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"In it together" - Telco Timing Ecosystems

In it together…

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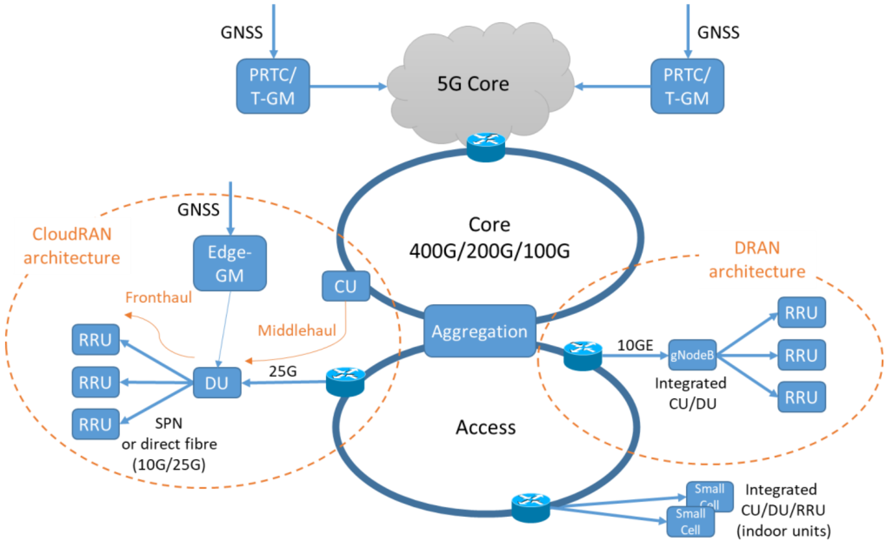
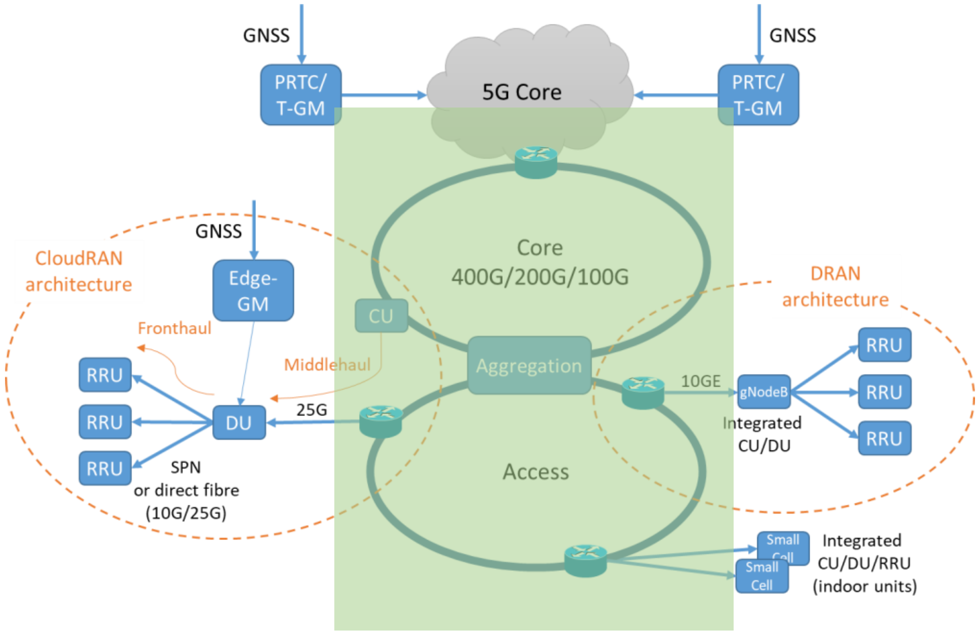
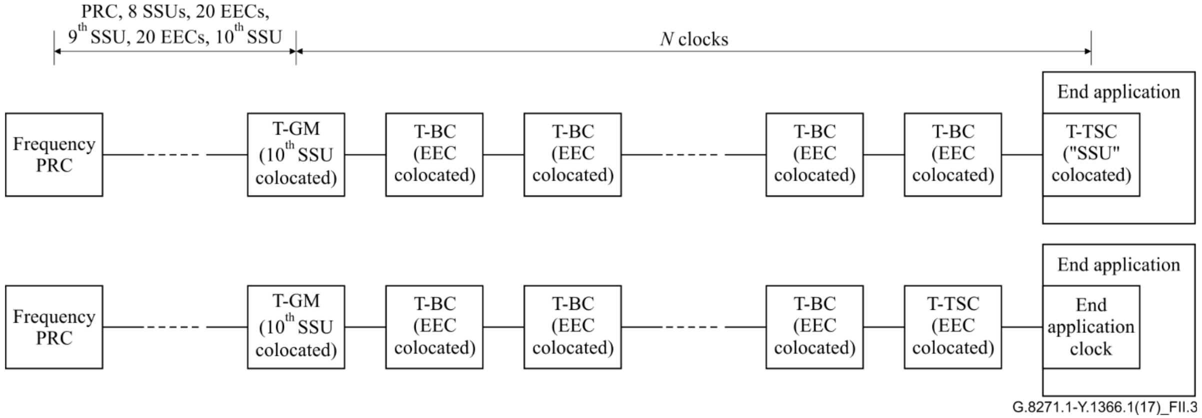
- Background: some 5G rollouts are **actually** happening!
- Some of the proposed use cases and technologies are becoming real too!
- Totally unbiased opinion(!):
  - Timing issues can be **<u>the</u>** blocker to deployment
- Components come in to play more than previously: **what are we going to do about it?!**



