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Sync-over-Packet: When can I deploy?

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Presentation overview

How will synchronisation be delivered as the telecom network moves towards the All Packet Network?

Industry Objective: Continue to deliver a high-quality sync source across the whole network.

What technologies should I consider and can I prove they are fit for deploy?

- Why change? What are the drivers for change?
- What options are under investigation?
- Can I prove they are fit for deployment?
- What is happening in the Standards?
- Summary: Can I deploy with confidence?

Why change? What are the drivers for change?

- Today, synchronisation is delivered using TDM infrastructure.
  - Timing transferred using clock recovery techniques based on Line Rate frequency
  - T1, E1, SDH/Sonet designed for Line Rate clock transfer.
- Cost pressure to move to All Packet Network.
  - Do not want to maintain parallel networks.
  - Want access to cost/performance benefits of new packet technology.
- Current Ethernet interfaces are not suitable for synchronisation transfer.
- Synchronisation required for delivery of all real-time sensitivity services.

The need for **network synchronisation** will remain indefinitely

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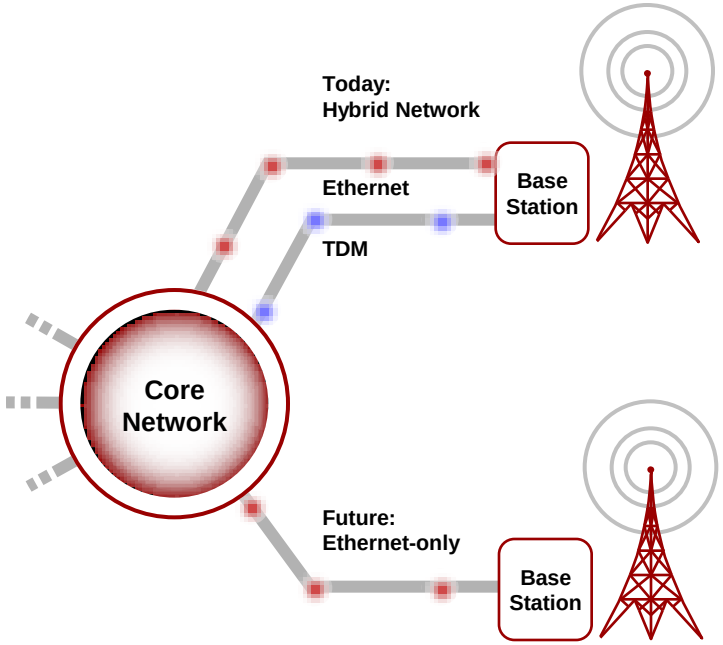
What's driving the telecoms industry?

- Networks migrating to Packet but mission-critical Comms and Data need accurate timing.
- Must continue to provide **the same quality** of synchronisation delivered today by TDM.
- Can this be done without the need to retain the T1/E1 links used today to transfer synchronisation?



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What are the options?

- **Hybrid Ethernet and E1/T1 TDM**
- Synchronous Ethernet (Sync-E)
- Sync-over-Packet technologies
  - Adaptive Techniques
    - Circuit Emulation of TDM Services (CES)
  - Clock Synchronisation Protocols
    - PTP (1588v2)
    - NTP

Features

- Clock recovered from the physical layer.
- Approach, techniques and implementation are mature as this has been the primary method of synchronisation transfer since the introduction of the digital network.
- ITU-T Standards
  - G.81x for clock signals
  - G.823 for E1
  - G.824 for T1
- Use one technology to deliver voice and synchronisation.

Benefits

- Well proven, mature technology.
- Wide range of solutions available.

Challenges

- Inefficient at carrying data traffic.
- Not scalable to match data growth predictions.
- Not compatible with All-Packet Network.
- 25% more OPEX on average compared to all-Ethernet.
- Need to maintain two separate technologies and networks (hybrid).

