Packet Sync
A Practical Approach

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Chronos Perspective

- Experiences in synchronisation deployments for UK and Scandinavia
- Some operators now have no SDH left in mobile access network
- Many operators have deployed PTPv2
  - Slave clocks from various vendors giving required performance
  - On-going and future deployments
- Growing interest in SyncE
  - Lab trials/field trials at present
- This presentation shows some things I have found of interest…

Mobile Sync Requirements

- **GSM, UM[illegible] FDD, LTE FD[illegible]** requires ±50ppb frequency [illegible] interface of RBS

Done!

- **LTE-TDD** requires ±10μ[illegible] accuracy between [illegible] RBS

Thanks to all!

- **LTE-Advanced co-ordinated MultiPoint (CoMP)** may require as low as ±1μs <u>phase</u> accuracy between distributed RBS
  - Varied methods of deploying CoMP, firm sync requirements are yet to emerge
  - This level of phase accuracy is difficult using packet transport using current systems and network architecture

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Mastering the Master Clock

- The timing budget starts at the master clock(s)
  - Here, the user has full control over sync quality
- 1PPS & Time Of Day accuracy at the receiver is affected if cable infrastructure settings are ignored
  - Incorrect antenna cable length delay adds ~45ns inaccuracy for every 10 meters
- GPS Jamming becoming an issue
  - important to have a resilient and redundant systems
  - Other PRC reference choices becoming available
    - PTP/Rb PRC
    - eLORAN
    - Other GNSS systems

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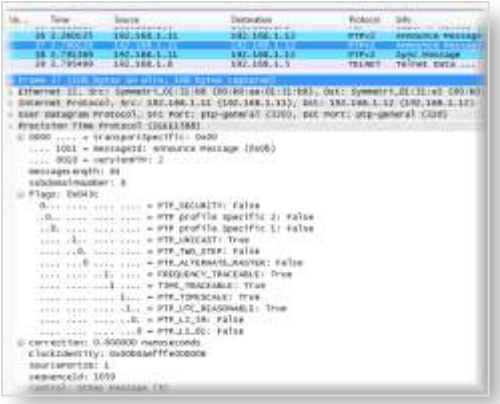
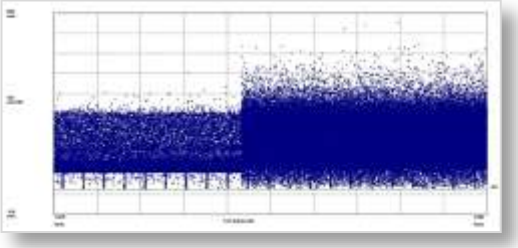
Timing Transport - PTPv2

- PTPv2 now fully trialled by a most operators and deployed by many
- Very noticeable variation in slave clock performance between vendors
  - Packet metrics and packet KPIs are not standardised
  - However, operators are able to engineer networks to achieve required performance
- Use of long-term sync monitoring solutions at selected sites of interest give confidence
  - Furthest from GM
  - High traffic