Timing through a network

- As a baseline, referring to Full On-Path Timing support deployed through a network intended to deliver 5G, with appropriate bounds on end-end and 'per node' performance.





T-BC/T-TSC/T-TC	cTE	dTE (MTIE)	max|TE|	dTE (High-Pass filtered)
Class A (with SyncE)	+/-50ns	40 ns	100 ns	70ns
Class B (with SyncE)	+/-20ns	40ns	70ns	70ns
Class C (with eSyncE)	+/-10ns	10ns	30 ns (T-BC) Under Study for T-TC	Under Study
Class D(with eSyncE) Only T-BC/T-TSC	Under Study	Under Study	5 ns *	Under Study

- Example for clarity, other applications have similar considerations

PAM4 and Digital Coherent Optics (DCO)

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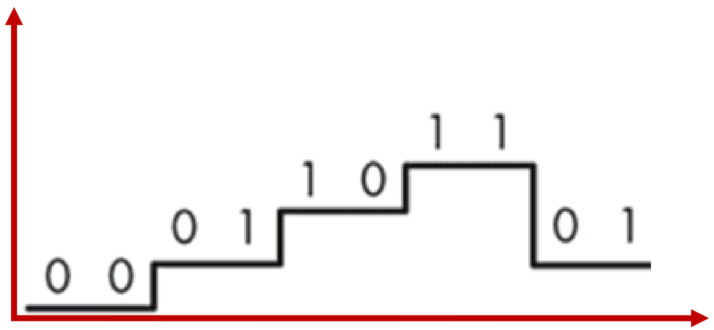
<u>PAM4 Optical transmission</u>

Benefits:

Main medium for introducing higher network rates

Downsides:

Complexity for host…



<u>DCO transmission</u>

Benefits:

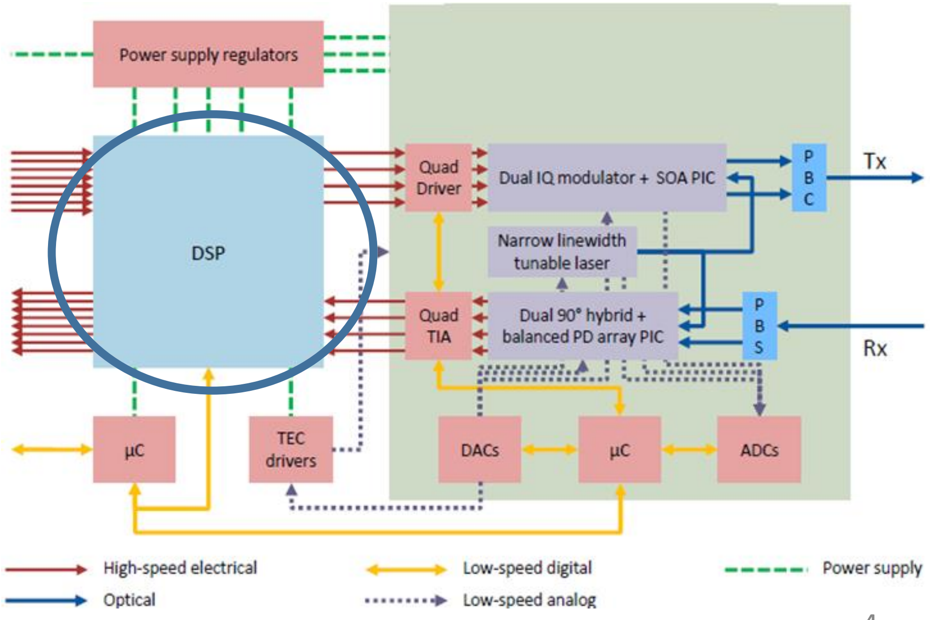
Higher network rates, long reach, flexibility/programmability

Complexity is in the modules rather than the host

Downsides:

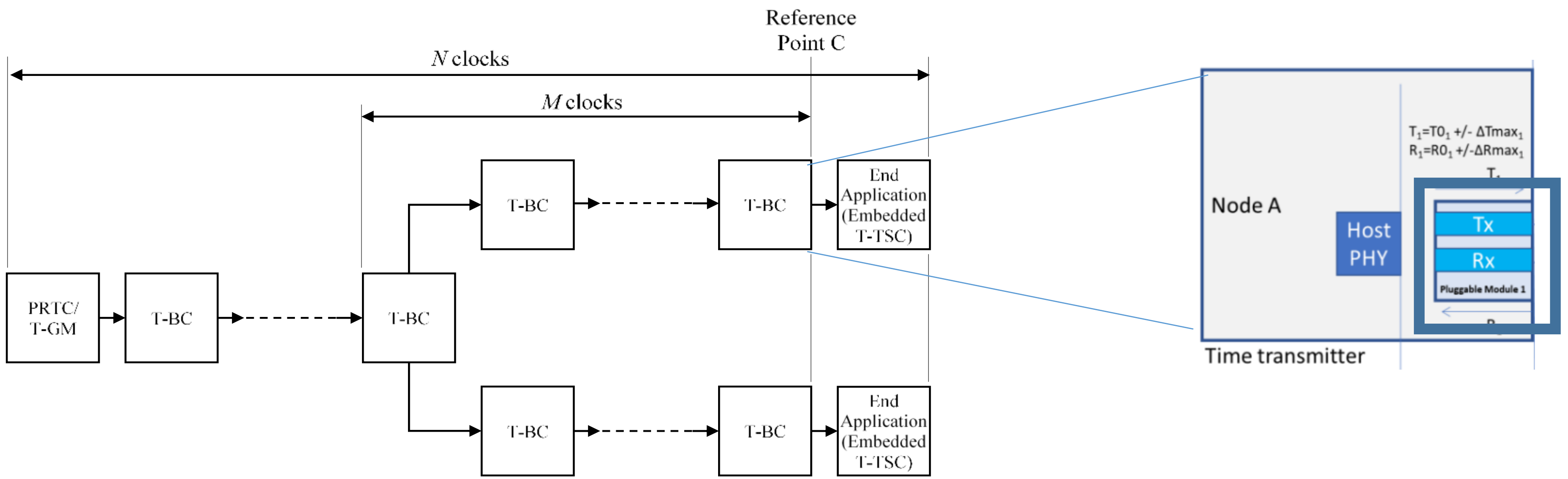
Power/Thermal

Complexity is in the modules rather than the host!



