Test patterns for time synchronization with partial timing support

Antti Pietiläinen

NOKIA

IEEE 1588-2008 PTP (Precision time protocol) profiles for telecom

Frequency

G.8265.1 profile (2010)
No on-path support
Unicast IP
Default domainNumber 4
clockClasses 80, 82,…

Time (and frequency)

G.8275.1 profile (2014)
Full timing support
Multicast Ethernet
Default domainNumber 24
clockClasses 6, 7, 135, 140, …

G.8275.2 profile (2016)
Partial and assisted partial timing support
Unicast IP
Default domainNumber 44
clockClasses 6, 7, 135, 140,…

Frequency and time

"IEEE 1588 Annex A.9"
"Telecom-2008".
Default domainNumber 0
clockClasses 6, 7, 13, 14,…
Proprietary, widely deployed by several vendors

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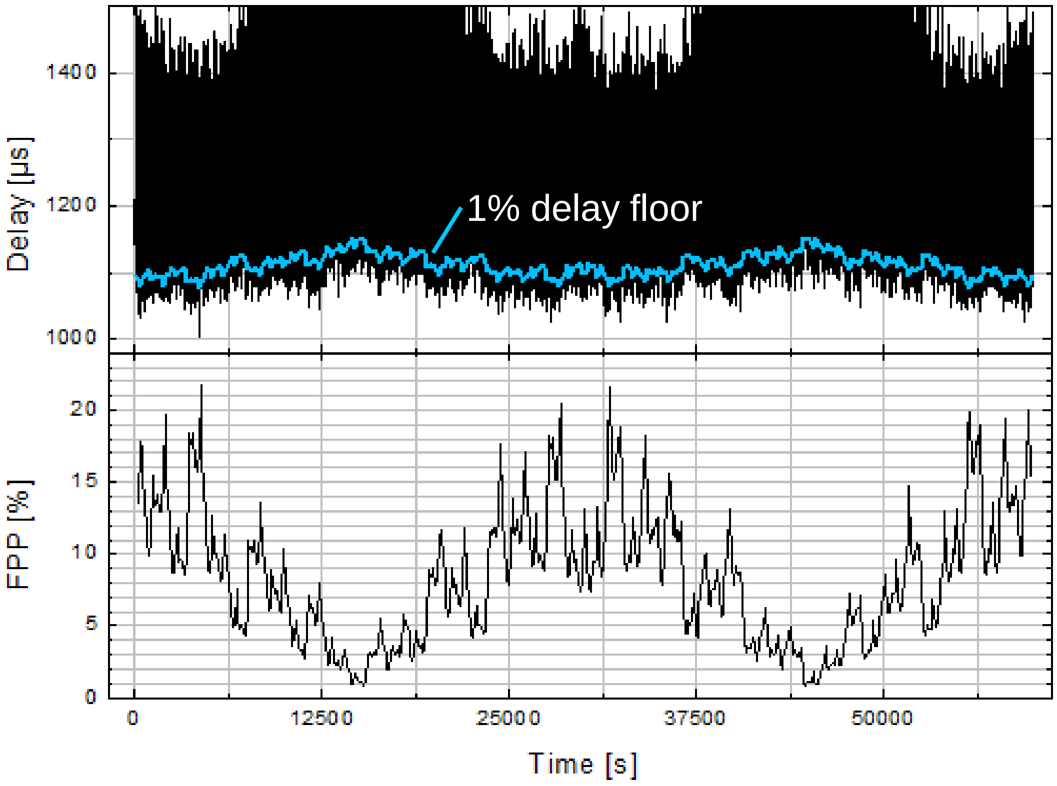
Before discussing G.8275.2 related issues – Recap of corresponding specifications for frequency profile G.8265.1

- (PTP) profile, G.8265.1 for frequency synchronization was approved in 2010, and packet delay variation (PDV) network limit metric G.8260 and network limit G.8261.1 in 2012.
  - The network limit metric was debated for almost 5 years. Better results would have been obtained if the discussion had been stopped half way through.
- Packet delay test patterns were published in an amendment to the clock specification G.8263 in 2014.

