Developing and deploying PTP now.

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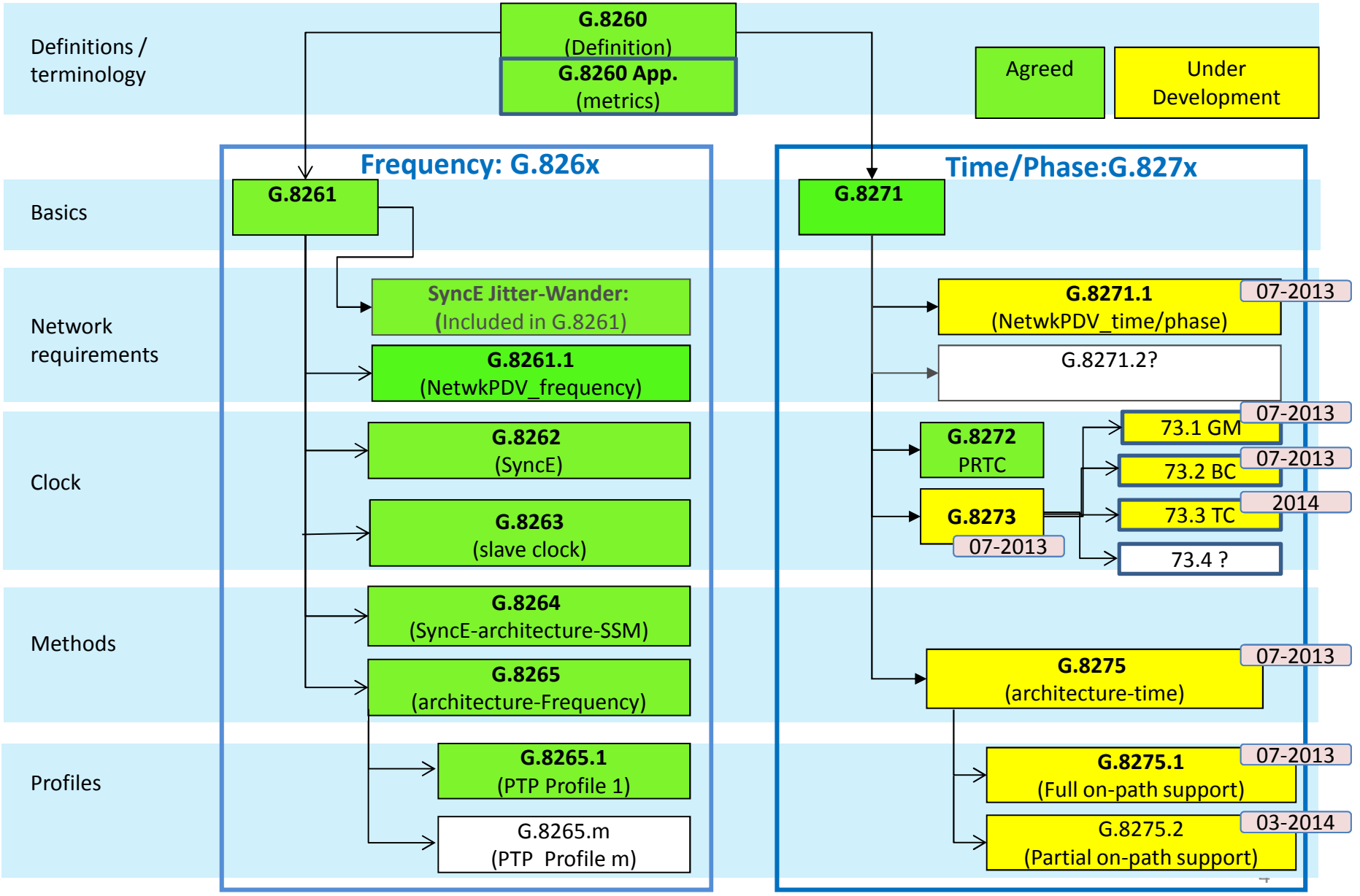
Synchronisation hot-topics over the last year: What's driving innovation?

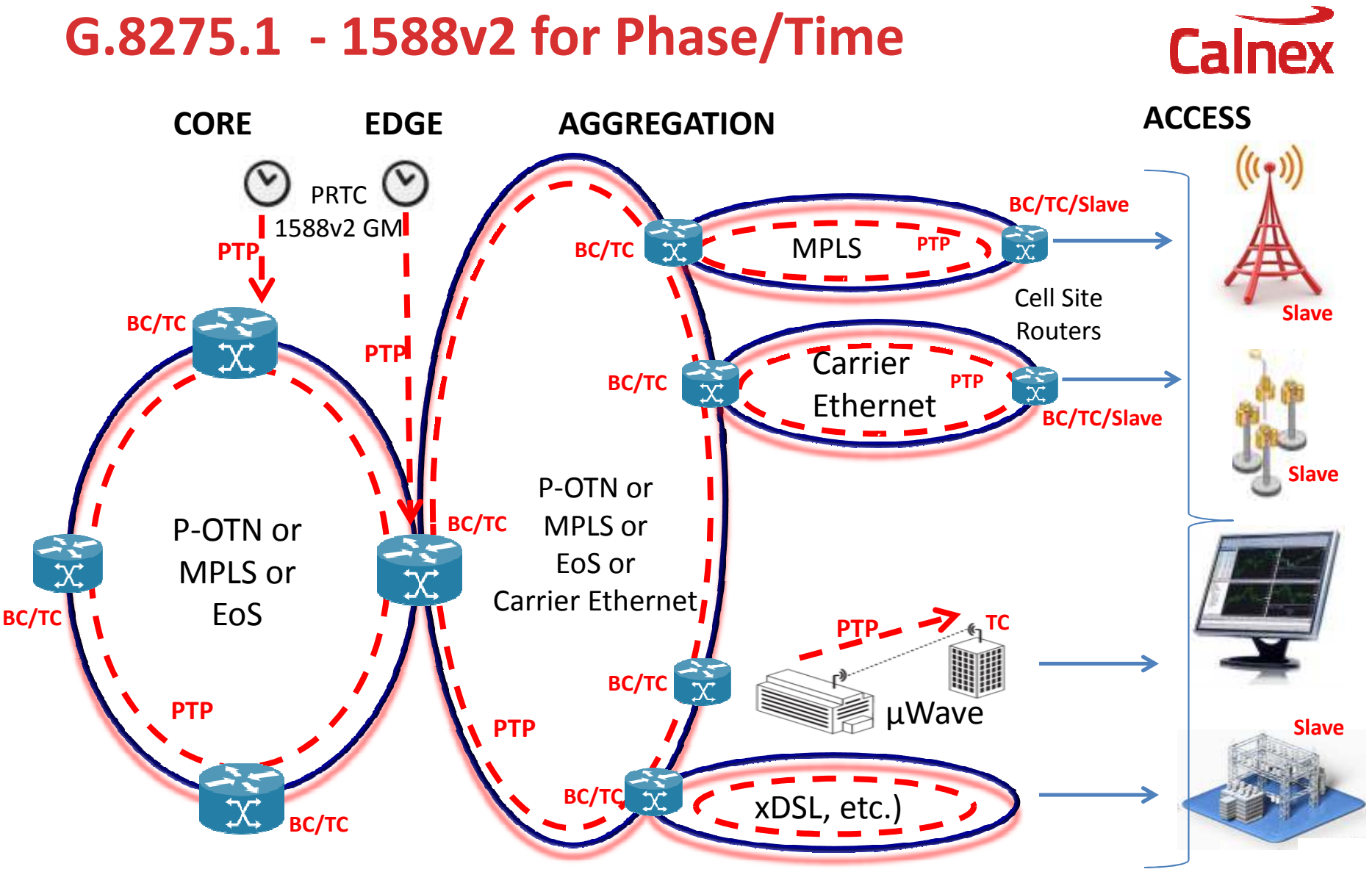
- Detailed investigation into delivery of Time/Phase.
  - Using T-BCs with/without SyncE .
  - Using T-TCs.
- Need for support of Partial On-path support topologies.
- Discussion on the needs of Small Cells & Small Cell clusters.
  - More bandwidth through more complex technologies.
- Proof of Concept trials by Operators.