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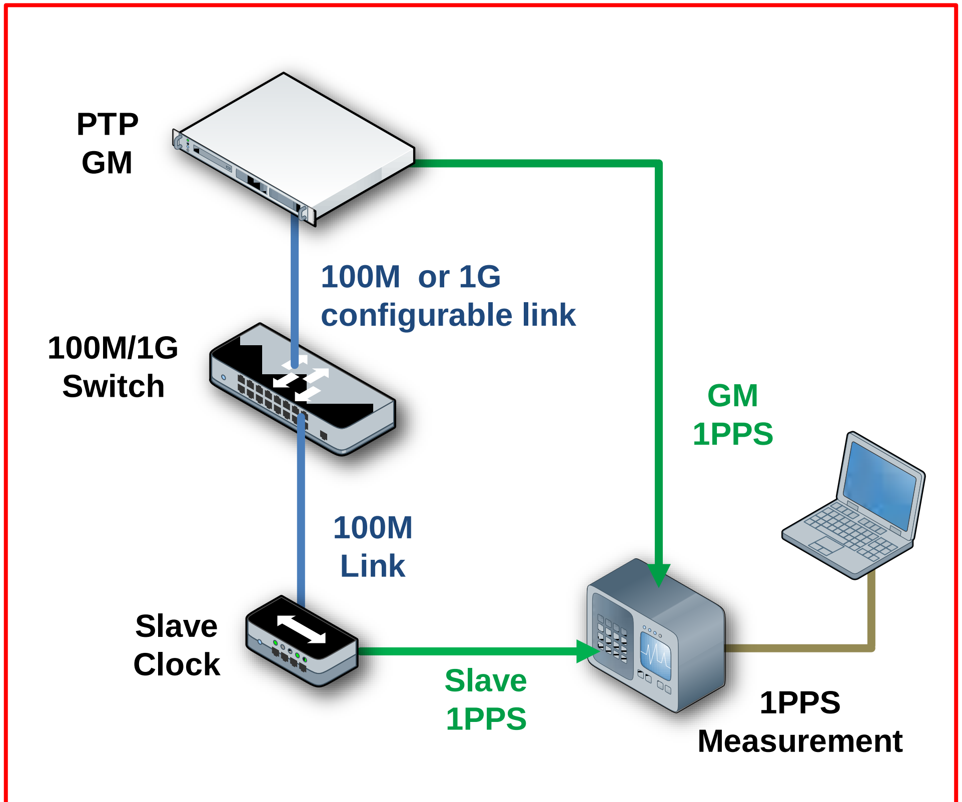
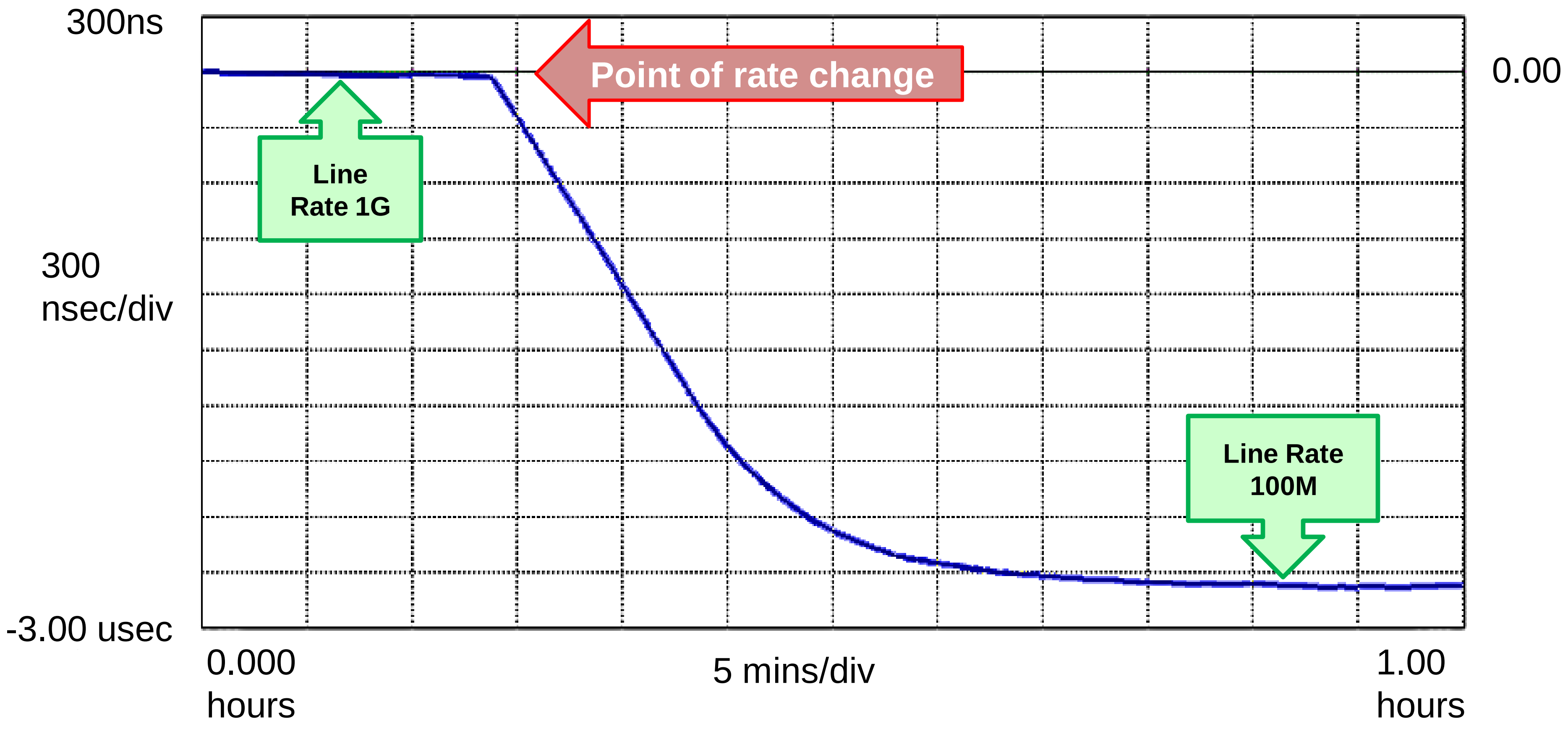
Ethernet Line Rate Asymmetry