Side note: Final comments on the network limit metric of G.8261.1, floor packet percentage, FPP

- As defined by the limit, the percentage of packets within 150-µs minimum-anchored cluster should be more than 1%.
- So - higher percentage means better network.
- However, the result does not give any indication whether the clock output requirement, 16 ppb, is at danger.
- In this example, the difficultness of the pattern, i.e. variations in the delay floor, remain the same over the duration of the pattern even though FPP reaches ”worst” values in two small areas.



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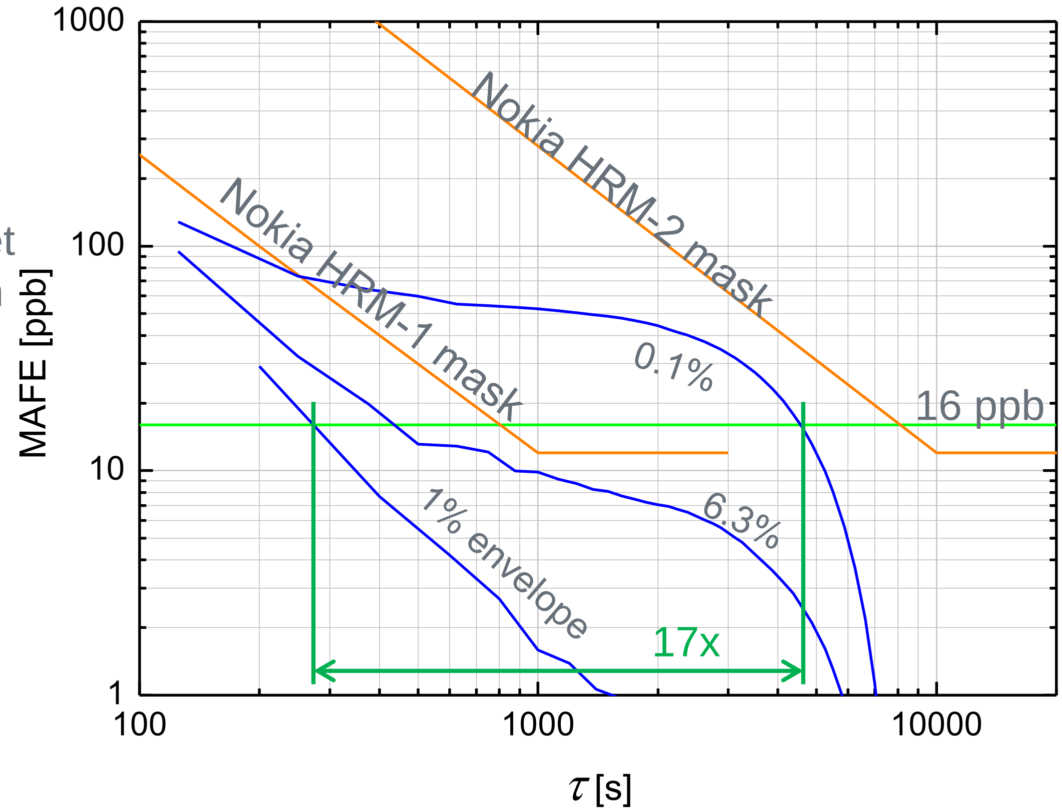
Final comments on the network limit metric, FPP, of G.8261.1, slide 2

- Single sinusoidal test pattern, an optional G.8263 test case, has constantly 1% FPP, i.e. same as the network limit.
- The pattern is highly sensitive to packet selection percentage - 17-fold variation in the challenge level to reach 16-ppb frequency stability
  - Low selection percentage, 0.1% requires long averaging time in the algorithm
  - Relatively high percentage, 6.3% yields same frequency error with 1/10th of the averaging time.
  - 1%-envelope selection yields superior results because it is based on the definition known to be used for creating the test pattern.