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Features

- Line rate of the Ethernet Interface used to transfer timing.
- No impact or demand on packet layers.
- Defines the use of a high stability oscillator to generate line frequency.
  - Ethernet 'Classic': ±100ppm.
  - Synchronous Ethernet: ±4.6ppm
- ITU-T Standards in place.
  - G.8262: Timing Characteristics for Synchronous Ethernet Equipment
  - G.8261: Timing and Synchronisation in Packet Networks

Benefits

- Techniques for transfer frequency by Line Rate well understood for both Equipment design and Network design.
- Independent of services.
- No bandwidth utilisation.
- Suitable for layered clock distribution topologies.
- Independent of PDV.

Challenges

- Cost: All interfaces need to be Sync-E compatible.
- Can not be used with existing equipment when transferring synchronisation.

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What are the options?

- Hybrid Ethernet and E1/T1TDM
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  - Clock Synchronisation Protocols
    - PTP (1588v2)
    - NTP

Features

- TDM signal/service encoded into packets.
- Arrival time of each packet used to transfer timing.
  - Packets launched on precise heart-beat e.g. with a 1ms inter-packet gap
- Standards in place

  IEFT
  - PWE3 Encapsulation of TDM
  - RFC5086 CESoPSN: Structure-Aware TDM over Packet Switched Network
  - RFC4553 SAT0P: Structure-Agnostic TDM over Packet

  ITU-T
  - Y.1431: TDM-MPLS
  - Y.1411: ATM-MPLS
  - Y.1453: TDM-IP
  - Service Encapsulation the same as PWE3

Benefits

- No additional bandwidth used for sync transfer.
- Compatible with currently deployed packet networks.

Challenges

- Sensitivity to PDV.

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What are the options?

- Hybrid Ethernet and E1/T1TDM
- Synchronous Ethernet (Sync-E)
- **Sync-over-Packet technologies**
  - Adaptive Techniques
    - Circuit Emulation of TDM Services (CES)
  - **Clock Synchronisation Protocols**
    - **PTP (1588v2)**
    - **NTP**

Features

- Separate packet flow used to transfer timing.
  - Timestamps embedded in packets to transfer timing
  - Two-way protocol employed to measure delay between Master and Slave devices
- Able to transfer frequency and time-of-day.
- Standards define devices/techniques to reduce uncertainty (Peer-to-peer & End-to-end Transparent Clocks) and to create hierarchical clocking topology (Ordinary Clocks, Boundary Clocks).
- Standards
  - IEEE: P1588v2; Precision Timing Protocol, PTP
  - IETF: RFC1305: Network Time Protocol, NTPv3 (NTP v4 under development, TICTOC group)
  - ITU-T: G.8264; Distribution of Timing through Packet Networks. (under development)

Benefits

- 1588v2 Standard ratified March 2008.
- Independent of services.
- Suitable for layered/complex clock distribution topologies.
- Compatible with currently deployed packet networks.

Challenges

- Cost: Extra bandwidth required.
- Protocol assumes symmetrical delays in up- and down-stream paths.
- Sensitivity to PDV.

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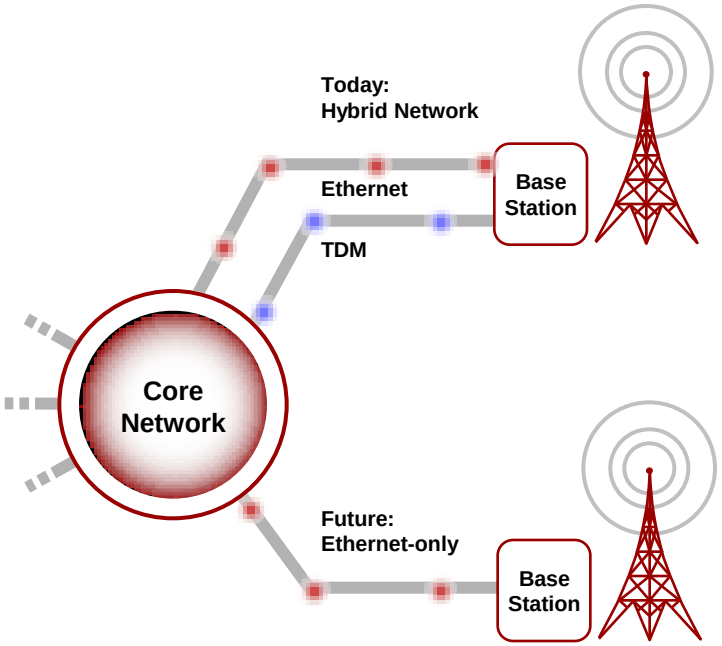
Testing to prove "fit-for-deployment"

Are there test solutions/methodologies that will enable me to test performance?

