Building new timing networks with new technology

Tommy Cook,
CEO

Presentation overview

- Framework for deployment of Sync-over-packet network.
  - For Frequency Transfer
    - Physical Layer transfer (SyncE)
    - Packet Layer transfer (1588v2)
  - For Phase/Time & Frequency transfer
    - Full-on Path support
    - Futures.
- Case Study: Example results from trial networks.
- Summary

Building SyncE Timing network

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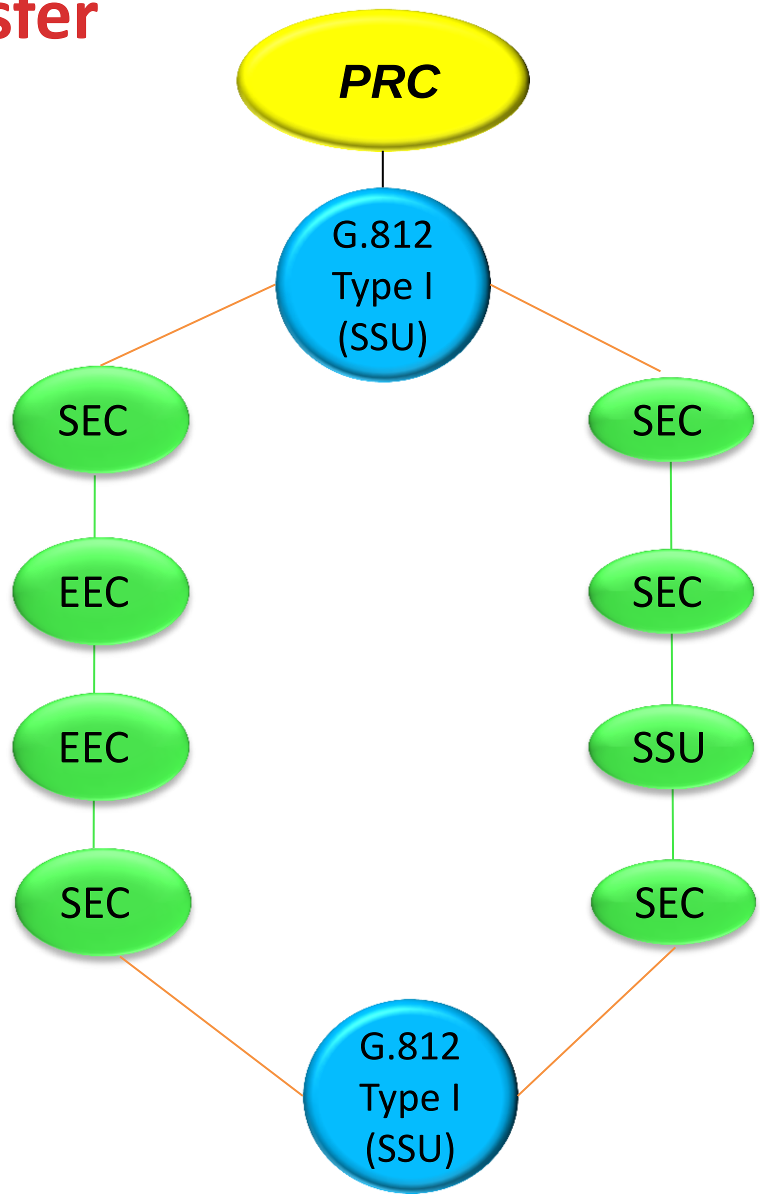
- **ITU-T Standards fully specify SyncE equipment and networks**
  - **G.8262,** July 2010
    - **Timing characteristics of a synchronous Ethernet equipment slave clock**
  - **G.8264,** Oct. 2008
    - **Distribution of timing information through packet networks**
- **The SyncE standards follow the principles used for timing distribution in TDM networks.**
  - **G.810,** Aug. 1996
    - **Definitions & Terminology for Synchronisation networks**
  - **G.811,** Sept. 1997
    - **Timing Characteristics of Primary Reference Clocks**
  - **G. 812,** June 2004
    - **Timing requirements of slave clocks suitable for use as node clocks in synchronization networks**
  - **G.813,** March 2003
    - **Timing characteristics of SDH equipment slave clocks (SEC)**