The Concern…

- Several areas of complexity, highly likely to add a degree of latency and latency variation
- Will this be manageable in systems relying on network timing…?



(First reported ITSF Brighton 2021) Investigations: Impact of Optics on ‘complete’ device timing performance

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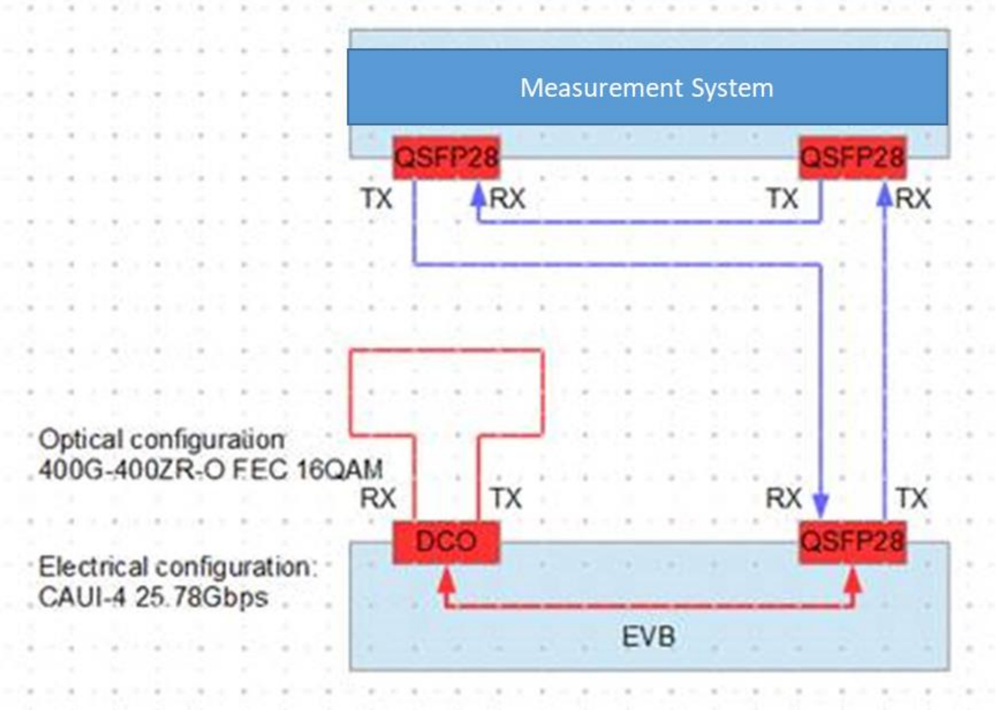
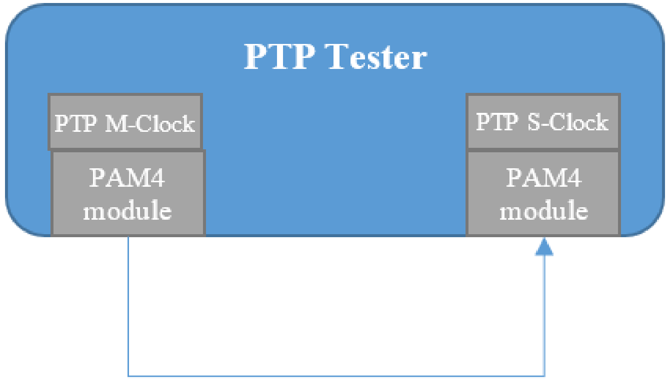
- Preliminary testing using known performance ‘golden’ optics and eval board loopback

(note: worst case impact of NRZ optics on latency/timing measurements is in the picoseconds)



Improved methodology:

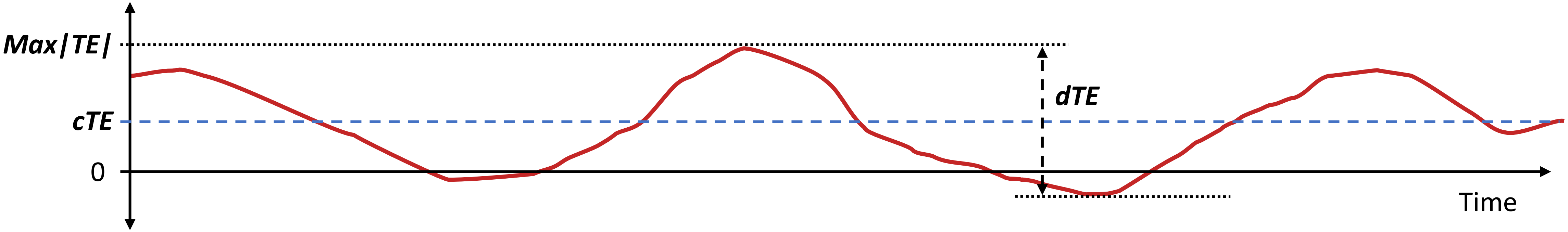
- More direct latency testing methodology
- Precision timestamped PTP packets used



Baseline measurement: 50G and 400G electrical DAC cables

Delta measured vs 50G SR,
400G SR8,
400G LR8 and
400G FR4 optics

Figure 1: Single device test configuration



Results:

- Multiple vendors, multiple modules measured
- Some reason for concern in all metrics
- Findings submitted to ITU-T

Test Case	Vendor	Mean Latency (ns)	Reset-to-reset Variation (ns)	Packet-to-packet Variaton (ns)
50G SR	Vendor A	68.0	2.1	<1
50G SR	Vendor B	60.9	1.5	<1
400G SR8	Vendor A	70.9	3.0	<1
400G LR8	Vendor A	64.8	3.5	<1
400G FR4	Vendor A	73.8	1.2	<1
400G FR4	Vendor C	74.9	1.4	2.5

Question(s): 13 **Meeting, date:** E-meeting, 3rd – 6th May 2022

Study Group: 15 **Working Party:** 3 **Intended type of document** (R-C-TD): WD13-xx

Source: Calnex

Title: Results of latency measurements of PAM4 optical modules

Latest Investigations (cont.):

- Simpler 25G NRZ optics may have a total latency of ~1ns. Therefore, any time error resulting from assumptions about the Tx/Rx latency split will be no more than 100-200ps.

- With PAM4 optics, the total latency is much larger, however, and the assumption that the Tx and Rx latency is the same can introduce significant time error…

Test Case	Asymmetry	Total Latency (ns)	Tx Latency (ns)	Rx Latency (ns)
400G SR8	Measured asymmetry	70.9	26.0	44.9
400G SR8	Assumed 50/50	70.9	35.45	35.45
400G SR8 Error	-		**-9.45**	**+9.45**

What about physical signal impact?

- Latest lab measurements for Digital Coherent Optics show very poor tolerance to physical signal variation, even well within G.8262 limits.
- **Breaks a SyncE chain and would be unusable for this purpose**

Optical module latency: Next Steps

1. Investigate improvements to ‘next-gen’ of optical modules:
   - Performance improvements
   - ‘e1pps’ or other methods to compensate for run-to-run variation ‘on-the-fly’
   - Not much progress…
2. More investigation – biggest delay/variation contributions?:
   - Needs capability to isolate Tx/Rx latency!
3. Short term, very close management of deployment conditions required?:
   - Needs an agreed industry approach