Hot Topic: Time/Phase delivery

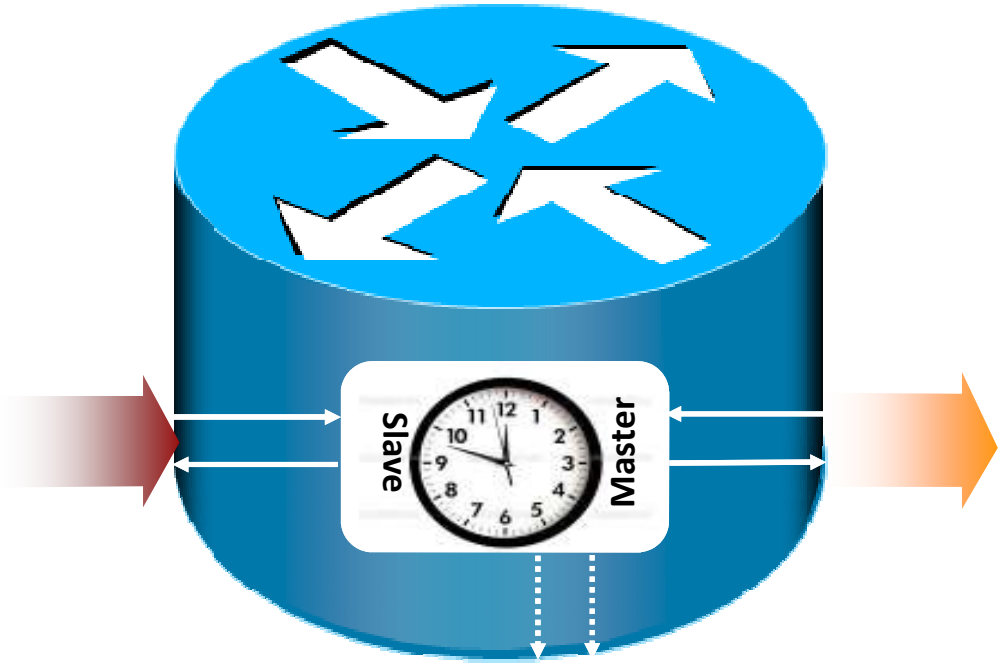
ITU-T Sync recommendations



G.8275.1 - 1588v2 for Phase/Time



Boundary Clock



Boundary Clocks reduce PDV accumulation by;

- Terminates the PTP flow and recovers the reference timing.
- Generate a new PTP flow using the local time reference, (which is locked to the recovered time).
- No direct transfer of PDV from input to output.

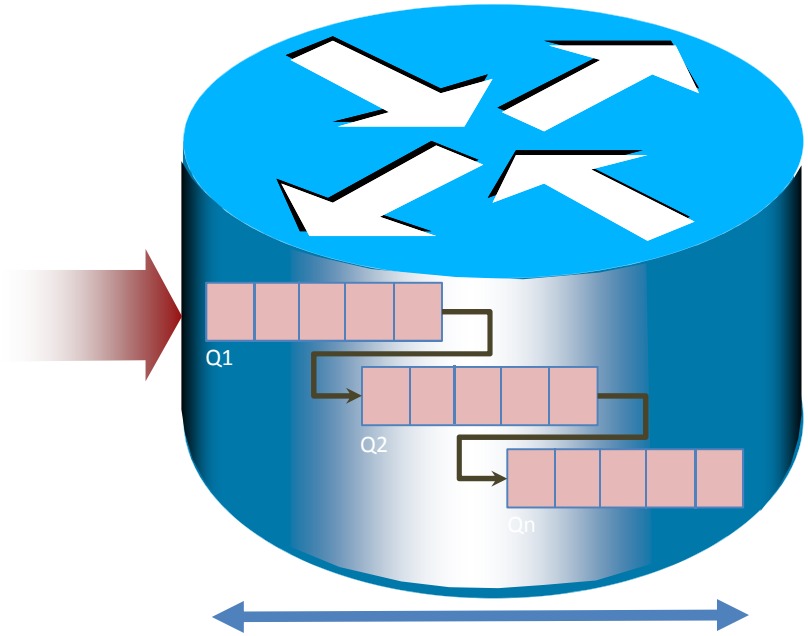
Boundary Clock is in effect a back-to-back Slave+Master.

- **Optionally can utilise SyncE for frequency transfer.**

Transparent Clock

Transparent Clocks reduce PDV by;

- Calculating the time a PTP packet resides in the TC device (in nsec) and insert the value into the correctionField.
- By using the correctionField, the Slave or terminating BC can effectively remove the PDV introduced by the TC.
- Can also be transferring SyncE in the Physical layer. SyncE will have less benefit to T-TC performance compared to T-BC performance case as ***'just'*** packet latency measured, which can be done with a good local oscillator.