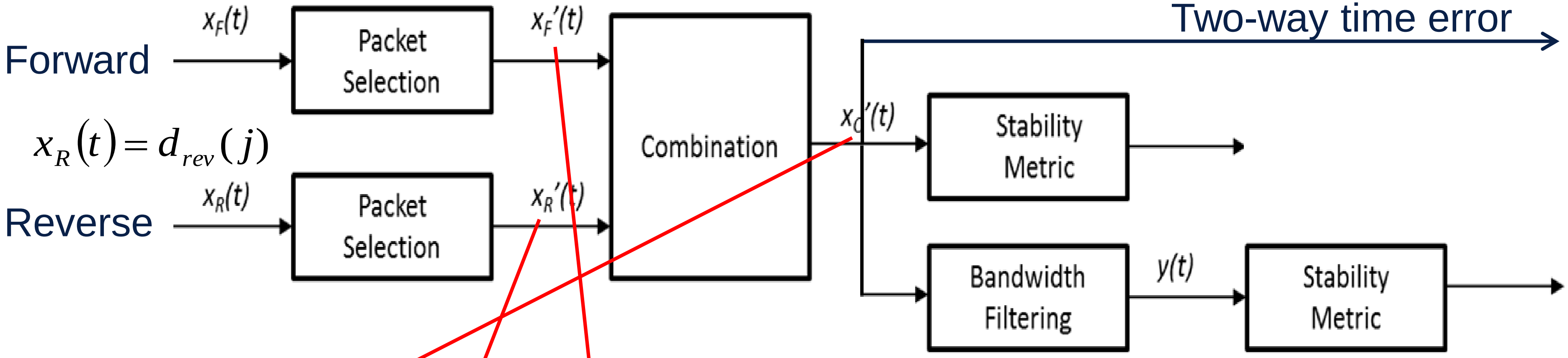
Specification for time profile using partial timing support G.8275.2

- PTP profile G.8275.2 was approved in June 2016.
- The corresponding network limit metric, pktSelected2wayTE, was selected in Sep 2015 and published in the revision of G.8260 in 2016.
- Candidate network limit values have been proposed for G.8271.2 since about 3 years but the decisions are still to be made.
- The clock specifications to be incorporated in G.8273.4 are still under way. Packet delay test patterns have not yet been proposed.

The metric, pktSelected2wayTE (packet-selected two-way time error)

Two-way time error based on percentile selections of forward and reverse delays

Forward time error is $x_F(t) = -d_{fwd}(i)$, where d_{fwd} is forward delay.



Two-way time error sequence is calculated using the packet-selected time error sequences:

$$x_C'(n\tau_s) = \frac{x_R'(n\tau_s) + x_F'(n\tau_s)}{2}$$

Selection window size, τ_s is e.g. 200 s.

Selection percentage is e.g. 0.25%.

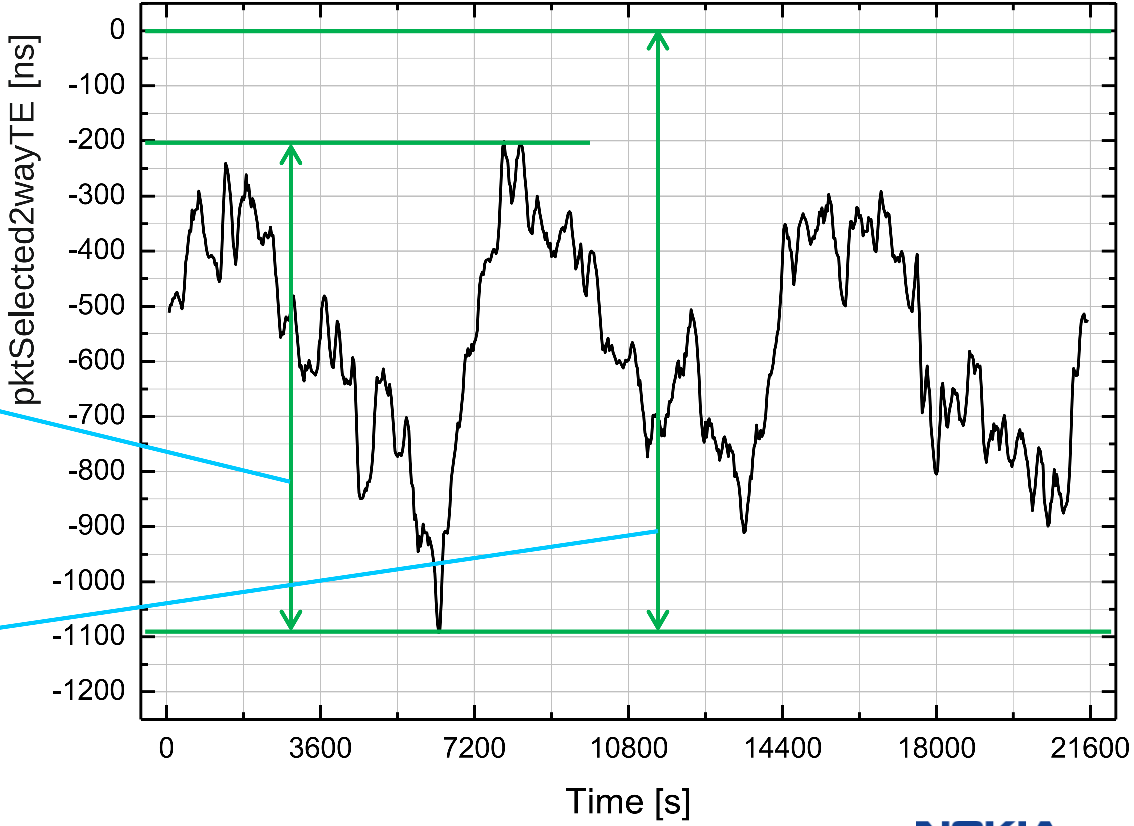
APTS (assisted partial timing support) and PTS (partial timing support) limit metrics