Frequency transfer using SyncE

G.8262 is Compatible with G.813

EEC – Ethernet Equipment Clock



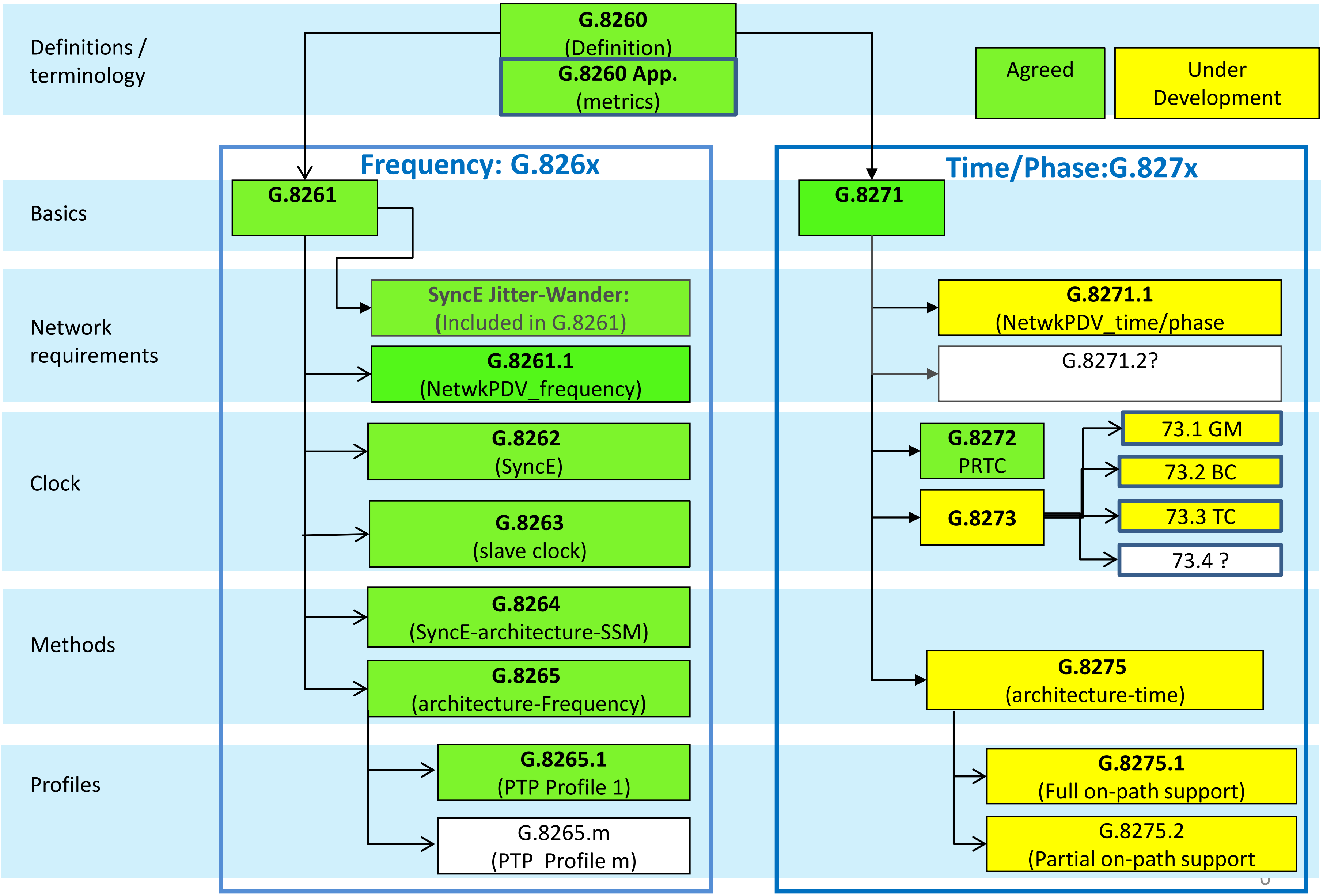
Number of G.812 type I clocks ≤ 10

Number of G.813 option 1 clocks ≤ 20

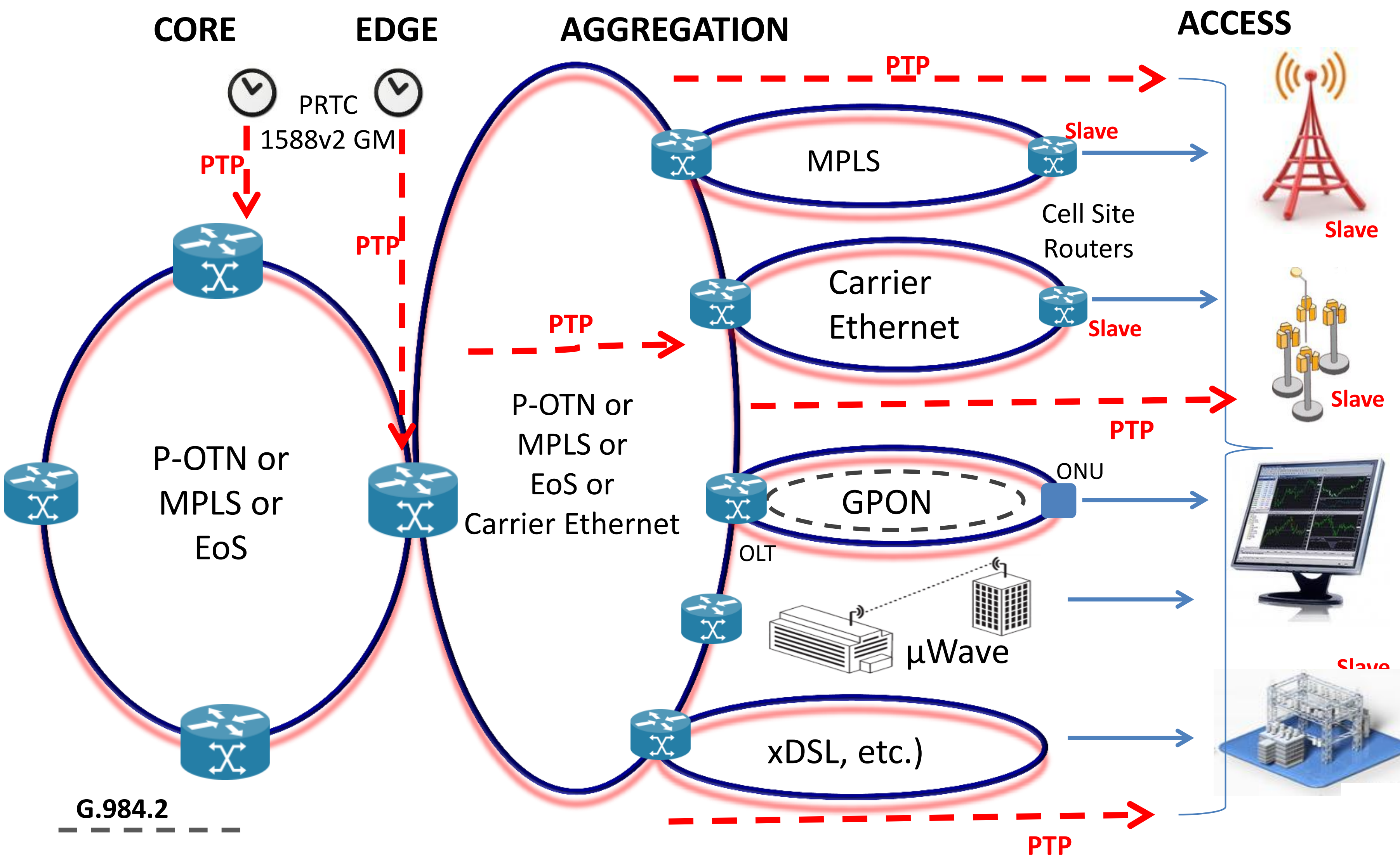
Total number of G.813 clocks in a sychronisation trail should not exceed 60