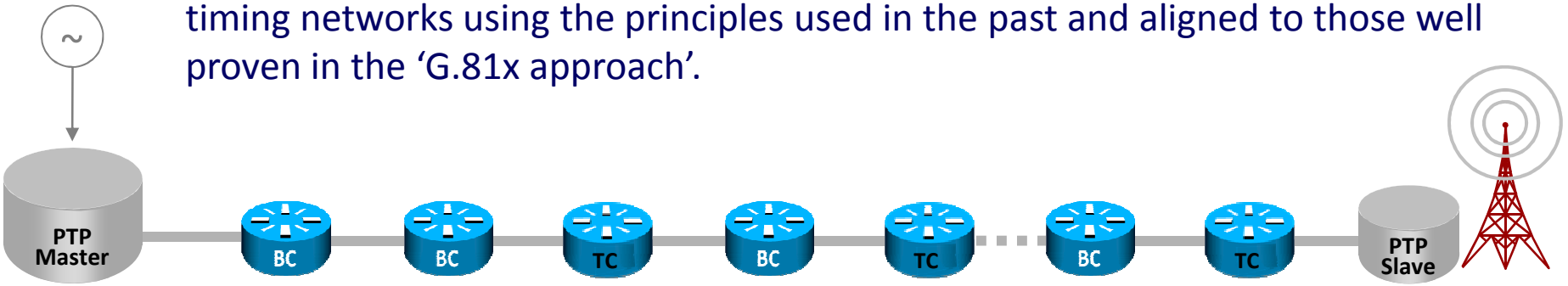


Packet Delay in TC Device
inserted into correctionField
at output of Transparent Clock device

PTP Message Header Format							
Bits							
7	6	5	4	3	2	1	0
transportSpecific				messageType			
Reserved				versionPTP			
messageLength							
domainNumber							
Reserved							
Flags							
correctionField							
Reserved							

Networks with '1588v2 aware' switches

- **The 'G.81x approach' offers a Standards-based structured, bottom-up approach.**
  - The performance of each device in the path is know and has been proven.
  - Adhere to topology guidelines and the resulting network performance **will be within defined performance limits.**
- **With full On-path support of 1588v2 aware switches, it should be possible to deliver packet networks using a 'G.81x approach'.**
  - Work on-going in ITU-T SG15, Q.13 to simulate networks of BCs with the objective of specific performance requirements of individual and chains of BCs.
  - Once specifications are in place, then BCs &/or TCs can be qualify and provided the guidelines to building networks is adhered to, it should be possible to build timing networks using the principles used in the past and aligned to those well proven in the 'G.81x approach'.



PoC: Network Evaluation for Full On-path Support

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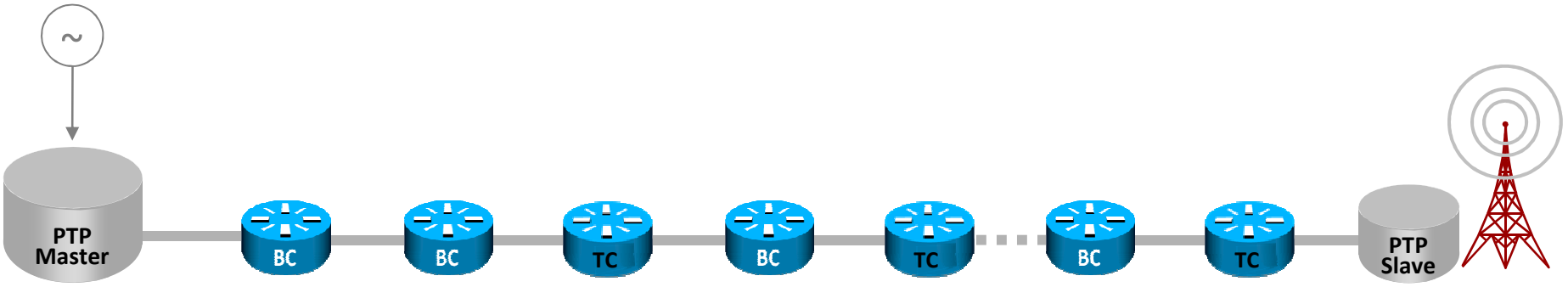
- **Evaluate each 1588v2 aware device.**
  - T-BC: Time Noise Generation, Time Noise Tolerance, Time Noise Transfer, etc.
  - T-TC: Accuracy of correctionField.
- **Evaluation of networks of devices**
  - Verification of error accumulation through chains of devices.
  - Verification of Slave performance when stressed with ‘accumulated error’.
- **Future: Performance specified in ITU-T Standards e.g. G.8273.2 for T-BC.**
  Today: Perform Lab Evaluation to develop deployment plan.



PoC: T-BC Noise Accumulation trial

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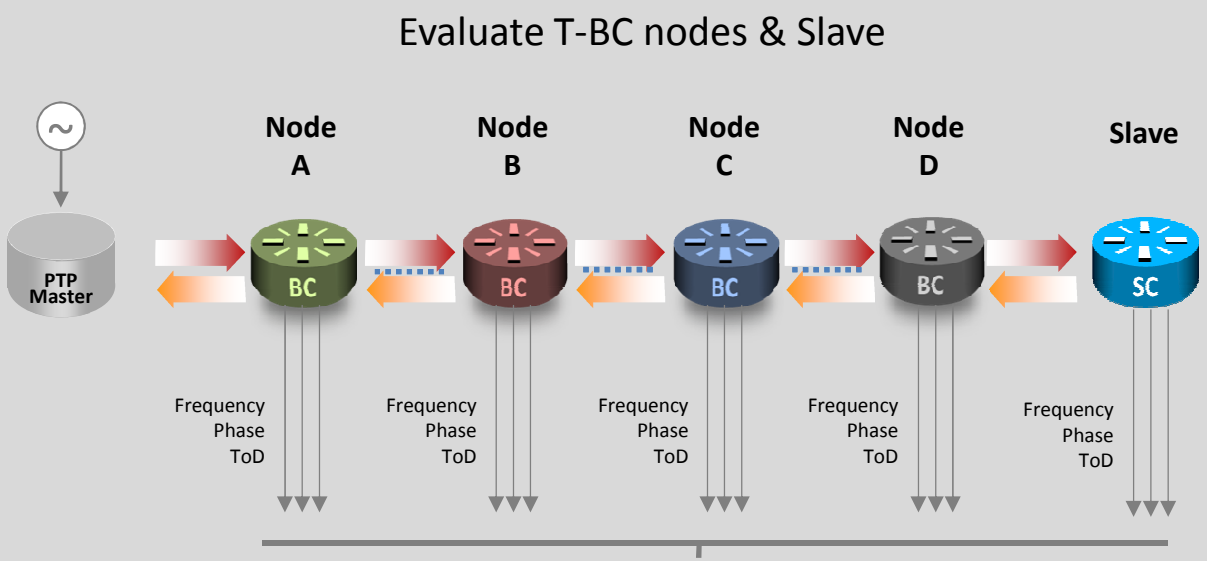

Time/Phase Time Error Accumulation

- Compare multiple T-BCs & Slave in a chain.
- Trial dependent on expected deployments.
  - Different or all the same manufacturer?
- Develop rules for your network.