APTS:
Here the constant time error can be learned using the local GPS when it is operational. PTP is used only for holdover.

peak-to-peak(pktSelected2wayTE)

PTS:
Here fixed and dynamic error are both counted in.

max|pktSelected2wayTE|



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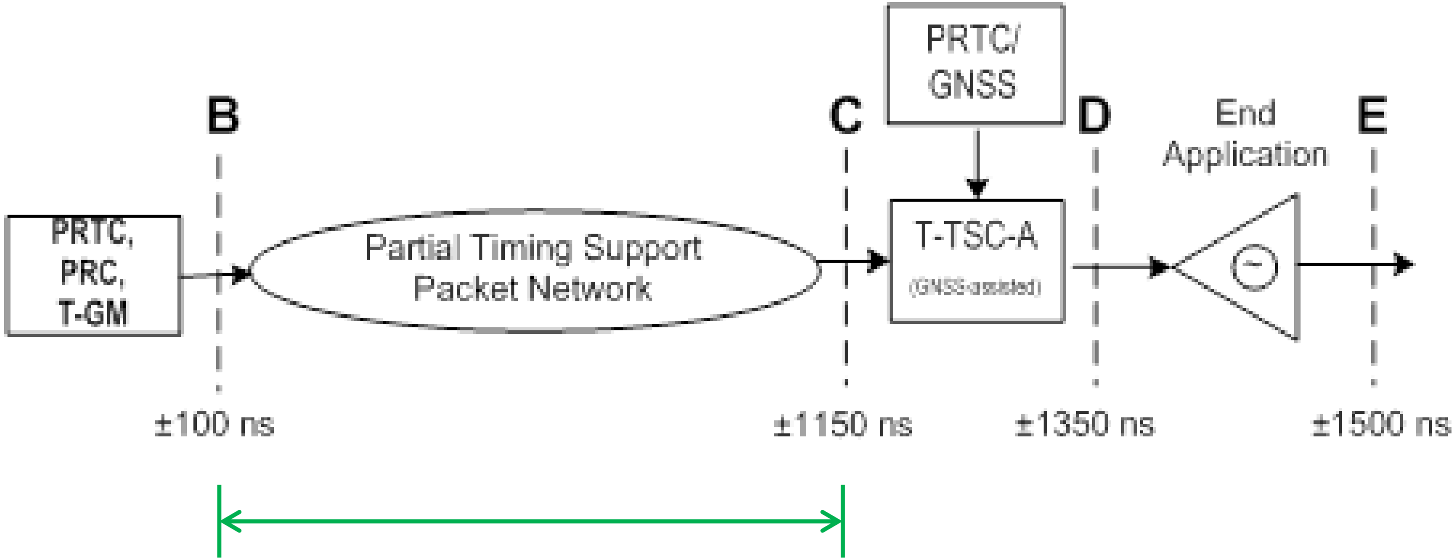
Defining a packet delay test pattern for APTS - Budget