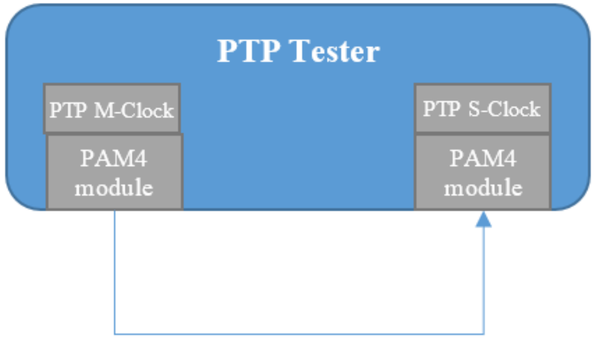
Verifying Optical Modules: Summary

- As shown previously, total latency through a pair of optical modules can be characterised today, using systems with performance timestamping

- However, if we do not know the Tx/Rx split, we could end up with a large asymmetry (>10ns) which is a major issue for e.g. PTP accuracy.

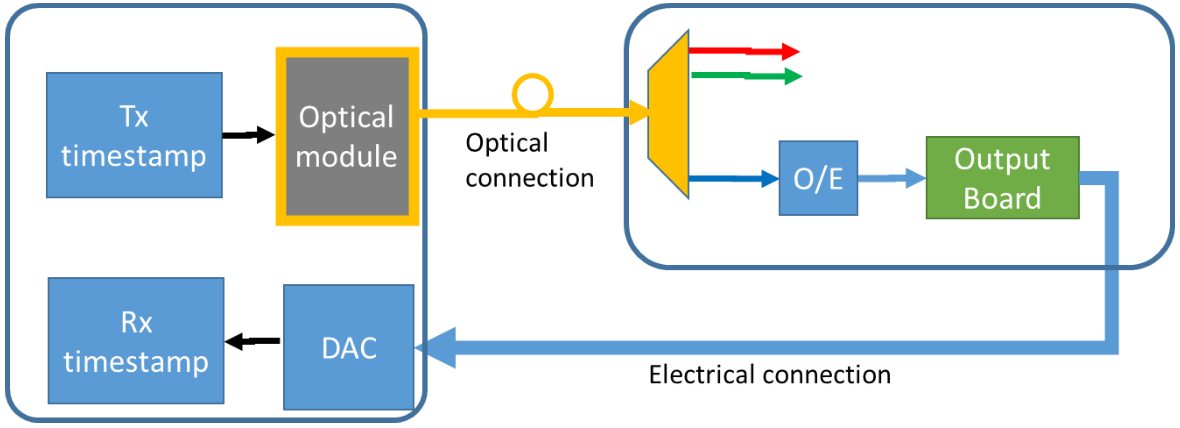
- Knowing Tx/Rx behaviour of modules could allow compensation - or at least allowance – in systems

- Often little/no information from Vendors about Tx/Rx latency.
  - Totally reasonable, as in the past, no applications suffered from latency in us/ns ranges



Verifying Optical Modules: A way forward?

- Test-bench solution created for investigations of 50G PAM4 modules – 400G PAM4 next
- Combines elements with known performance (i.e. error contributions in low ns range)
- Isolating Tx latency is possible
- Rx latency can hence be derived from measurements of Total Latency and Tx latency.



Latest progress on industry focus!


Mobile Optical Pluggables Alliance

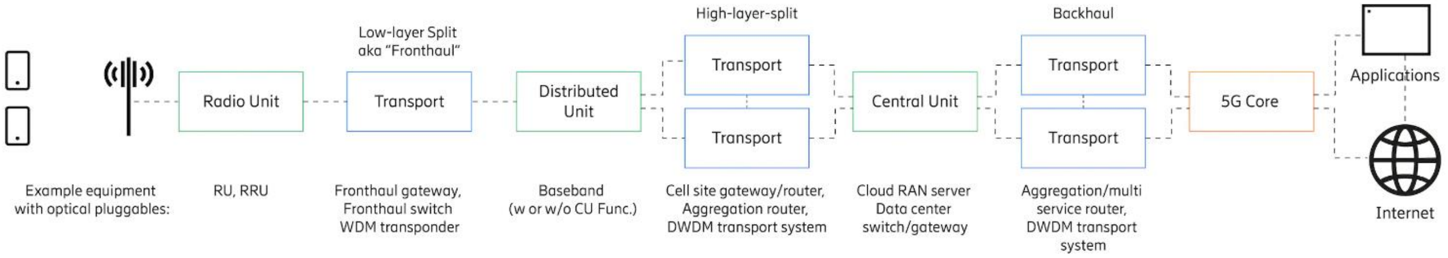
Mobile Optical Pluggables Alliance (MOPA)