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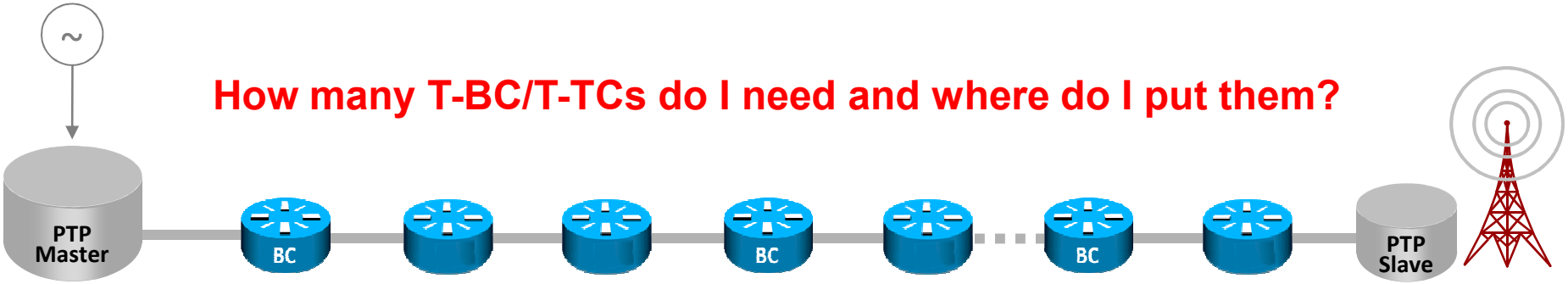
Hot Topic: Partial On-path

Partial On-path Support

G.8275.2: The second ITU-T Time profile will specific Partial On-path support networks for Time transfer.

- Operators, lead by US Operators (AT&T, Sprint, Verizon) highlighting to ITU-T Q.13 the practical need for a set of documents to define the use of Partial On-path Support.
  - Not practical for all nodes to be T-BCs or T-TCs every time 1588v2 is transported across a network.
- Definition work underway in ITU-T Q.13.



PoC: Partial On-path support

Time/Phase Time Error Accumulation

- Evaluate sub-network combinations to develop rules for **'how many?'** and **'how often?'**
- Evaluate performance of each 1588v2 aware device.
- Evaluate networks of devices aligned to expected topologies.
- Develop rules for your network.

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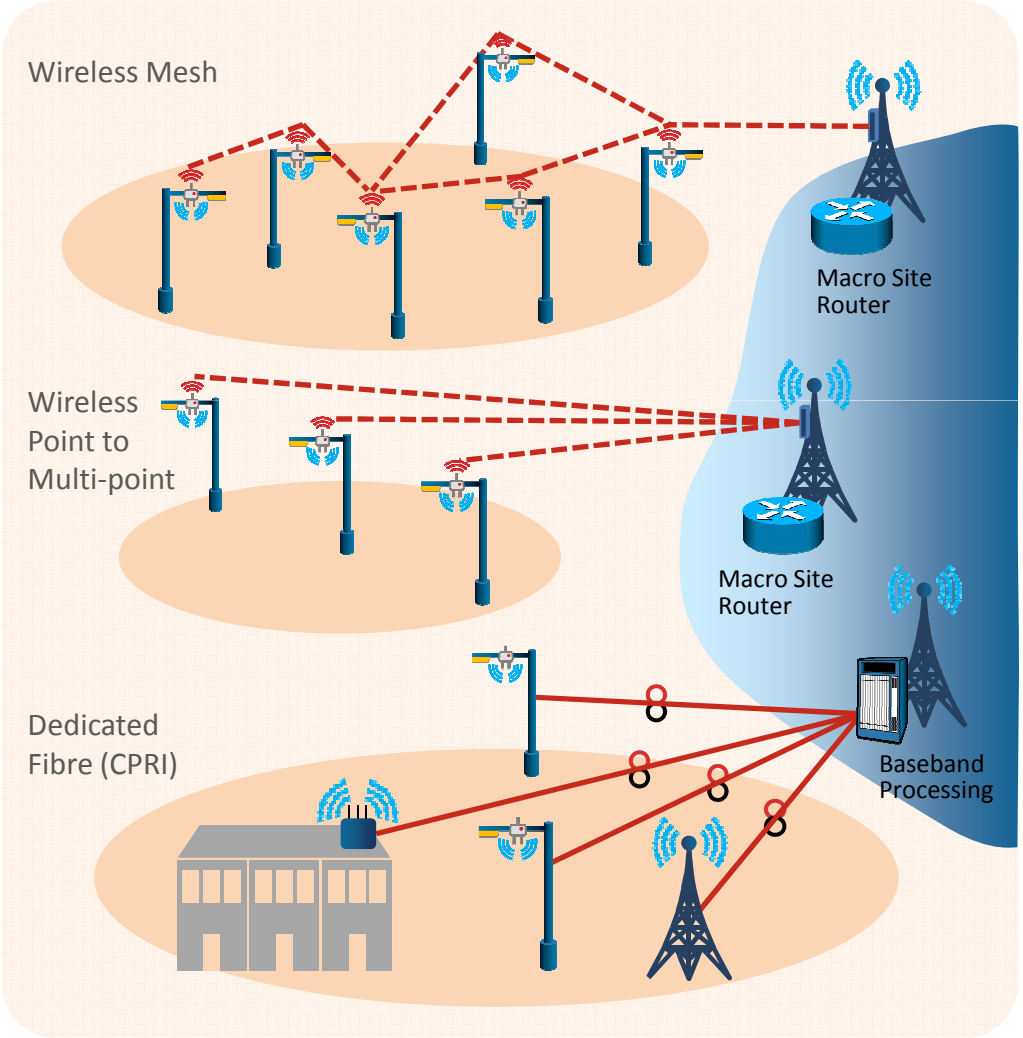
Hot Topic: Small Cells

The Need for Small Cells

- **Increase capacity and coverage in high usage pockets**
  - Town Centres, Shopping Malls, Sports arena, Business parks, etc.
- **Benefits**
  - Increase capacity
  - Offload congested Macro cells
  - Densify coverage
- **Deployment method**
  - Wirelessaccess
  - Fibre access
- **Technology proliferation**
  - eICIC, MIMO, CoMP, etc.
- **Frequency & Phase/Time sync required**
  - Delivered through wireless links
  - Tight requirement necessary especially for new technologies



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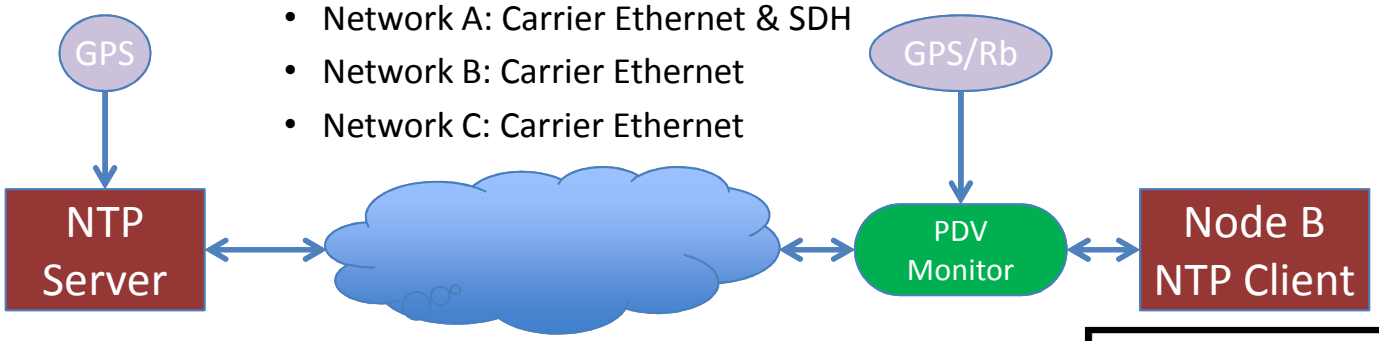
PoC: Case Studies – Network Trials