Frequency Transfer: Packet Layer transfer

Overview of ITU-T Sync recommendations



G.8265.1 - 1588v2 for Frequency



The role of 1588v2 Ordinary Clocks

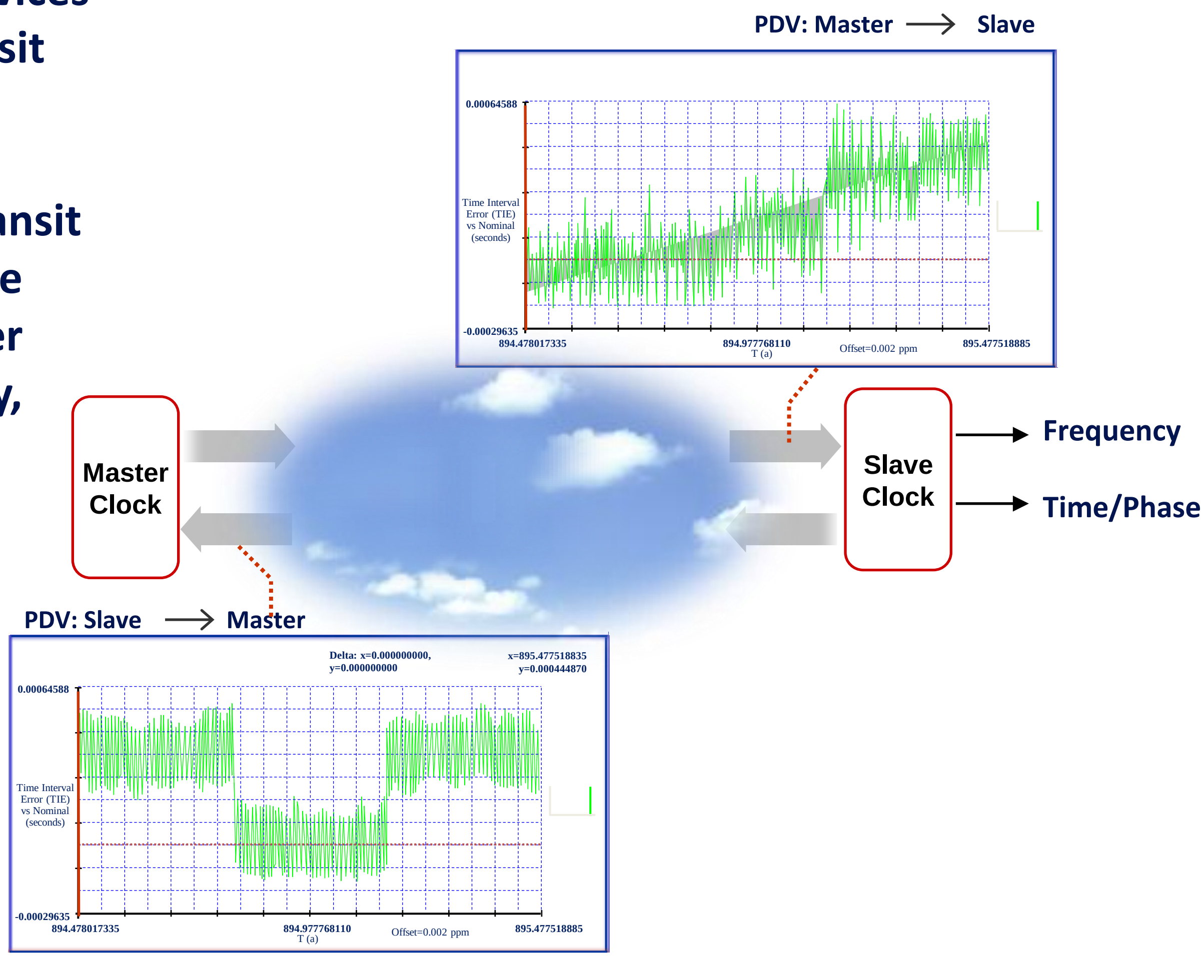
- Master;
  - Source of 1588v2 Message flow which contains the timestamp information on Master's reference clock.

- Slave;
  - Destination of a 1588v2 message flow where the timestamps are used to recover the time, phase &/or frequency of Master's reference clock.

The impact of the Network on 1588v2

- Congestion in network devices results in variation of transit time for each packet.

- The more disruption to transit time, the more difficult the task of the Slave to recover and align to the Frequency, Time &/or Phase of the Master Clock.



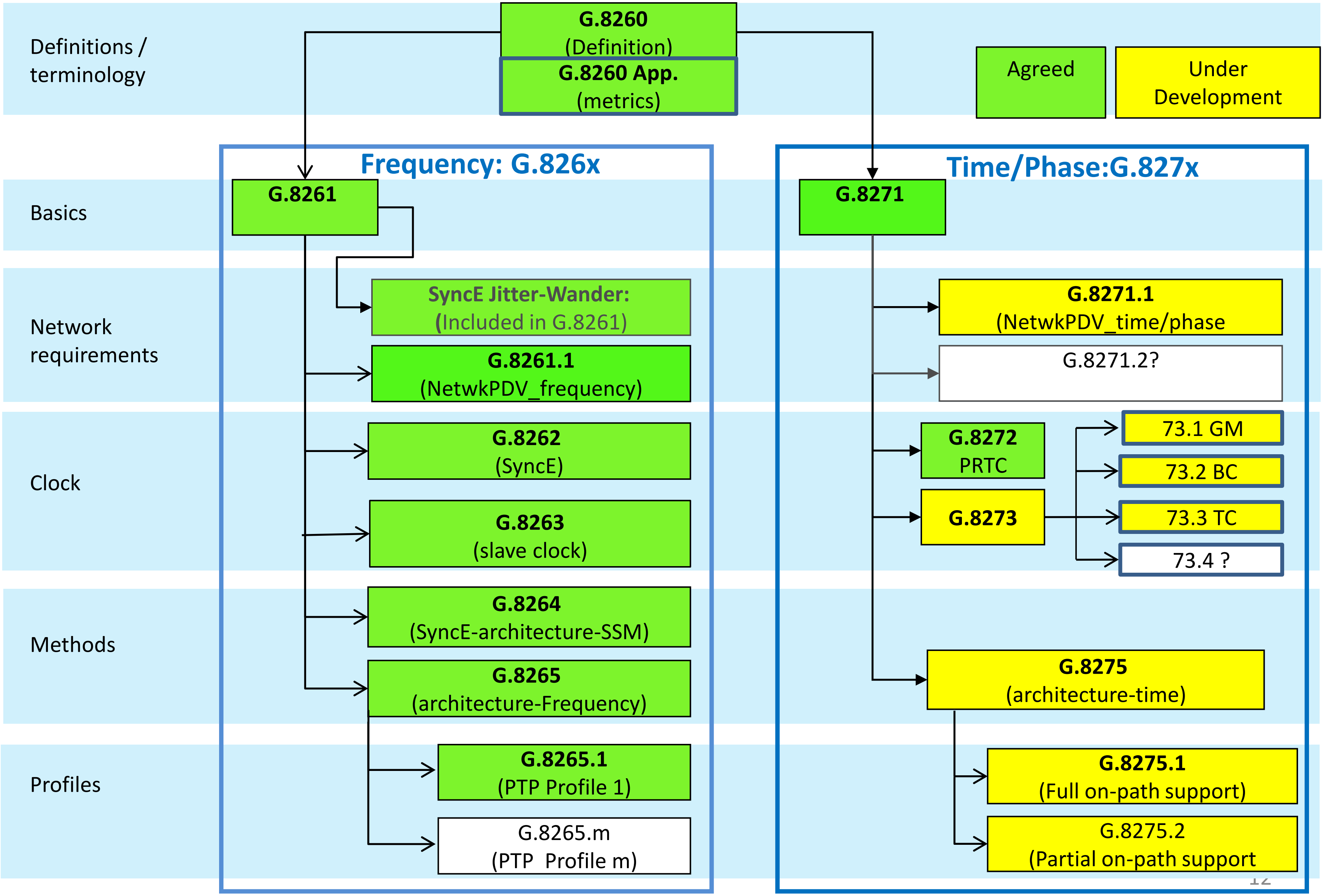
Network Evaluation

- ***Network Limits:***
  - **G.8261.1 Section 8: PDV Network Limit.**
    - **Floor Packet Percentage, FPP ≥ 1% of packets within 150µsec of floor delay in each 200sec window.**