- How do I approach testing each technology?
- What test solutions are available?
- What challenges do I face in evaluating equipment?



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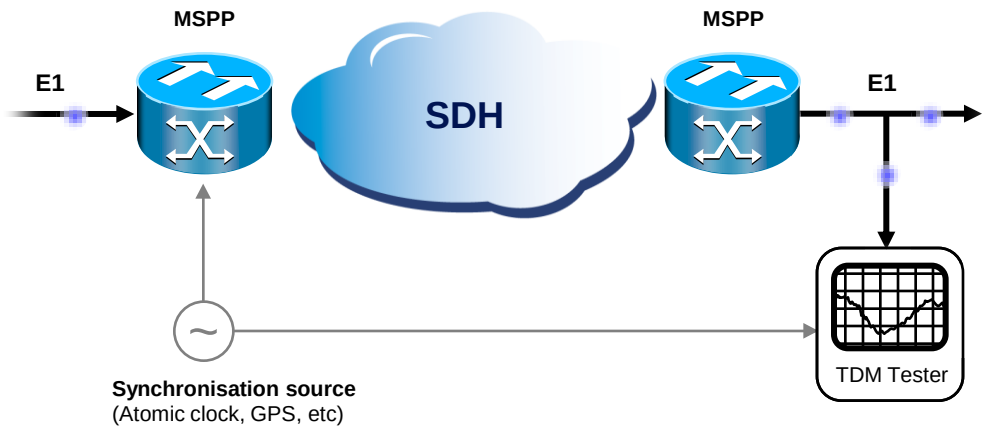
Verify fit-for-deployment?

- **Hybrid Ethernet and E1/T1 TDM**



Testing Methodology

- Measure Line Rate wander test
  - Recover the clock from Signal under test and compare to the Master Reference clock.
- ITU-T Standards
  - G.81x for Clock signals
  - G.823 for E1
  - G.824 for T1

Available Test Solutions

- Solutions available for all TDM interfaces from a number of suppliers.
- Test methodologies / approaches well understood and established.

Evaluation Challenges

- None

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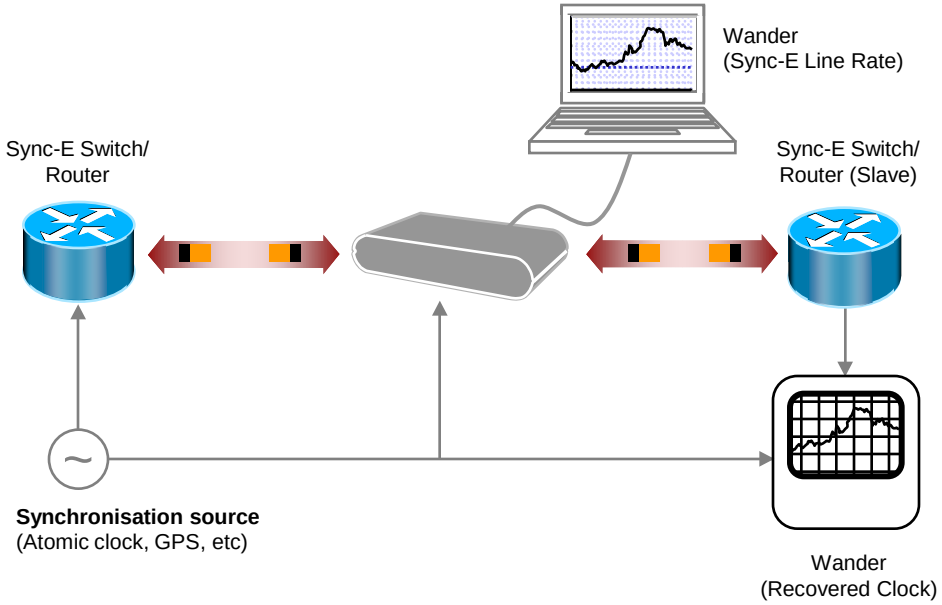
Verify fit-for-deployment?