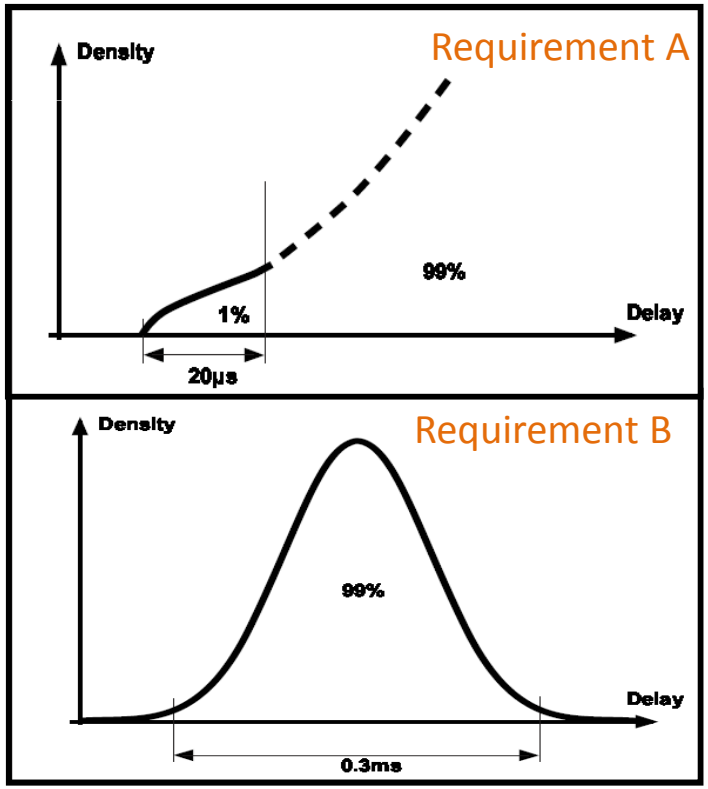
Case Study 1: Network and Requirements



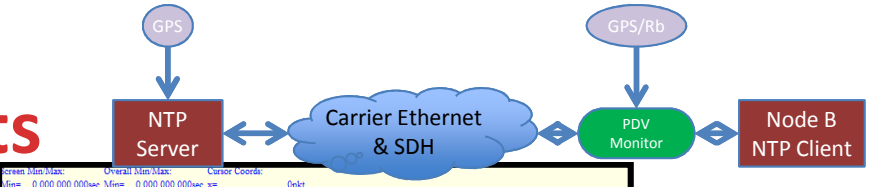
- Network A: Carrier Ethernet & SDH
- Network B: Carrier Ethernet
- Network C: Carrier Ethernet

Node B requirements:

- The Node B will lock within a 16 minute period if either
  a) 1% of packets within 20µsec of Noise Floor, or
  b) 99% of packets with <0.3msec spread.
- If case b) is greater than 0.3msec, then
  - If 99% with <3msec spread, will lock within 60 minutes.
  - If 99% with <10msec spread, will lock within 180 minutes.



Network A Results



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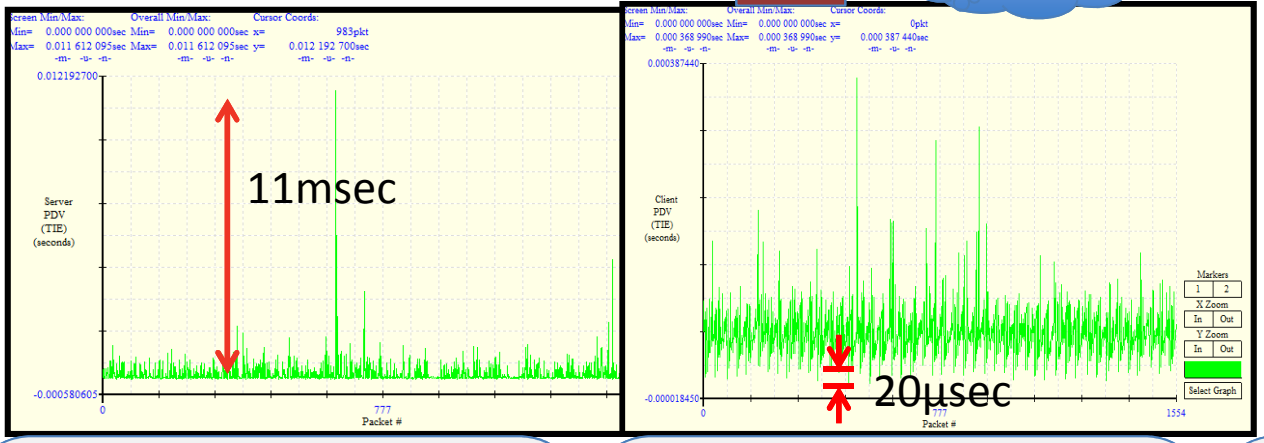
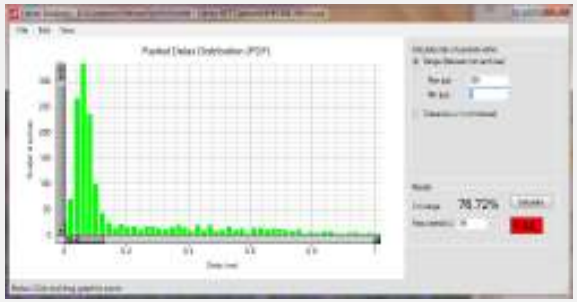


For 16 min Lock, either
- a) 1% within 20µsec, or
- b) 99% with <0.3msec spread.