- Typical PTPv2 slave clock Ethernet line rates are 1Gbps or 100Mbps
- Typical PTPv2 GM line rates are 1Gbps
- Line rate affects the time taken to ‘read in’ packets before processing
- Differing line rates cause asymmetry in the network path
- Asymmetry = phase offset at the slave clock



Test Setup for Line Rate Effects

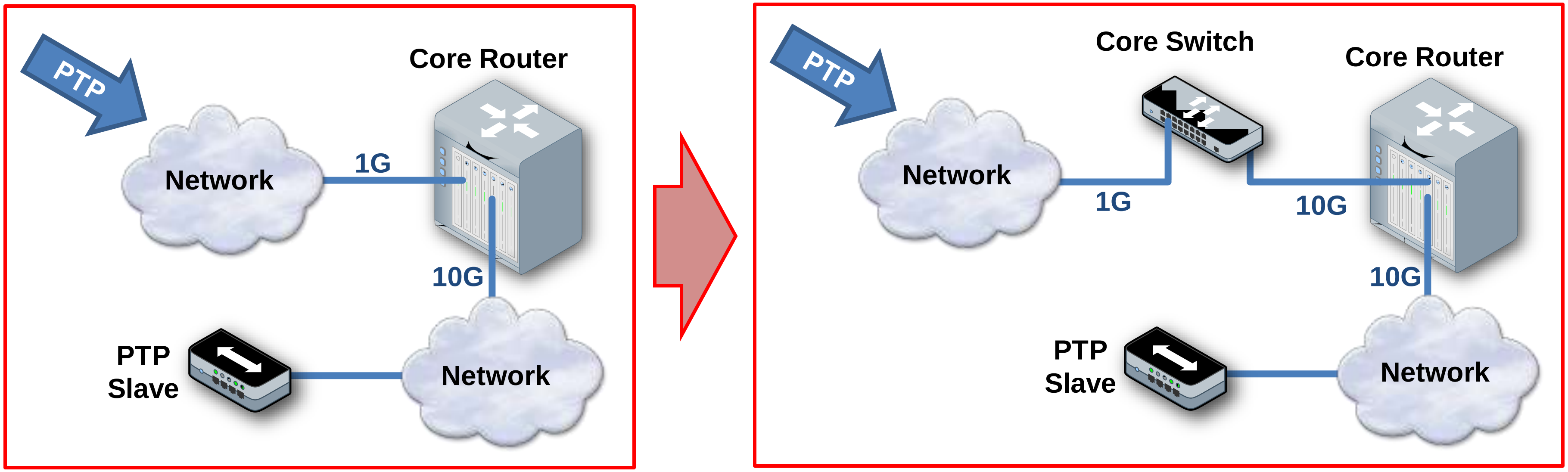
Changed Line Rate - 1PPS Slave Offset



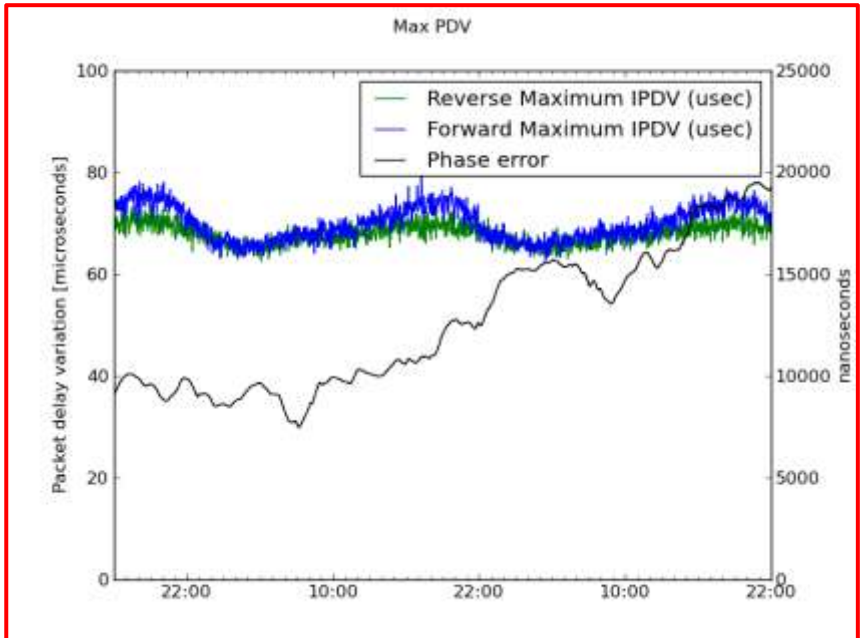
-2.8μs offset as a result of 1G to 100M Ethernet line rate change