Technical paper

Version 2.0

September 18, 2022

- Joint effort of Nokia, Ericsson, II-VI, Lumentum, Sumitomo Electric
- Makes the case for reducing the wide range of optics available/proposed for telecoms networks
- ‘Optical blueprints’ – **including target specifications for module latency**



-------- = **Optical pluggable**
(10G, 25G, 100G, gray, DWDM...)

MOPA: Time Error in pluggables

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6. A proposed methodology to define propagation delay accuracy classes of optical pluggables

Pluggable propagation delay accuracy classes can be based on “node” classes, by adding a simple percentage number.

An **“X.Y”** class pluggable would support node-level accuracy **Class X** and consume **Y%** of the relevant cTE budget (see Table APB.1 below where the G.8273.2 “node” accuracy classes are listed again for convenience). This creates a link between the node/application level and optical pluggables and defines the target optical pluggables specification.

G.8273.2 “node” accuracy classes	Class A	Class B	Class C
Max constant time error	+/50ns	+/-20ns	+/10ns

Table APB.1: G.8273.2 “node” accuracy classes.

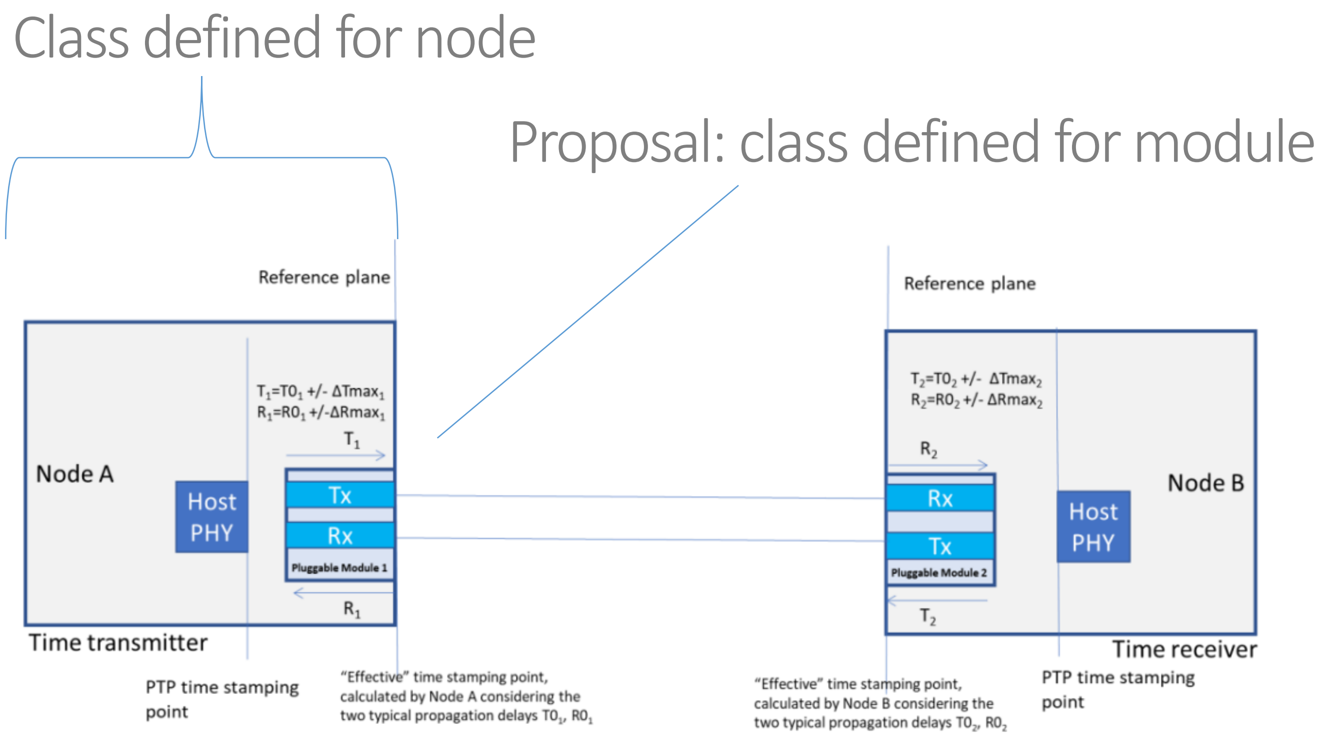