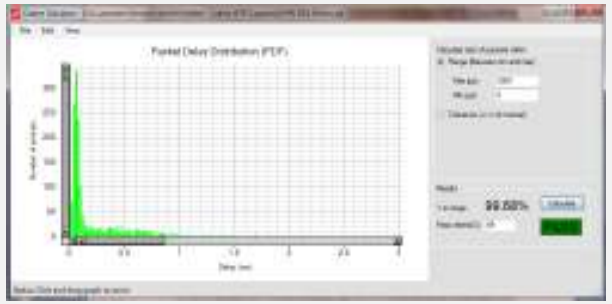
For 60min Lock,
- If 99% with <3msec spread

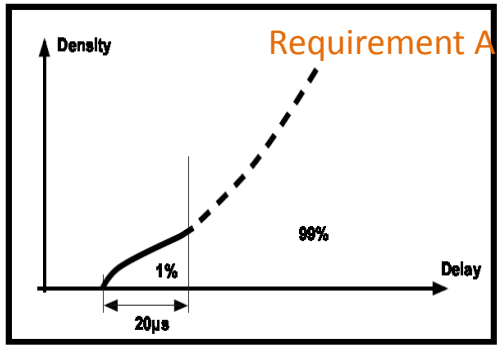
Result A: 1% in 20usec, FAIL

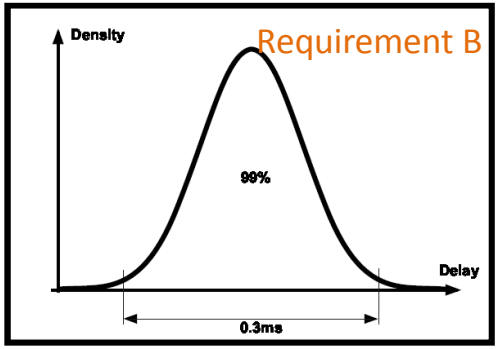
Result B: 99% in 0.3msec spread,



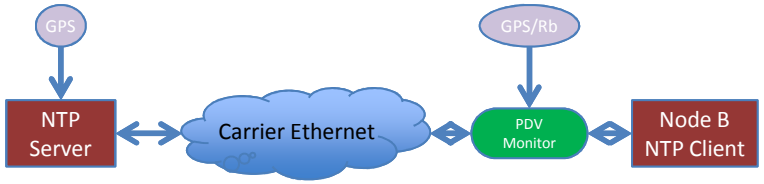
Result C: 99% in 3msec spread, **PASS**







Network B Results



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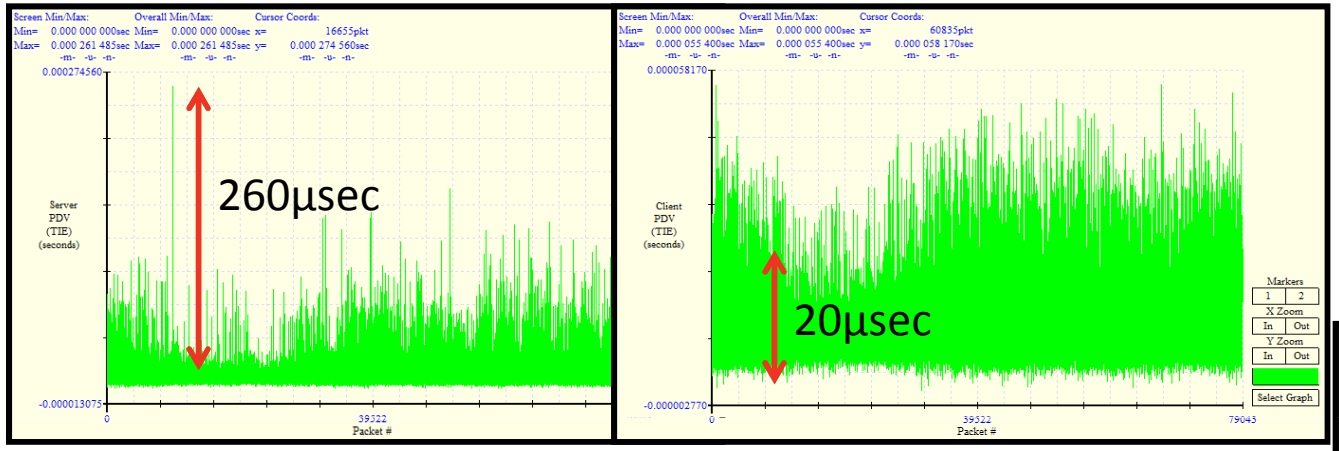

For 16 min Lock if either

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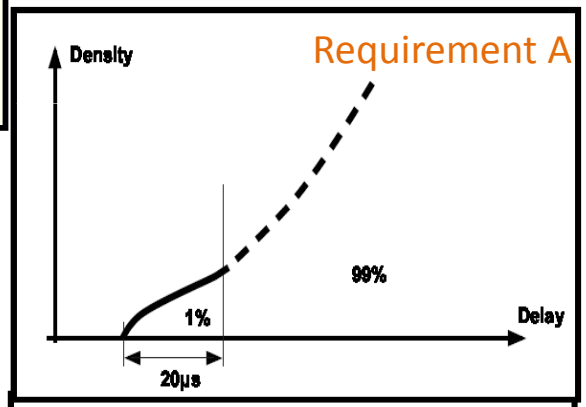
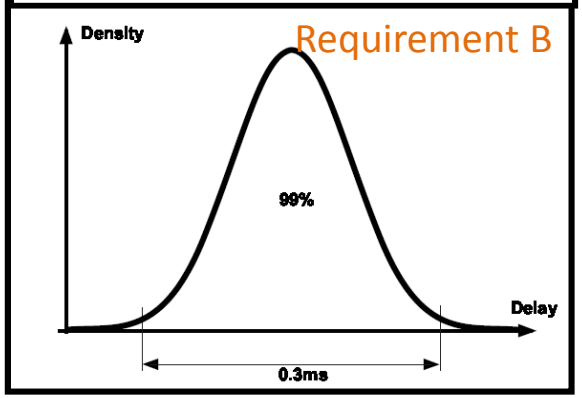
For 60min Lock,

- If 99% with <3msec spread

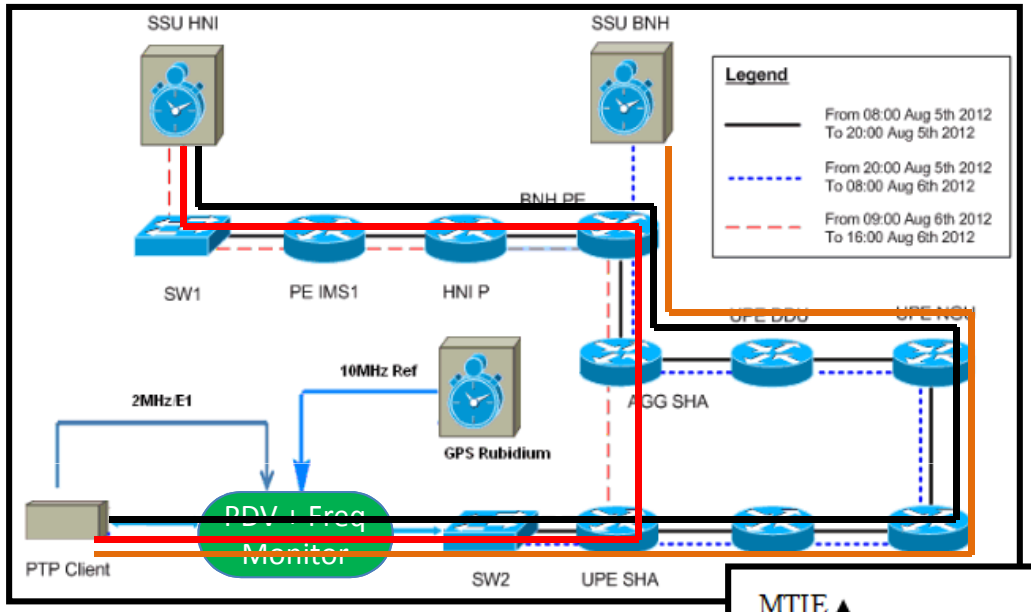
Result A: 1% in 20µsec, **PASS**

Result B: 99% in 0.3msec spread, **PASS**





Case Study 2: Network and Requirements



Three different routes through the network.