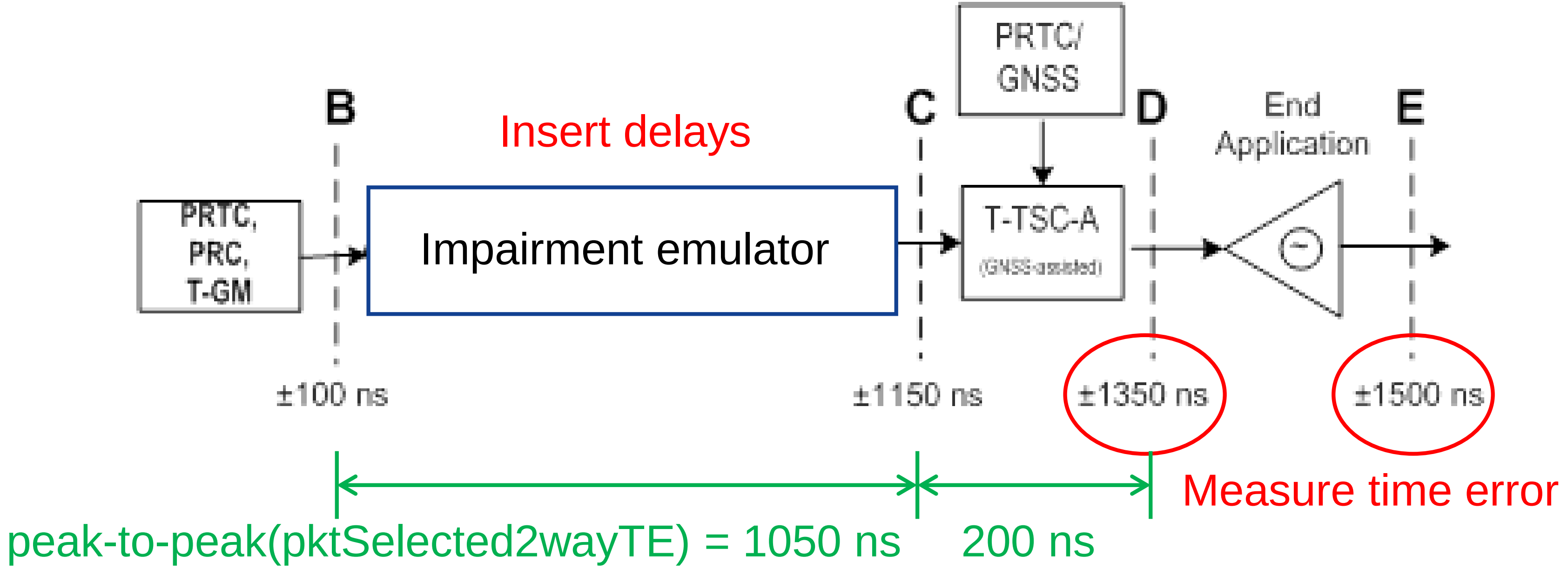
- Below is a scheme for APTS error budget (G.8271.2 draft Sep 2016)
- The peak-to-peak(pktSelected2wayTE) should be 1050 ns.



peak-to-peak(pktSelected2wayTE) = 1050 ns

Testing slave clock performance using the test patterns

- Load the patterns in an impairment emulator and measure the performance of the slave clock in the measurement setup below.