- **Synchronous Ethernet (Sync-E)**



Test Methodology

- Measure Line Rate wander test
  - Recover the clock from Signal under test and compare to the Master Reference clock.
  - ITU-T: G.8262 MTIE & TDEV masks.
- Stress Eye test
  - Adjust the sampling point within the eye of the signal to determine the margins before errors are introduced.
  - IEEE: 802.3

Available Test Solutions

- 1GbE Sync-E Wander - today.
- 10GbE Sync-E Wander - Q1 '09.
- 10GbE Sync-E Stress-eye - today.

Evaluation Challenges

- None

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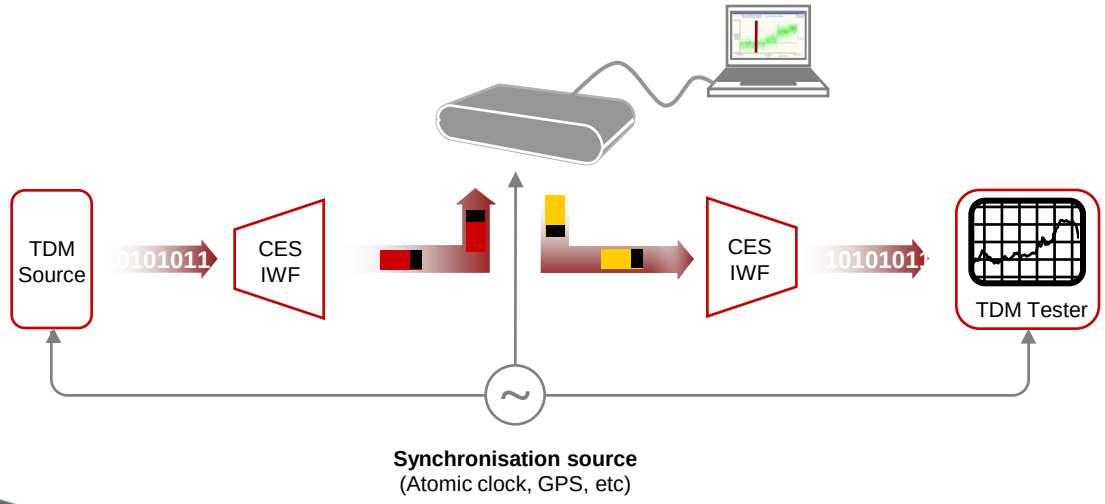
Verify fit-for-deployment?

- **Sync-over-Packet technologies**
  - **Adaptive Techniques**
    - **Circuit Emulation of TDM Services (CES)**



Test Methodology

Packet Interfaces
- Emulate a congested network on the Packet interface.
- Emulate Packet corruption events
  - Lost, errored, repeated, mis-ordered.
- Standards
  - ITU-T G.8261, Appendix VI

Recovered Clock / TDM service
- Measure the Wander on recovered clock.
- Standards
  - ITU-T G.81x

Available Test Solutions

Packet Interfaces
- Accurate injection PDV profiles to emulate congested networks available.
- Inject Packet corruption events.

Recovered Clock / TDM service
- Wander meters that test to G.81x.

Evaluation Challenges

- What PDV patterns fully emulate congested networks?

