Exploring Time Synchronization and Performance Considerations for Fronthaul using TSN

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***Abstract* — IEEE Std 802.1CM-2018 Time-sensitive networking (TSN) for fronthaul, is an IEEE standard developed to connect a cellular network's radio equipment to its remote controller via a packet network, particularly through a bridged network over IEEE Std 802.3 Ethernet. However, support for synchronization in the bridged network is not essential, as it is likely specified in the O-RAN S-plane specification. The synchronization data used for CPRI frame and time alignment is not a synchronization function within a bridge implementation. A TSN bridge may not function as a PTP instance. Therefore, we studied the time synchronization distribution in IEEE 802.1CM TSN for fronthaul, both with and without ITU-T G.8275.1 PTP telecom profile (full timing support from the network) and measured the performance of PTP T-BC or T-TC functionality in the TSN bridge.**

TEST SCENARIOS —

There are three test scenarios. The first involves distributing PTP messages over a pair of TSN bridges that are non-PTP instances. The second involves distributing PTP messages over a pair of TSN bridges that are PTP T-BCs. The third involves distributing PTP messages over a pair of TSN bridges that are PTP T-TCs.

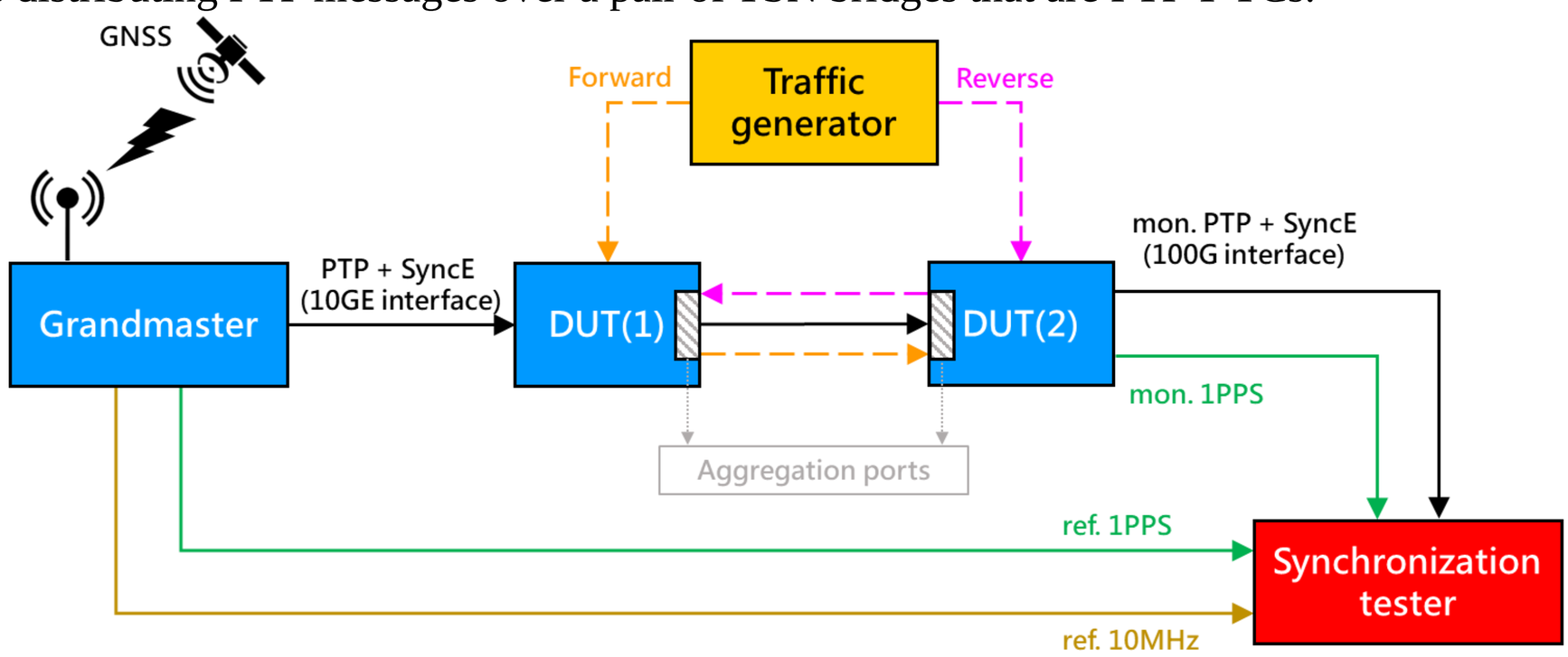

Figure 1 – Test setup for three scenarios

No matter whether the TSN interfaces carry other traffic in addition to PTP and ESMC traffic, the TSN bridge must be a T-BC or a T-TC to distribute PTP messages and comply with the time error limits of the 3GPP. The traffic test pattern for time clocks defined in ITU-T G.8273 is used as the interfering traffic in these three test scenarios.

The distribution of **packet sizes** of the **interfering traffic** is:

1) 5% of the load must be the largest size packets supported by the SUT (maximum transmission unit, MTU); Ethernet jumbo frame MTU 9018 octets
2) 55% of the load must be large size packets (1 518 octets);
3) 30% of the load must be small size packets (64 octets);
4) 10% of the load must be medium size packets (576 octets).
5) Largest size packets will occur in bursts lasting between 0.1 s and 3.0 s.
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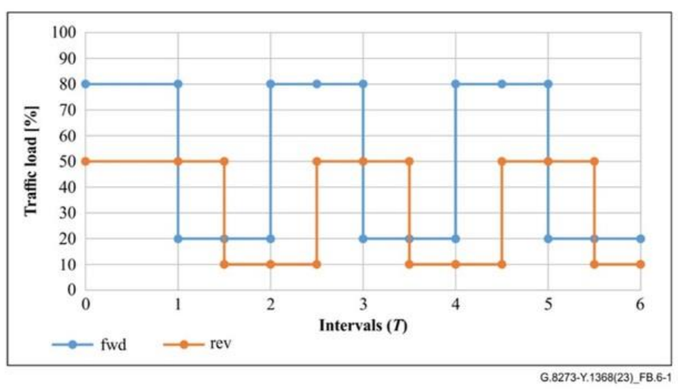

Figure 2 – ITU-T G.8273 Traffic load for testing time clocks

PTP Clock	G.8273 interfering traffic	SyncE support	PTP cTE	PTP dTE	Frequency departure
Non-PTP	N/A	Non-SyncE	1.23 ns	188.12 ns	1 530 ppb
	10 GE loading		139 449 ns	647 620 ns	863 ppb
	Preemptible 10GE loading		139 740 ns	640 736 ns	1 546 ppb
T-BC	N/A	SyncE I/O	2.48 ns	15.71 ns	0.25 ppb
	10 GE loading		8.26 ns	8.15 ns	0.25 ppb
	Preemptible 10GE loading		8.24 ns	14.09 ns	0.25 ppb
T-TC	N/A	SyncE I/O	7.67ns	11.18 ns	0.25 ppb
	10 GE loading		7.67 ns	12.03 ns	0.25 ppb

Figure 3- Analysis of PTP time error

CONCLUSION —

We also studied the Profile B defined in IEEE 802.1CM with IEEE 802.1Qbu frame preemption to avoid the worst-case latency of non-fronthaul traffic without restrictions on the maximum frame size. The interfering traffic included the largest size packets (9018 octets) and was preemptible. However, frame preemption may actually decrease the queuing delay caused by non-PTP messages. In fact, we concluded from the test results that frame preemption provides no benefit. To ensure the transmission performance of PTP messages, we recommend enabling the synchronization clock to maintain the quality of PTP message delivery. Additionally, it is advisable to take traffic load into consideration for synchronization performance.