PTPv2 packets experienced 5.6μs longer ‘read in’ time in upstream - halved

Ethernet Line Card PDV

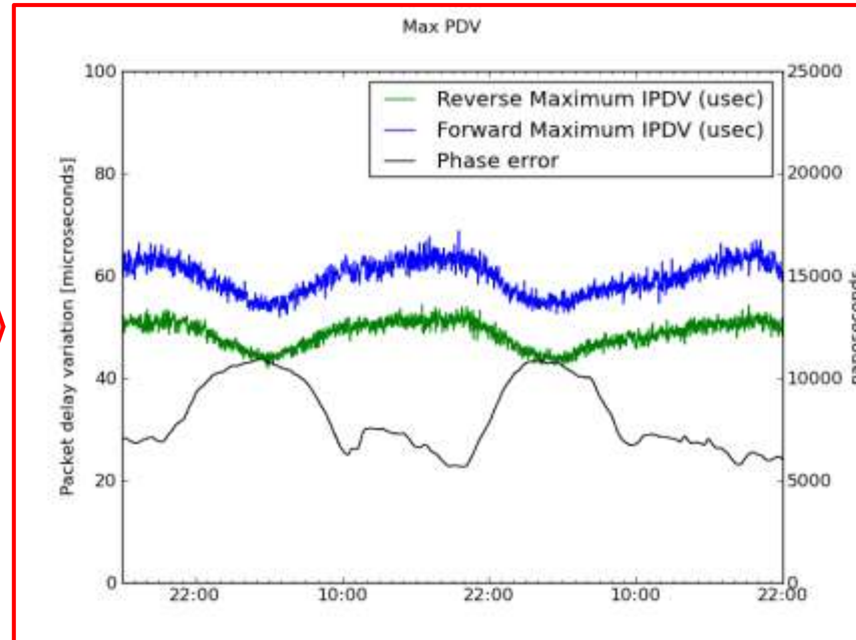
- Some Ethernet line cards can add more PDV than an extra 'hop'
- Example of this - mobile operator monitoring the measured flow stats at slave clock noticed unusually high 'Max IPDV' statistic…
- ….Isolated it to a 1G line card and removed this from path by using another switch to perform the required link speed change before problem card
- This added a network 'hop' but reduced max IPDV seen at slave clock by 20µs