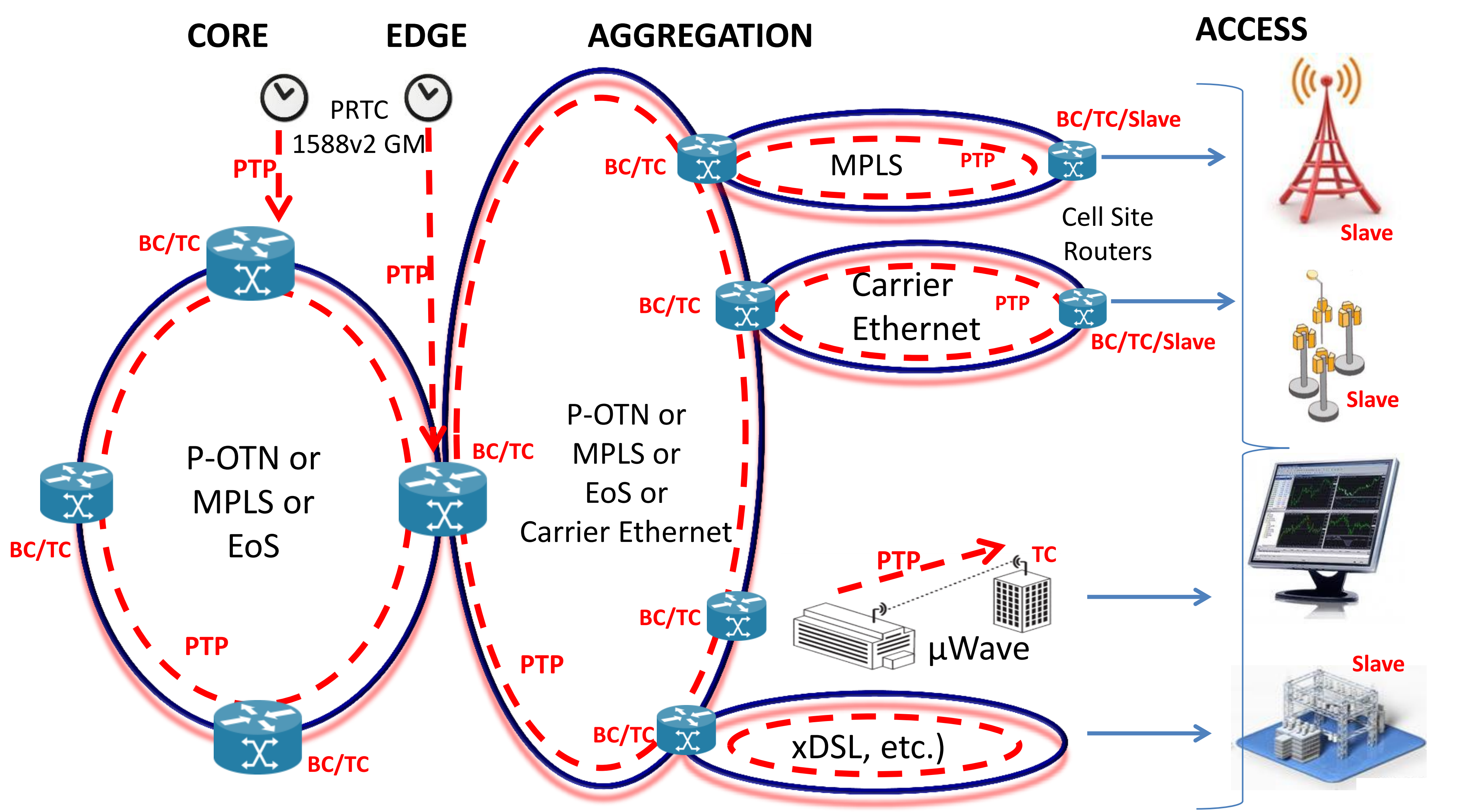
- **G.8260 Appendix I: Definitions and properties of packet measurement metrics**
  - FPR, FPP, FPC - Floor delay packet population, ratio/percentage/count.
  - MATIE, minMATIE - Maximum Average Time Interval Error
  - MAFE, minMAFE - Maximum Average Frequency Error
  - minTDEV, PercentileTDEV, BandTDEV (TDEV – Time Deviation)
  - pktfilteredTIE, pktfilteredMTIE, pktfilteredTDEV, pktfilteredFFO
  - ClusterTDEV

Phase/Time & Frequency Transfer: Full On-path support

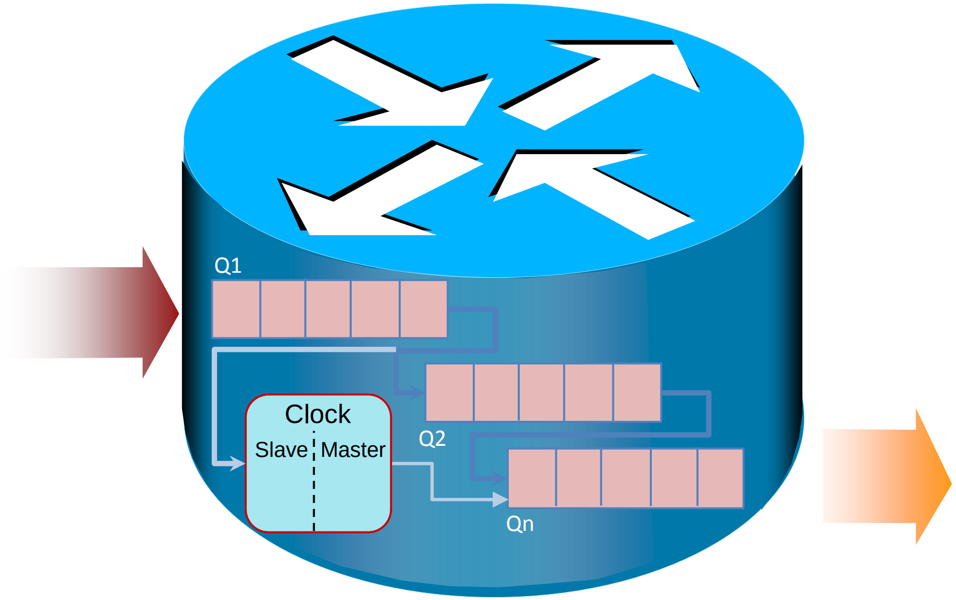
Overview of ITU-T Sync recommendations



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.