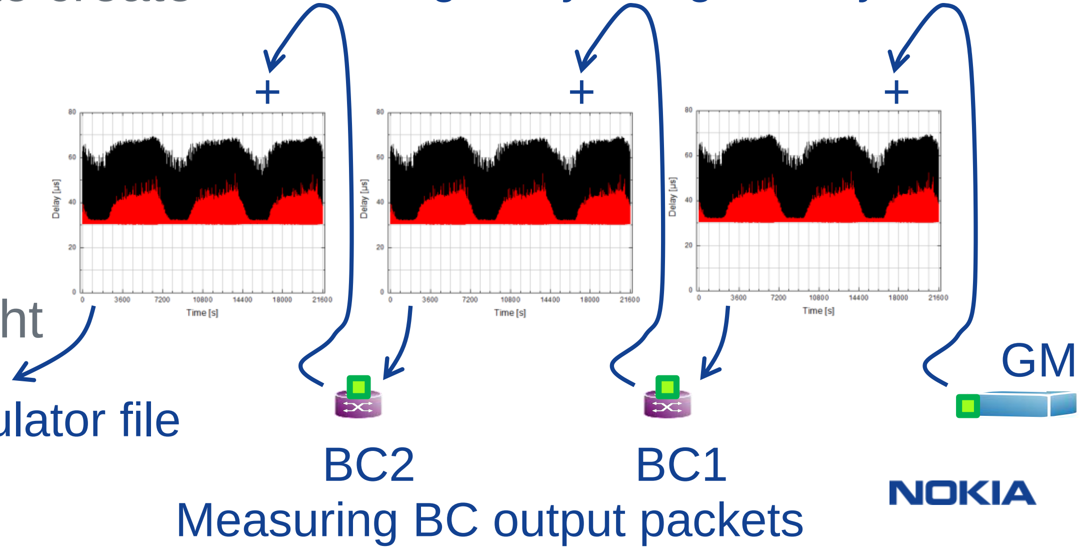


Packet selection window width and selection percentage – tentative values

- Normal-stability slave clock
  - Selection window width 100 s
  - Selection percentage 0.5%
- High-stability slave clock
  - Selection window width 200 s
  - Selection percentage 0.25%