IPDV at Slave – Line Card Changed



Max IPDV with original line card:
Forward=70µs Reverse=70µs



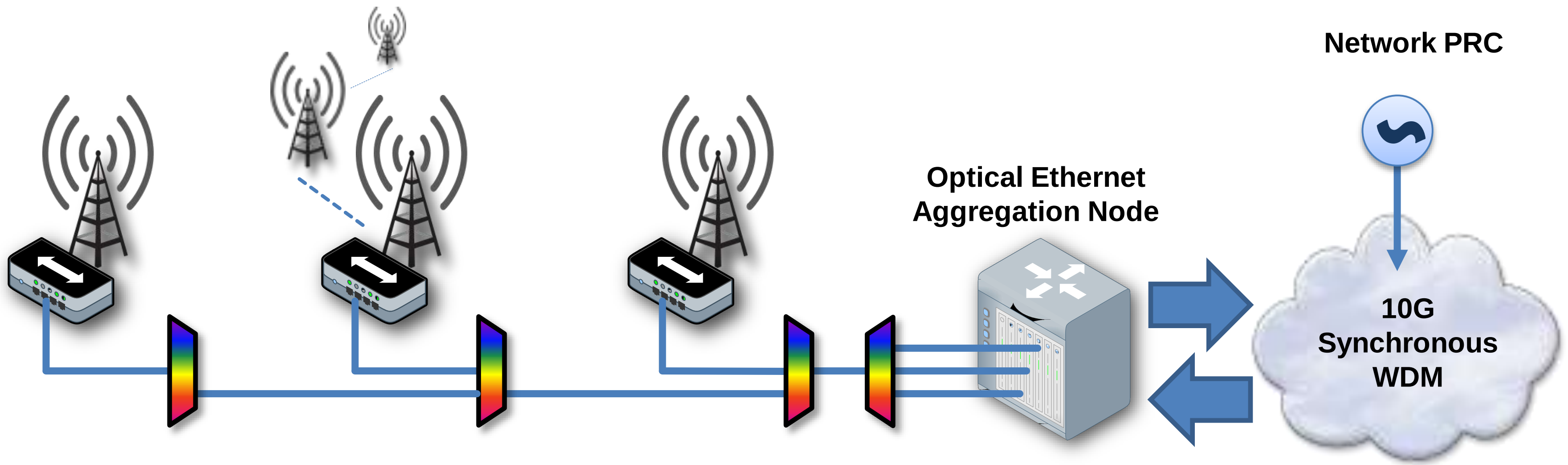
Max IPDV with added switch:
Forward=60µs Reverse=50µs

- IPDV Measurements were made by slave clock only. Slave TIE had GPS reference.
- Forward IPDV now greater than reverse (normal) – another ‘feature’ of line card?
- Slave Clock TIE (E1 test point). Shows better medium/long term stability.
- All results also show diurnal increase/decrease in IPDV due to overall network traffic

Timing Transport - SyncE

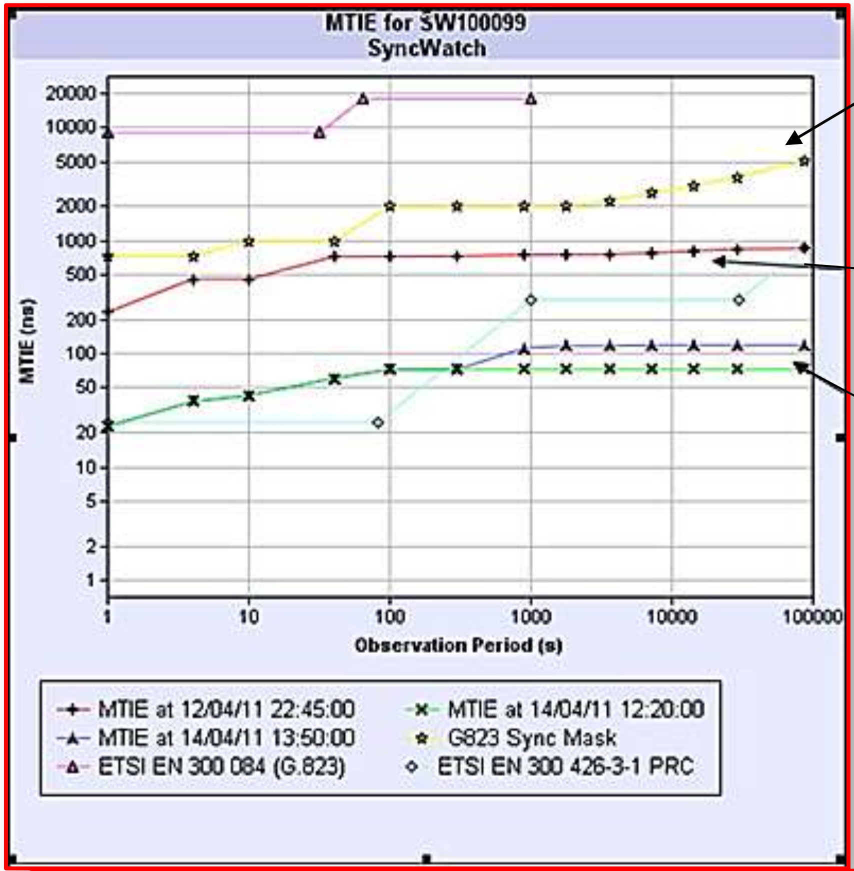
- Physical layer, frequency only distribution currently…
  - Maybe by the time I present this slide I will know of developments in this area!
- Seeing big interest in this as a ‘drop in’ sync replacement for SDH core and access networks
  - Especially when utilising existing GSM, GSM-R and 3G base stations
- Possibility to use existing SDH Sync Supply Units (SSU) alongside SyncE distribution
  - Recovered SyncE clock jitter can be attenuated by SSU and reinserted, allowing longer sync chains