Transparent Clock

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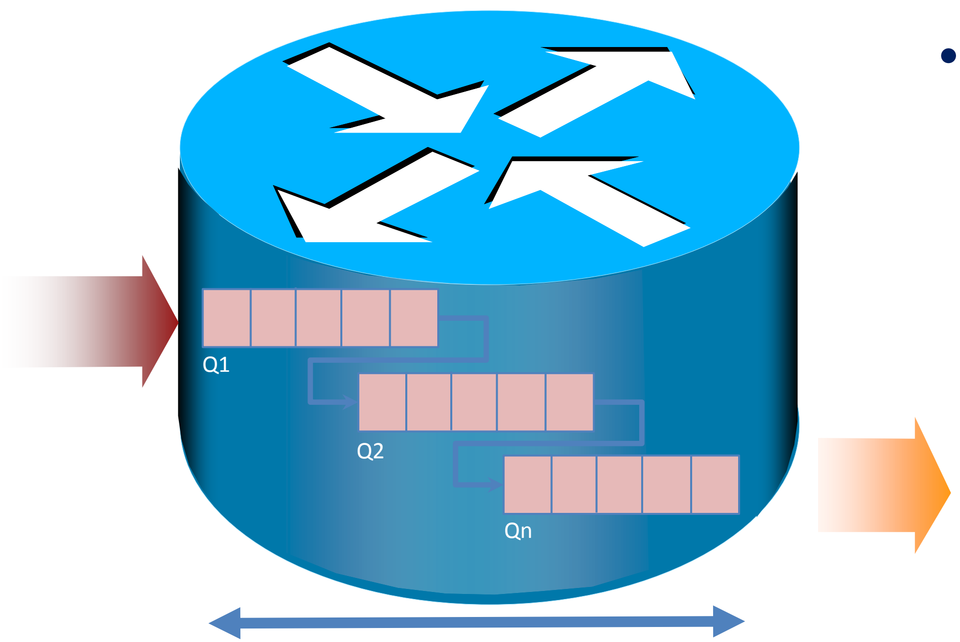
Transparent Clocks reduce PDV by;

- 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.



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

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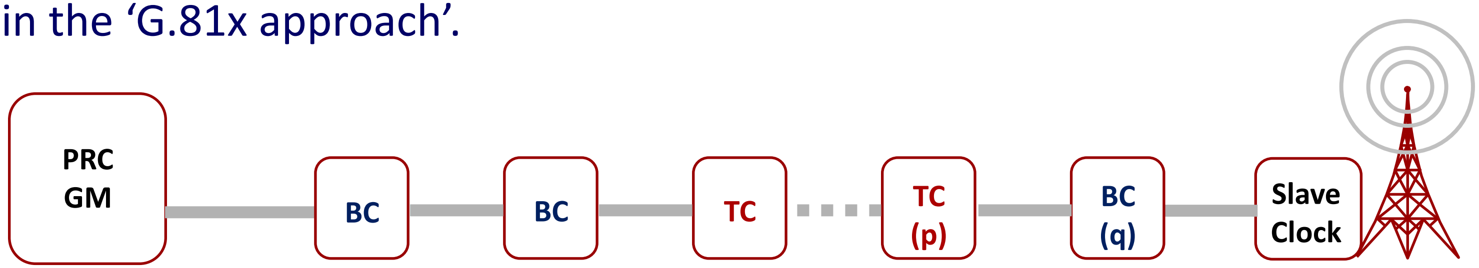
- **The 'G.81x approach' offers a Standards-based structured, bottom-up approach.**
  - The performance of each device in the path is know and has been proven.
  - Adhere to topology guidelines and the resulting network performance **will be within defined performance limits.**
- **With full On-path 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'.



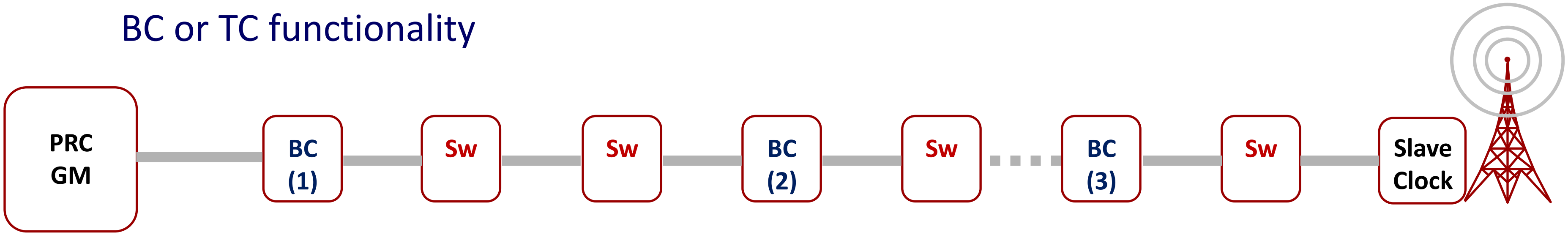
Network Evaluation

- **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.

Phase/Time & Frequency Transfer: Future ITU-T Profiles

Partial On-path Support

- **G.8275.2 (future): The second Time profile will specific Partial On-path support networks for Time transfer.**
- In Partial On-path Support networks, not all devices in the chain provide BC or TC functionality

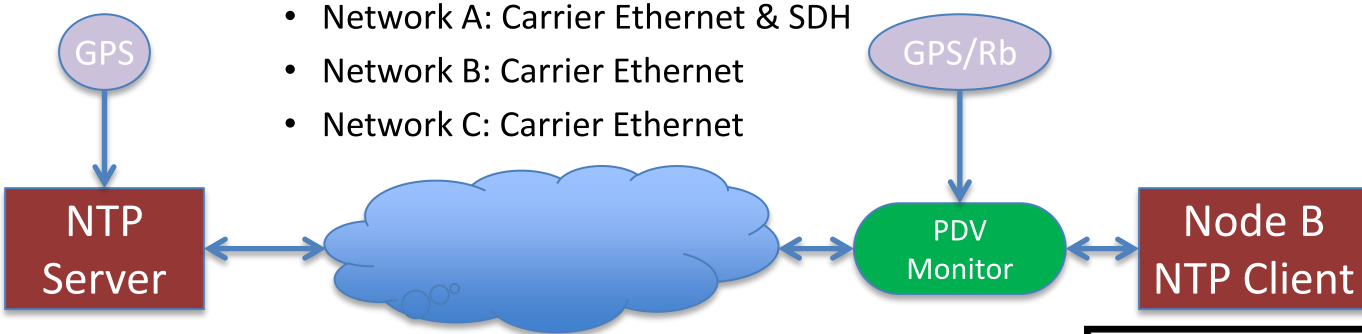


- **Evaluate each 1588v2 aware device.**
  - T-BC: Time Noise Generation, Time Noise Tolerance, Time Noise Transfer, etc.
  - T-TC: Accuracy of correctionField.
- **Evaluation of networks of devices**
  - Verification of error accumulation through chains of devices, and sub-chains of devices e.g. 2 Switches followed by a T-BC.
  - Verification of Slave performance when stressed with ‘accumulated error’.
- **Future: Performance specified in ITU-T Standards.**
  Today: Perform Lab Evaluation we develop deployment plan.