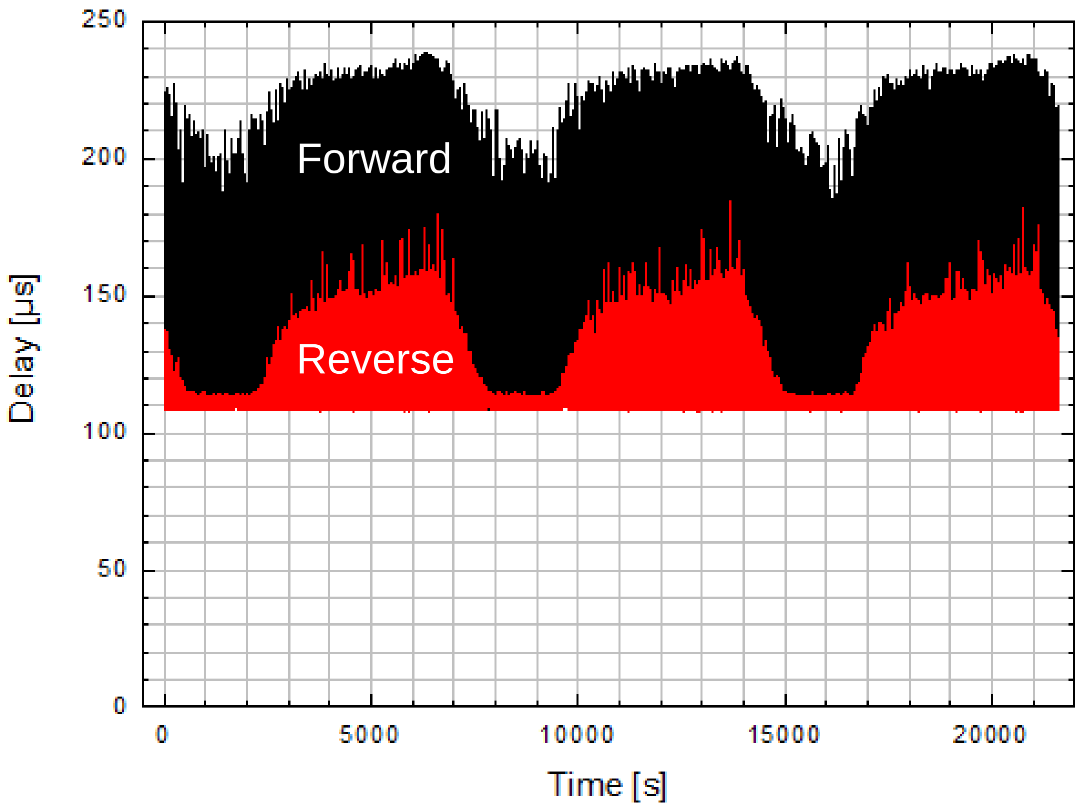
Creating a delay pattern

1. Simulate a base station load pattern
2. Measure delay as a function of load of a router
3. Map the simulated load pattern 1 to measured delays 2 to obtain PDV of a dynamically loaded router.
4. Add 3 times incoherently to create a chain of 3 routers.
5. Create a longer chain by measuring BCs and adding the PDV again twice more, see on the right



Delay files

- The forward and reverse delays were multiplied by 3.35 to obtain large enough floor delay variation that would match the 1050 ns limit using the high-stability slave clock parameters.