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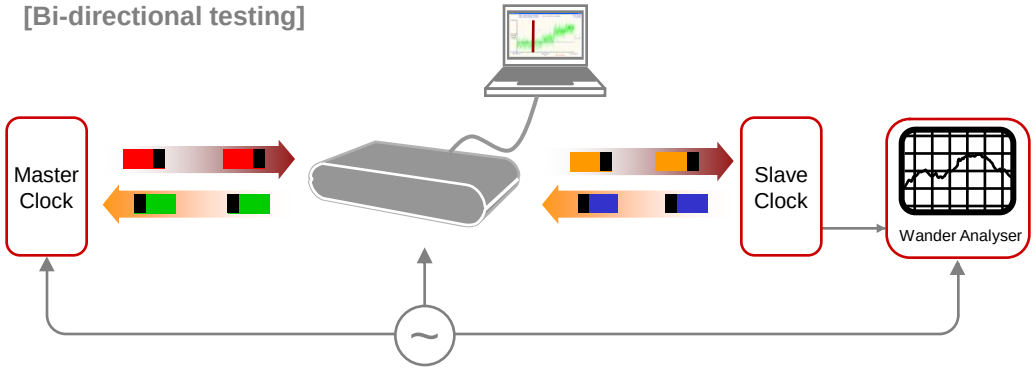
Verify fit-for-deployment?

- **Sync-over-Packet technologies**
  - **Clock Synchronisation Protocols – PTP (1588v2); NTP**

[Bi-directional testing]



Test Methodology

Packet Interfaces
- Emulate a congested network on the Packet interface.
- Emulate Packet corruption events
  - Lost, errored, repeated, mis-ordered
  - Handshake message corruptions
- Standards
  - ITU-T G.8261 Appendix VI

Recovered Clock
- Measure the Wander on recovered clock.
- Standards
  - ITU-T G.81x

Available Test Solutions

Packet Interfaces
- Accurate injection PDV profiles to emulate congested networks available.
  - Capture from real-work or G.8261
  - Extract embedded timestamp and compare to arrival time
- Inject Packet corruption events.

Recovered Clock
- Wander meters that test to G.81x.

Challenges

- What PDV patterns fully emulate congested networks?

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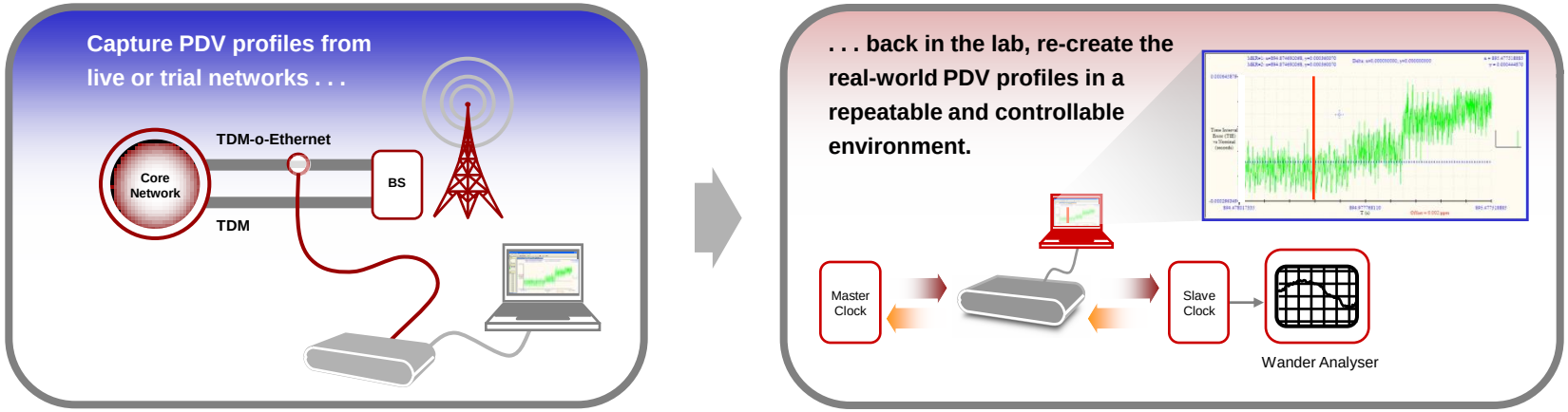
Create a Library of Dependable PDV Profiles



. . . additionally:

- Record and replay from G.8261 Reference Network

  (Removes repeatability issues and minimizes resource effort.)

- Generate pseudo-real world profiles

  (Edit real-world profiles to create precisely defined test cases based on real-world traffic models.)