Case Study – Network Trials

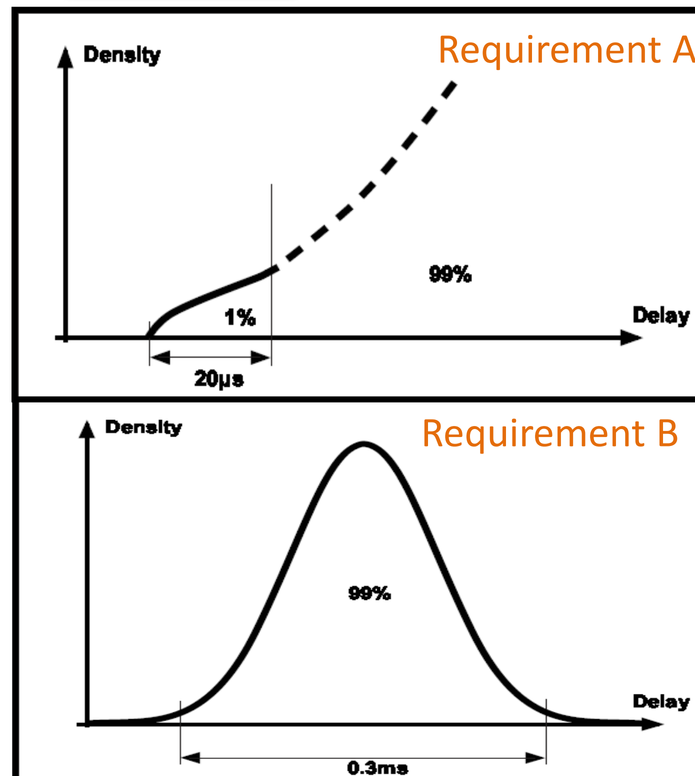
Case Study 1: Network and Requirements

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

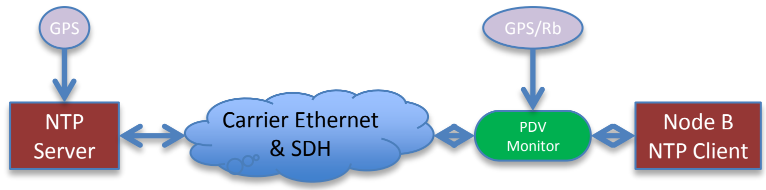


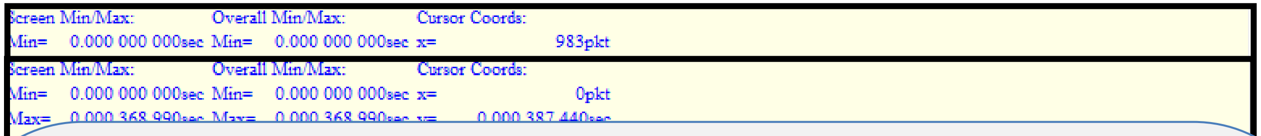
Node B requirements:

- 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

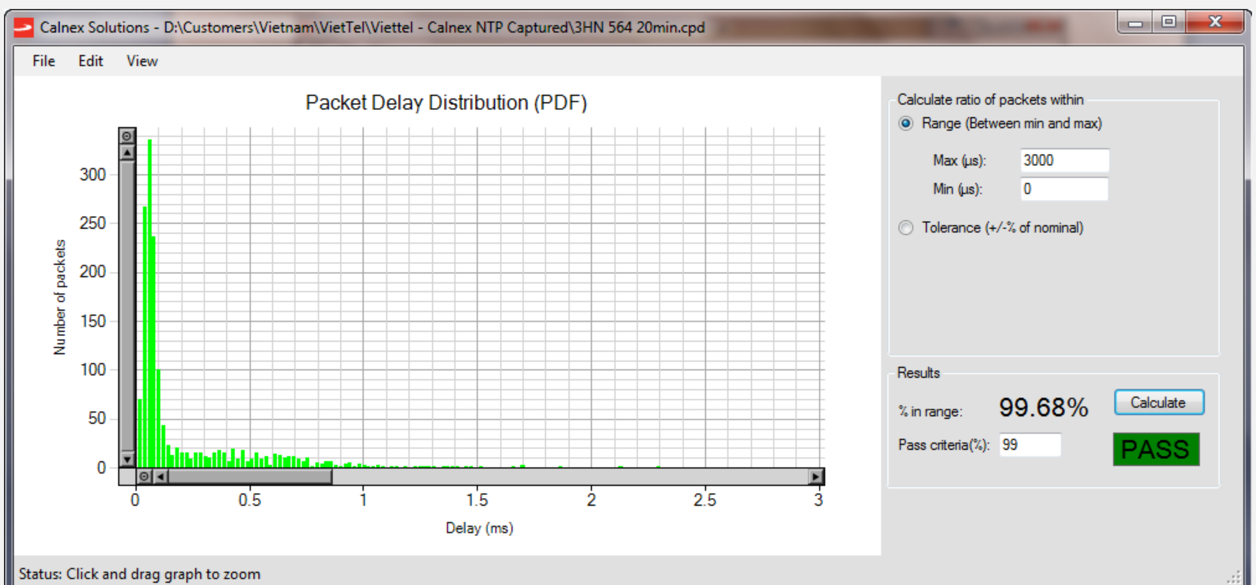




Result A: 1% in 20µsec, FAIL

Result B: 99% in 0.3msec spread, FAIL

Result C: 99% in 3msec spread, PASS

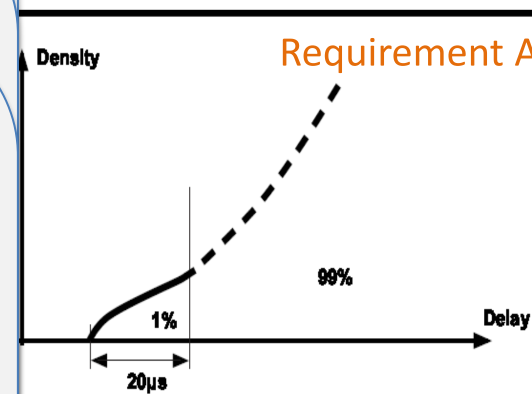


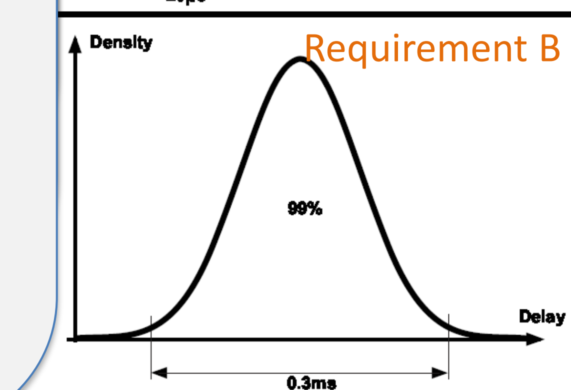
For 16 min Lock, either

a) 1% within 20µsec, or
b) 99% with <0.3msec spread.