Tested - Packet Optical System



- Method of transporting sync and data backhaul to/from RBS
- Use of passive optical splitters instead of active nodes
  - No jitter or wander introduced to SyncE
  - Zero ‘hops’ for PTPv2
- Better sync at ‘head end’ base stations allows budget for longer ‘chains’ of microwave-to-microwave links with ‘in spec’ sync at the furthest node

Packet Optical System - Results



Yellow – G.823 Sync mask.

Red - The performance of the E1 based sync in the existing network

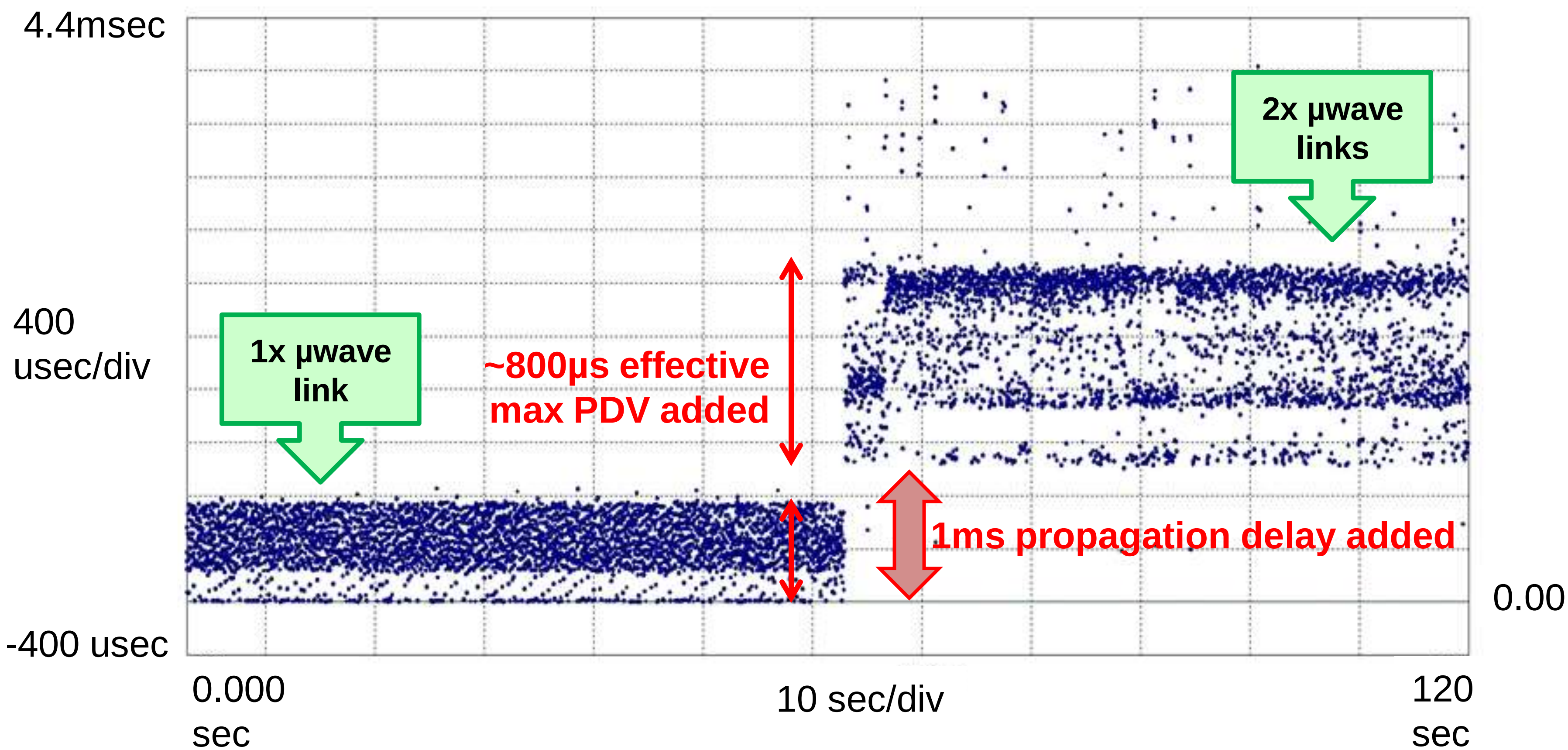
Green - The even better performance with SyncE over Packet Optical System.