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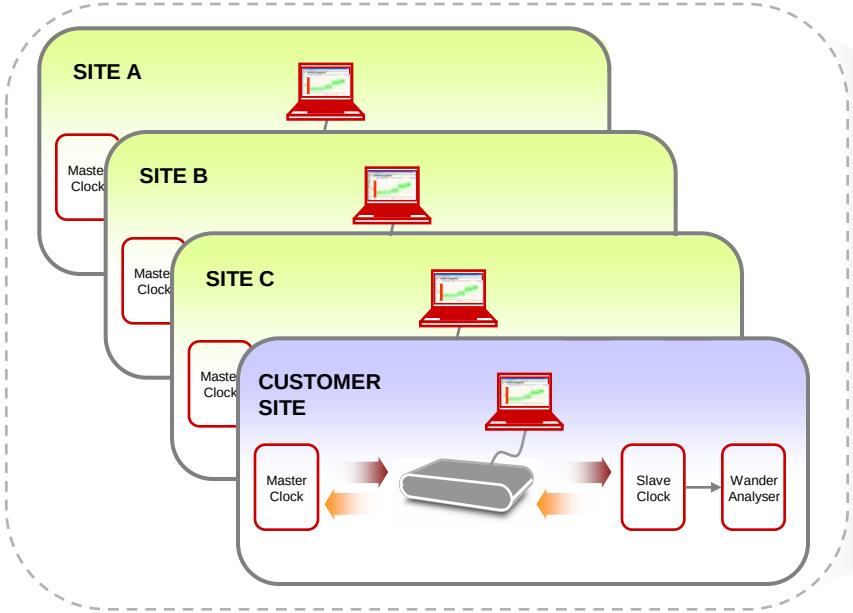
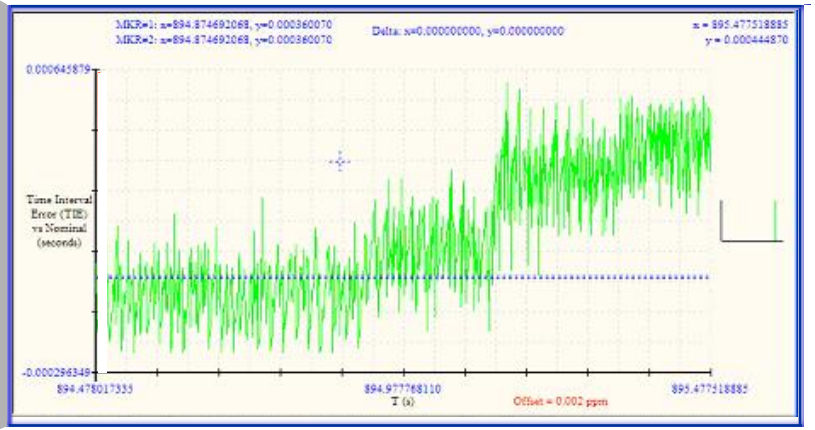
Test the same way everywhere, every time





- Applicable to all Adaptive and Two-way protocol technologies.
- Applicable to **Standards**- and **non-Standards**-based packet structures.

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Standards activity

ITU-T SG15, Q13

At the recent Interim Meeting in Rome, topics discussed;

- PDV definitions (CES,1588v2)
- 1588v2
- Sync-E

- Appendix VI: Measurement Guidelines.
- Metrics for analysing PDV (minTDEV, bandTDEV, MATIE, MAFE).
- Modelling of PDV.

Configuration Profiles for the Telecom's applications:

- Recommended mechanisms.
- Recommended topologies.

IEFT TICTOC

- Defining NTPv4

Recommended topologies.

Enhance NTPv3 to better meet the needs of timing across the Telecom application.

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Can I deploy my Packet Network timing solution with confidence?

Technology	Tools	Challenge/Issue
TDM	☑	Not Compatible with all Packet Network.
Sync-E	☑	All timing paths must be Sync-E, no Ethernet ‘Classic’.
CES	☑	PDV Profiles – How to assess (metrics); – Which tests/profiles to use?
1588v2 NTP	☑	Topology and configurations to use. PDV Profiles – How to assess (metrics); – Which tests/profiles to use?

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Calnex Paragon Sync

- IEEE 1588v2
- CES
- Sync-E
- NTP