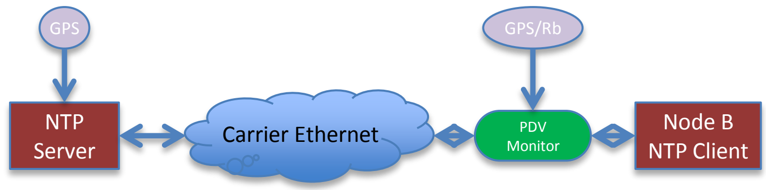
For 60min Lock,

- If 99% with <3msec spread





Network B Results



Screen Min/Max: Overall Min/Max: Cursor Coords:
Min= 0.000 000 000sec Min= 0.000 000 000sec x= 16655pkt
Screen Min/Max: Overall Min/Max: Cursor Coords:

For 16 min Lock if either

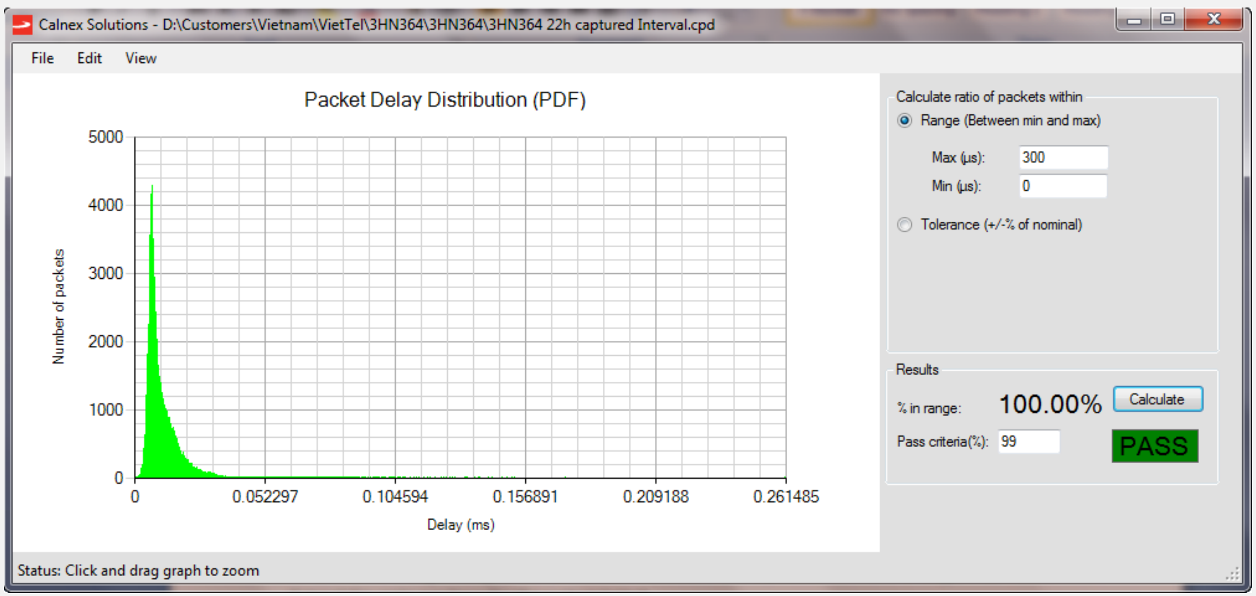
a) 1% within 20µsec, or
b) 99% with <0.3msec spread.

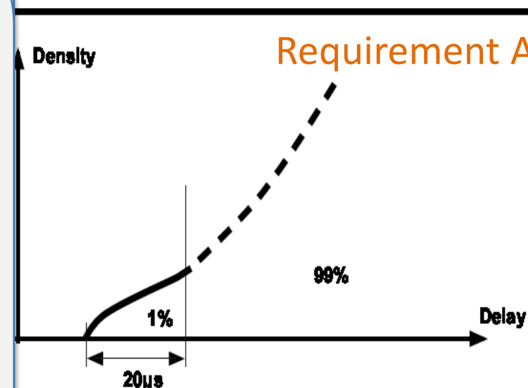
For 60min Lock,

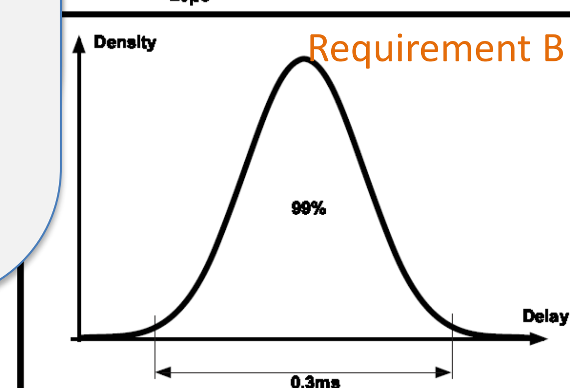
- If 99% with <3msec spread

Result A: 1% in 20µsec, **PASS**

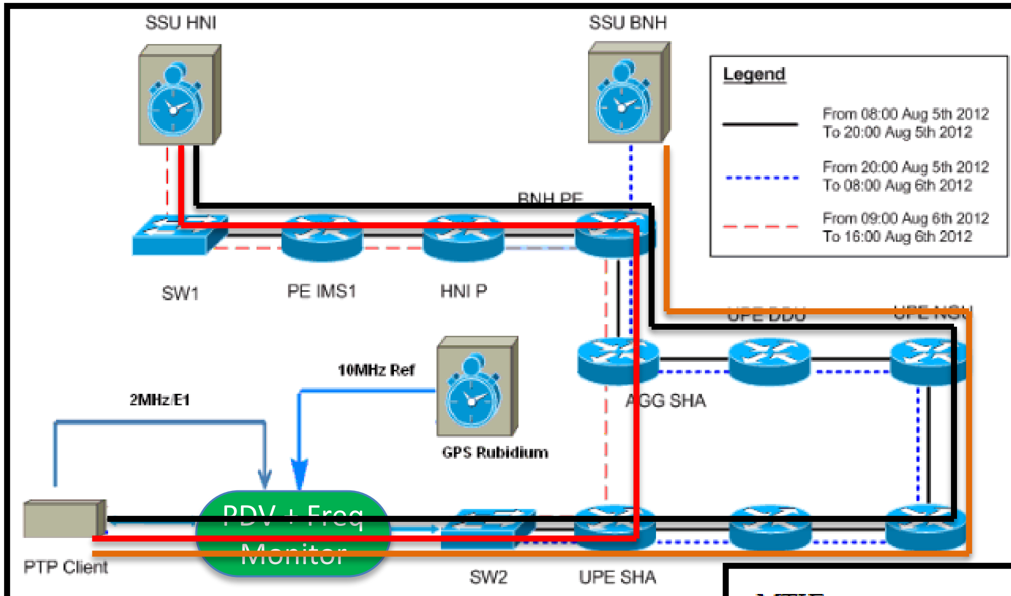
Result B: 99% in 0.3msec spread, **PASS**







Case Study 2: Network and Requirements



Three different routes through the network.