PTP Client Frequency output to meet G.8261.1 MTIE Mask

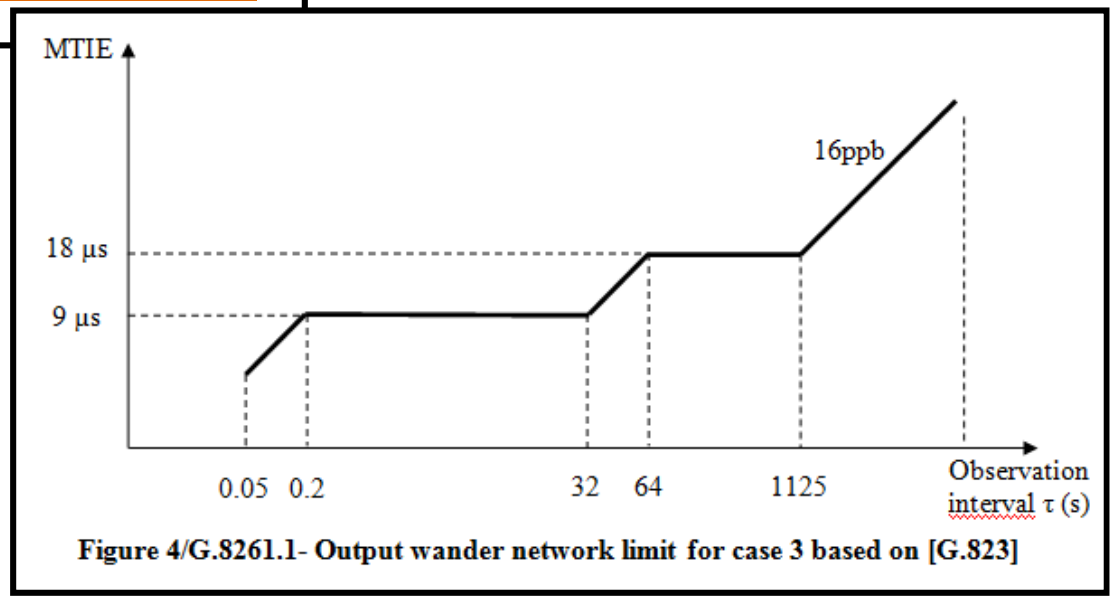
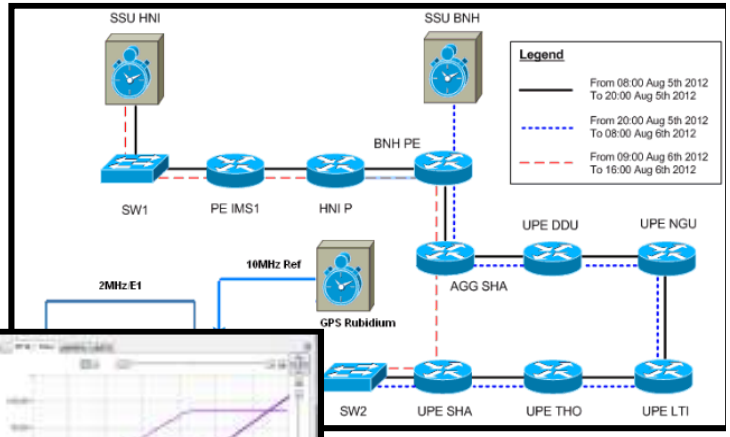


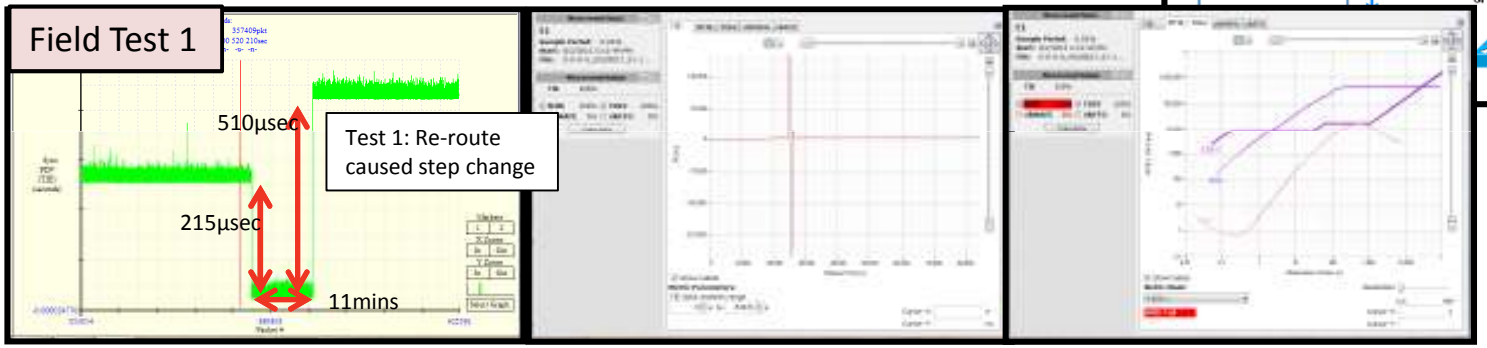
Figure 4/G.8261.1- Output wander network limit for case 3 based on [G.823]

Case Study 2: Network and Requirements

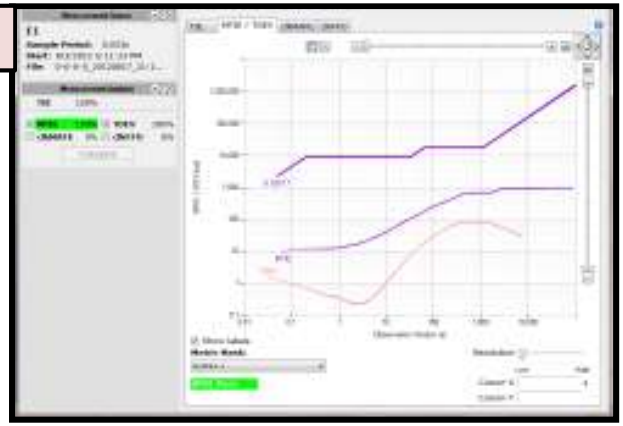
test	GM Site	Number of Nodes	Max Sync PDV (s)	G.8261.1 MTIE mask
Field Test 1	SSU BNH	n/a	0.000 550 285	FAIL
Field Test 2	SSU BNH	n/a	0.000 438 685	PASS
Field Test 3	SSU HNI	11	0.014 638 985	PASS
Field Test 4	SSU BNH	8	0.000 111 775	PASS
Field Test 5	SSU HNI	7	0.016 397 735	PASS