Measurement performed over a period of a month in a live network.
Multiple fibre distribution units over 200+ km live network (6 equipment 'hops')
Traffic running at 100% throughput

Microwave Transport

- Microwave is a ‘harsh’ environment for PTPv2 transport
- Microwave factors that affect on PTPv2:
  - Adaptive Coding and Modulation – link speed varies, usually due to weather conditions
  - Above can cause variable buffering
  - Blocking of PTPv2 packets can occur if frames are already in the process of being transmitted
- Native SyncE should not incur the above (PTPv2) issues but expect signific jitter increase per ‘hop’
- Proprietary solutions provide exclusive channels for PTPv2 traffic or transfer SyncE
  - Not performed much testing in this area at present but would like to!

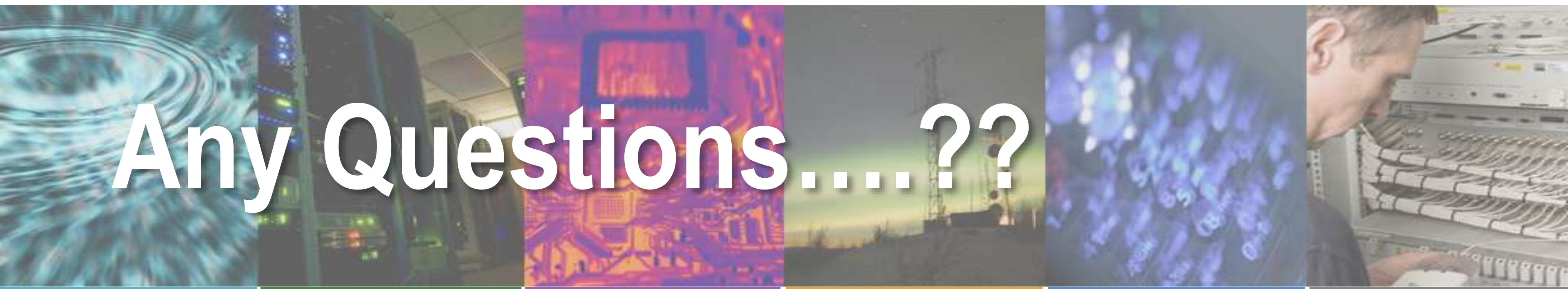
PTPv2 – Adding a µwave Link



Network traffic load at 90% at all times (PTPv2 traffic was in highest QoS class)
1ms change in propagation delay as effect of added link (symmetric)
Large increase in PDV compared to fixed line 'hops'

Conclusions

- **Master Clock**
  - Measure the cable delay
  - Resiliency and redundancy in all aspects
- **PTPv2**
  - Know, and compensate for, asymmetry
  - Characterise the network transport hardware
- **SyncE**
  - Very good frequency performance is achievable
  - Being seen as a ‘drop in’ replacement for TDM in networks/segments
- **Microwave Sync Transport**
  - Sending standard sync traffic across µwave links is a challenge
  - Using dedicated sync channels should give better sync transfer – testing required
- **Testing and monitoring is key..**
  - Before, during, and after deployment…!



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