Figure APB.8 from
MOPA_Technical_Paper-v2.0-Final.pdf (mopa-alliance.org)

MOPA: Time Error in pluggables

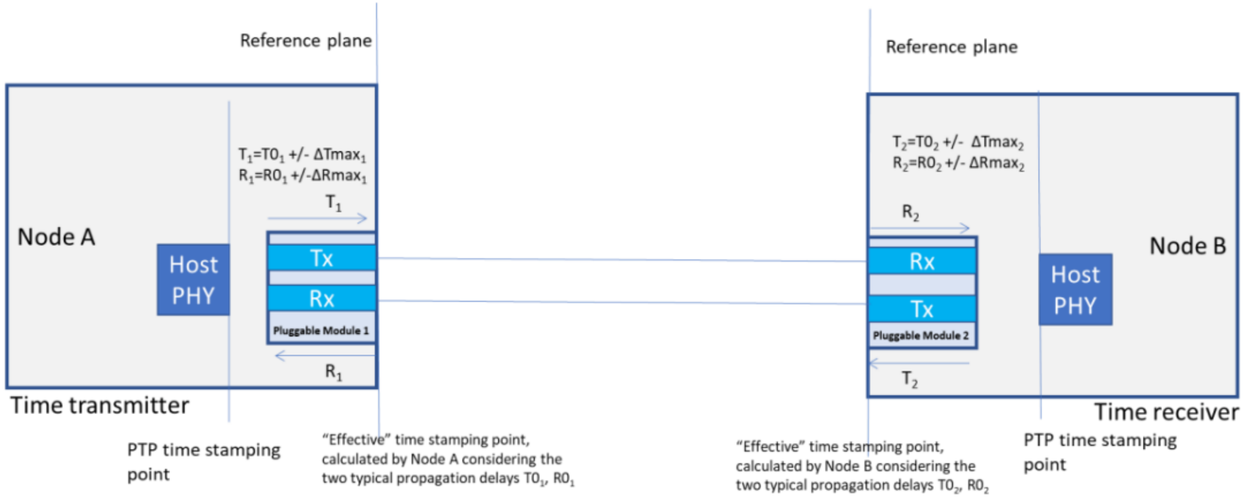

Figure APB.8 from
MOPA_Technical_Paper-v2.0-Final.pdf (mopa-alliance.org)

Examples:

- A **"Class C.10"** pluggable : **10% of the cTE budget ITU-T G.8273.2 allocated for Class C nodes.** (+/-1ns)
  "For very simple pluggable implementations, maintaining an analogue signal chain."

- A **"Class A.20"** pluggable : **20% of the cTE budget ITU-T G.8273.2 allocated for Class A nodes.** (+/-10ns)
  "**To enable use of complex digital parts inside the pluggable**."

Proposals to ITU-T planned...

Summary and Conclusions

- It is known and accepted that new technology iterations pose challenges when meeting sync performance requirements – the industry as a whole has good reason to believe these can be overcome!
- **The concept of optical modules as a significant factor is new – and not all required information is available**
- Significant progress in the last 6 months, in terms of industry recognition and potential to verify modules
- **We are ready to go further!**

Photo by Melinda Gimpel on Unsplash

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