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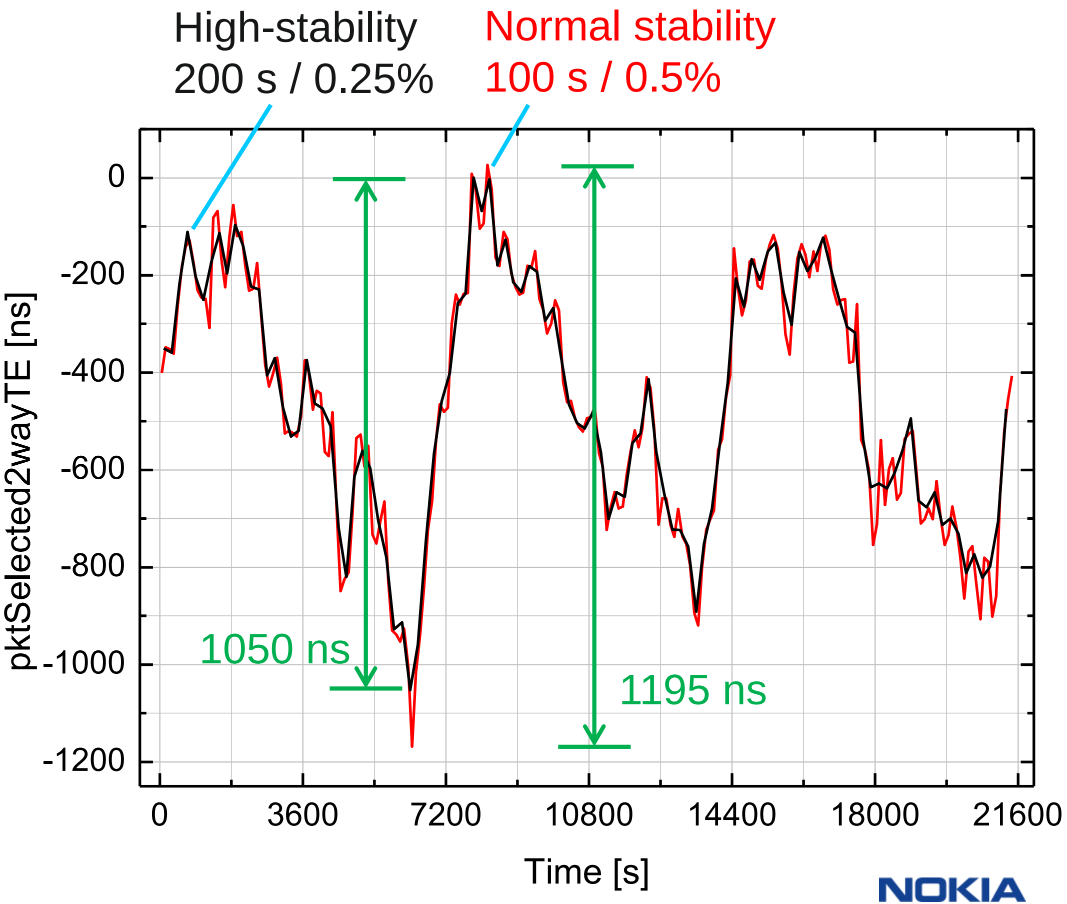
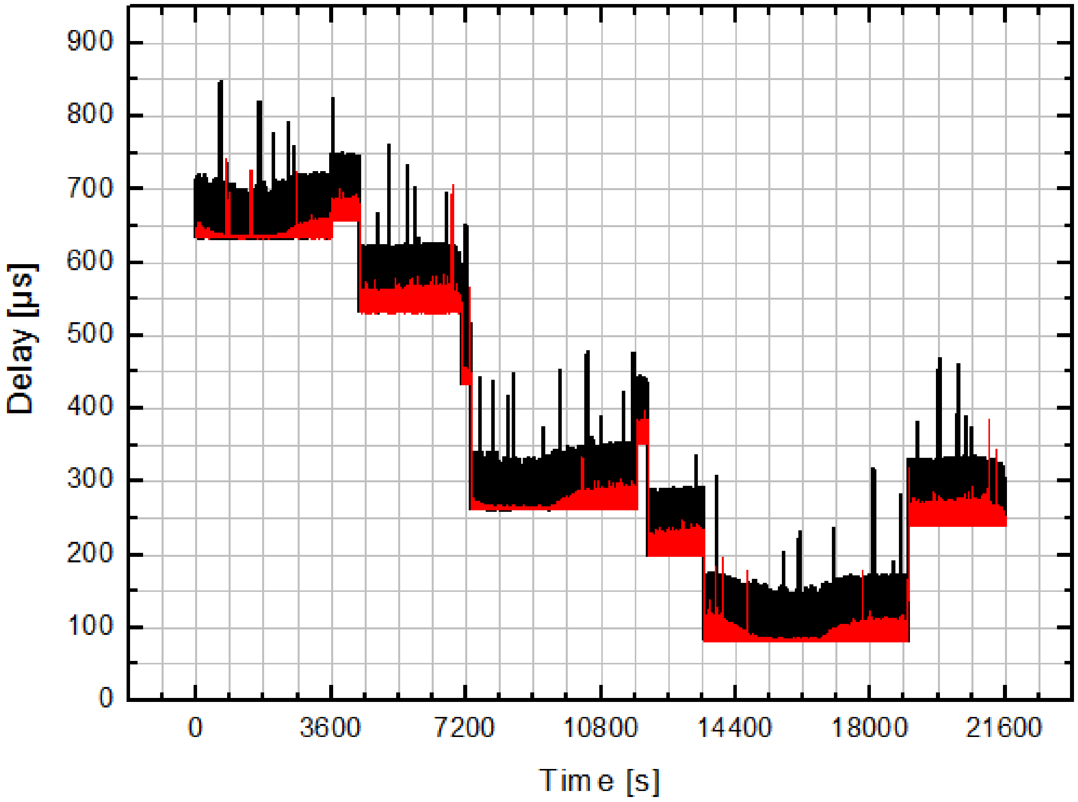
Peak-to-peak(pktSelected2wayTE) of the test pattern

- The difference between normal and high-stability clock is relatively small in this case because only 3 unaware hops are filtered by the slave.
- The delay file amplitude should be reduced by 12% to match the normal stability selection parameters.



Symmetric delay jumps and asymmetric delay bursts

- It is difficult to define limits for irregular phenomena in the G.8271.2 network limit.
- Therefore, adding such artifacts in the packet delay patterns in G.8273.4 could satisfy the need.
- The jumps mimic route changes and the bursts mimic temporary traffic bursts raising the delay floor to either fwd or rev direction for a maximum of 15 s.



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Conclusions

- For completing the recommendations related to partial timing support profile, G.8275.2, network limit in G.8271.2 and slave clocks in G.8273.4 need to be defined.
- The network limit for assisted partial timing support (APTS) is near completion and could be consented by the next SG15 plenary in June 2017. PTS limits could be approved too because the framework is converging and there are two interims to go before the plenary.
- By that time, at minimum, vendors and operators should have had the opportunity to test various delay patterns intended for G.8273.4.

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