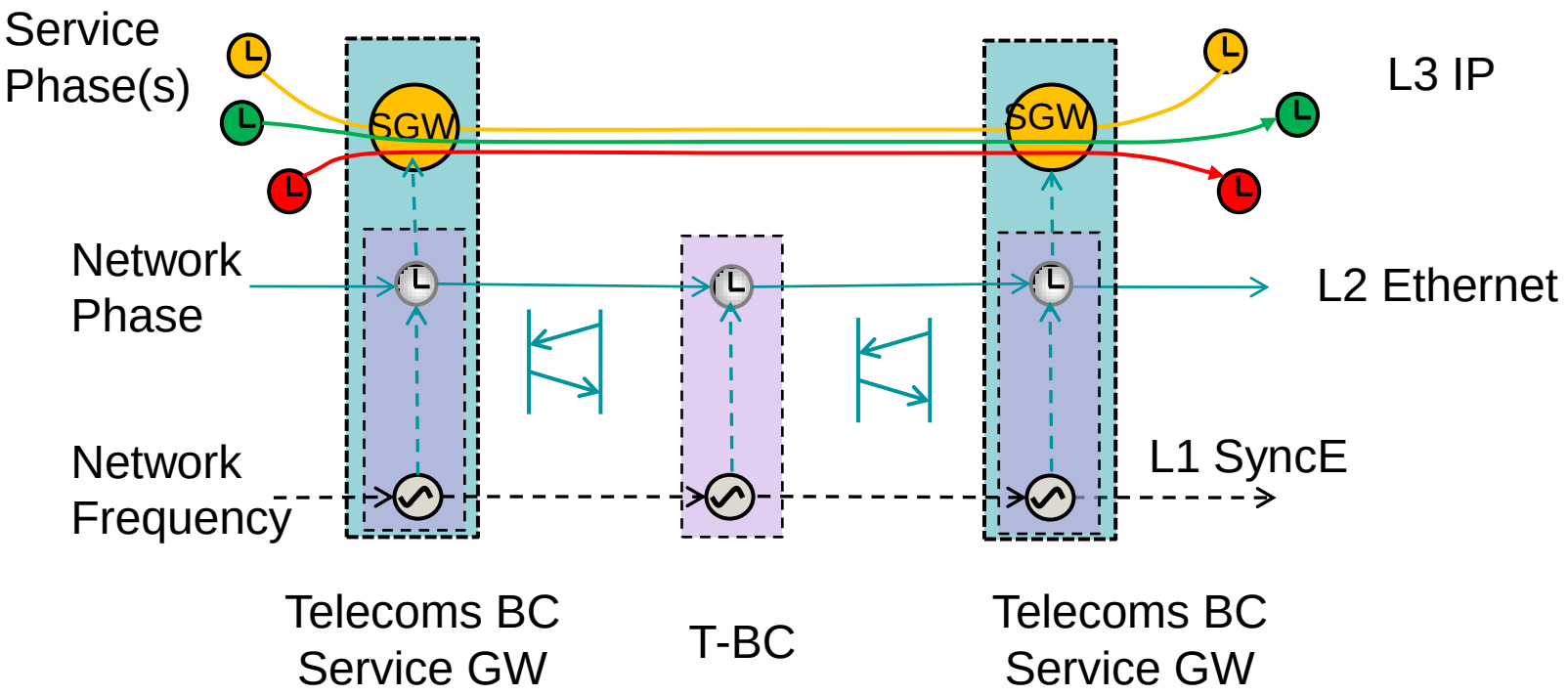
IEEE1588 Delay Request Mechanism

$$T_{offset} = \frac{-T_1 + T_2 + T_3 - T_4}{2}$$

ESMC timestamp mechanism (Phase Synchronous Ethernet)

IEEE1588 Pdelay Request Mechanism (Sync message free for ”Service Phase”)

Service phase and Network Phase



E.g. When a carrier has several mobile customers...

5. Conclusions

- Everyone is leaving “Legacy Land” on...
  - SyncE; PTP; Hybrid (or anything that floats)
- Packet Equipment clocks - ready for Ethernet prime-time
- PEC output monitoring gives a confidence boost
  - Last service of the “Last E1”
  - Large-scale, live network, field monitoring is available
- Prepare for 2nd migration
  - Phase support needs new clocks (Nodes “HW phase ready”)

“SSM” and the sync hierarchy remain the same!

Thank you!

Questions?

Enabling the mobile Internet

A PEC's got to know it's limitations