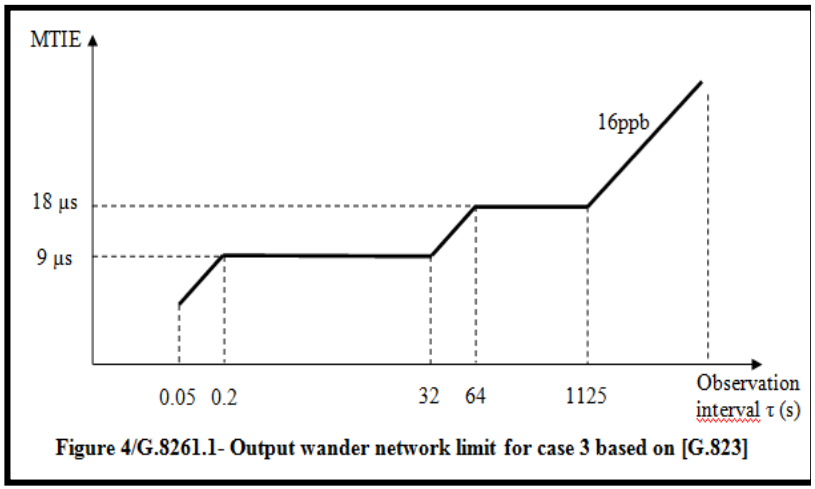


Field Test 1



Field Test 2





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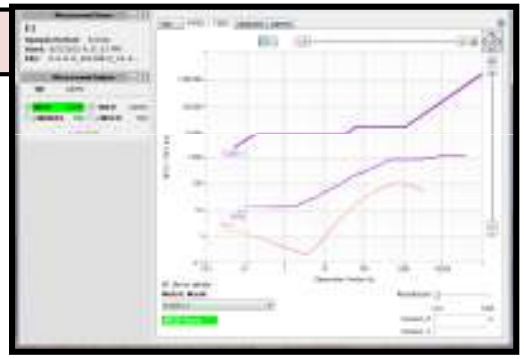
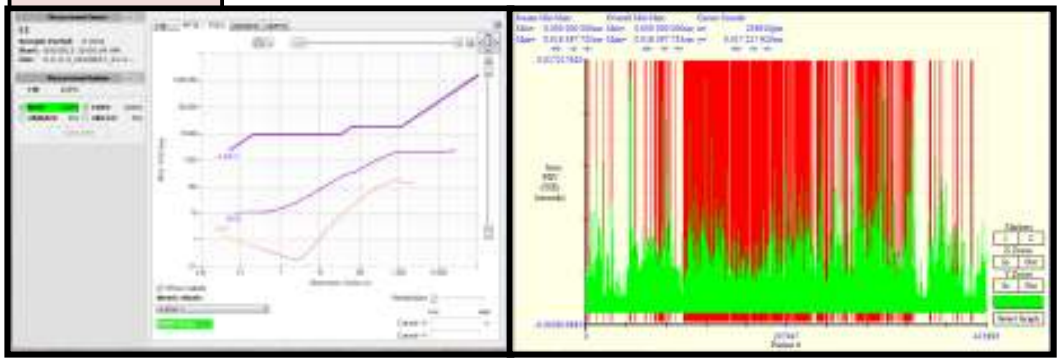
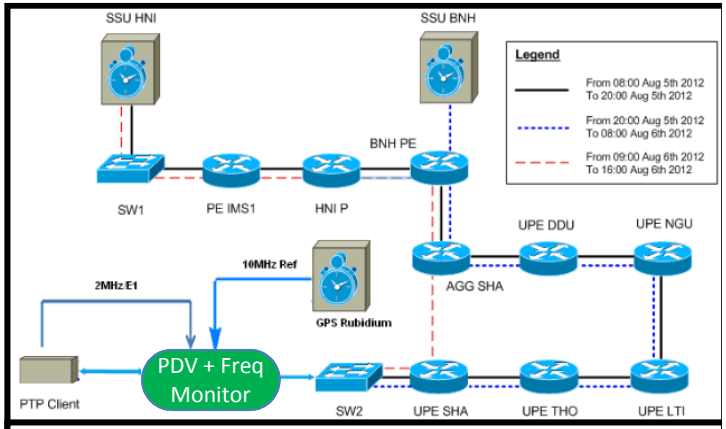
Field Test 3	SSU HNI	11	0.014 638 985	PASS
Field Test 4	SSU BNH	8	0.000 111 775	PASS
Field Test 5	SSU HNI	7	0.016 397 735	PASS

Field Test 4



Field Test5





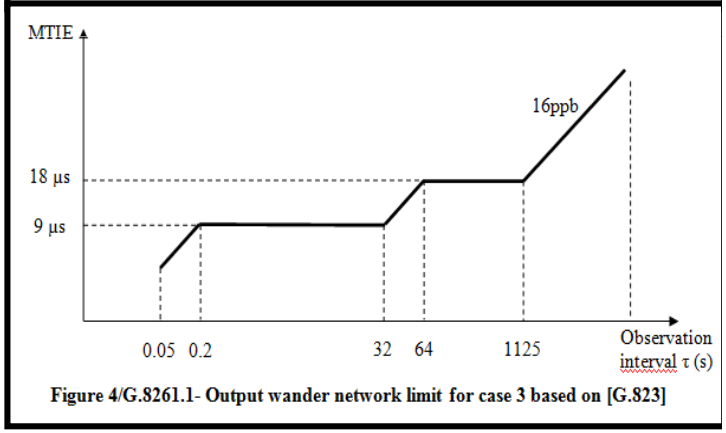


Figure 4/G.8261.1- Output wander network limit for case 3 based on [G.823]

Summary – What is driving innovation?

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Phase/Time & Frequency Deliver in tomorrow's networks

- **Deliver of Time & Phase with Standards compliance.**
  - G.8275.1 Full-on Path support
  - G.8275.2 Partial On-path support.
- **The need for Partial On-path support will drive innovation to achieve the required performance.**
- **The need for Frequency & Phase delivery to Small cell clusters utilising new technologies (e.g. MIMO, CoMP) necessary for proliferation of mobile access.**
- **Experiences from PoC trials will impact the industry direction & speed of progress.**
  - Enable deployments prior to Standards availability.
  - Enable quantitative comparisons between devices.
  - Enable development of depolyment rules, e.g. address the 'how many? & 'how often?' questions.

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