PTP Client Frequency output to meet G.8261.1 MTIE Mask

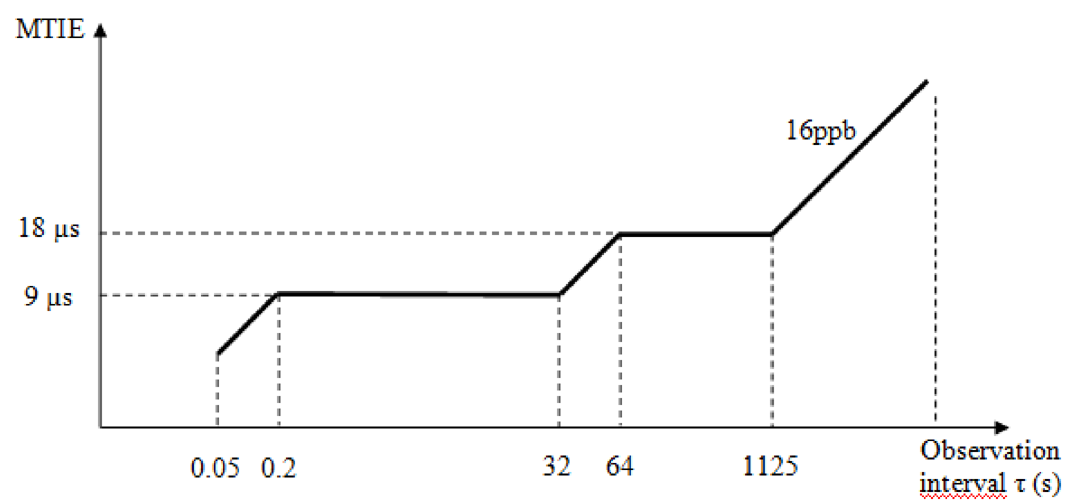
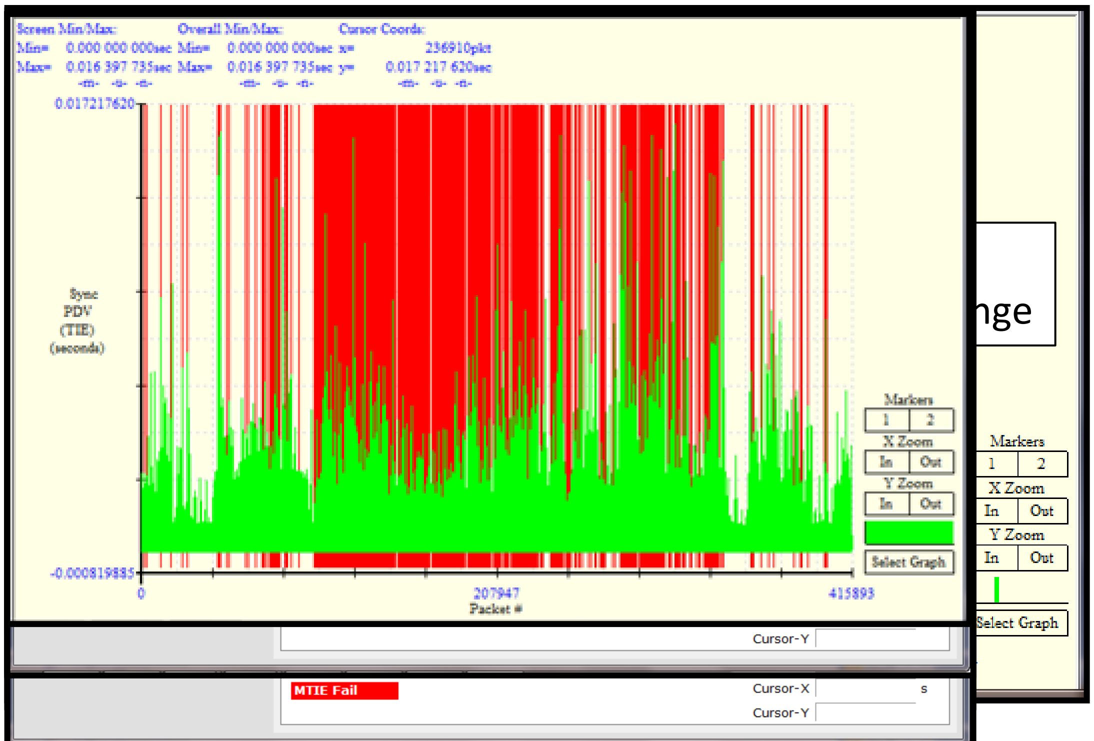
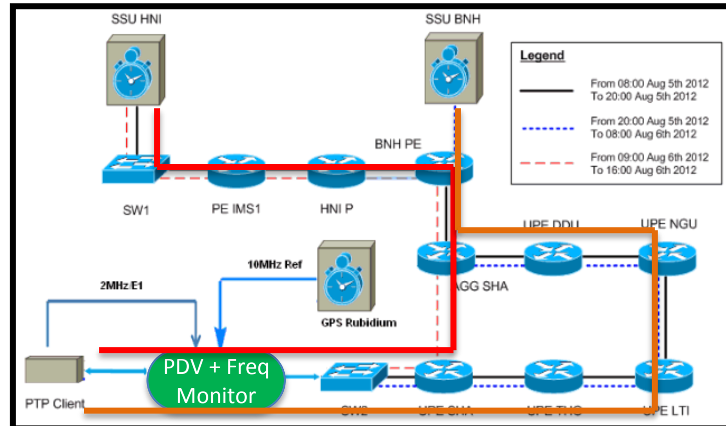


Figure 4/G.8261.1- Output wander network limit for case 3 based on [G.823]

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





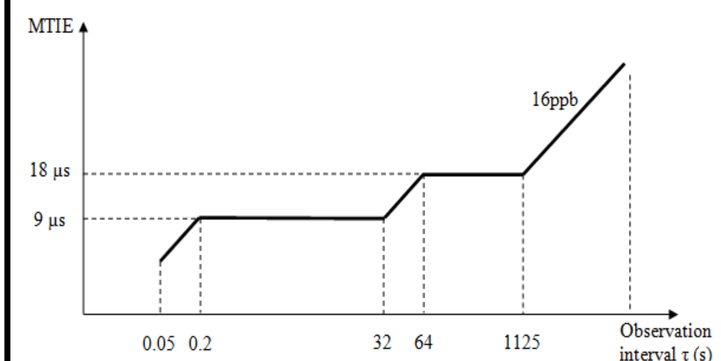


Figure 4/G.8261.1- Output wander network limit for case 3 based on [G.823]

Framework for deployment - Summary

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Frequency Transfer

- **Physical Layer transfer (SyncE)**
  - G.8262 & G.8264 ITU-T standards in place.
- **Packet Layer transfer (1588v2)**
  - G.826x Series of standards available
    - G.8265.1 provides the deployment Profile.
    - G.8261.1 provides network limits.
- **Perform equipment and Network evaluation to develop deployment guidelines.**
  - G.8260 Appendix A defines a number of metrics.

Phase/Time & Frequency Transfer

- **G.827x series of standards under development.**
  - G.8275.1 Full-on Path support
- **Futures**
  - G.8275.2 Partial On-path support.
  - G.8275.x ?
- **Perform equipment and Network evaluation to develop deployment guidelines.**
  - Test individual T-BC/T-TC devices.
  - Test networks &/or chains of devices.
  - Evaluate terminating equipment with results from chains of devices.

CALNEXSOL.COM

Tommy Cook
tommy.cook@calnexsol.com
+44 (0) 1506-671-416