

Time synchronization with partial on-path support

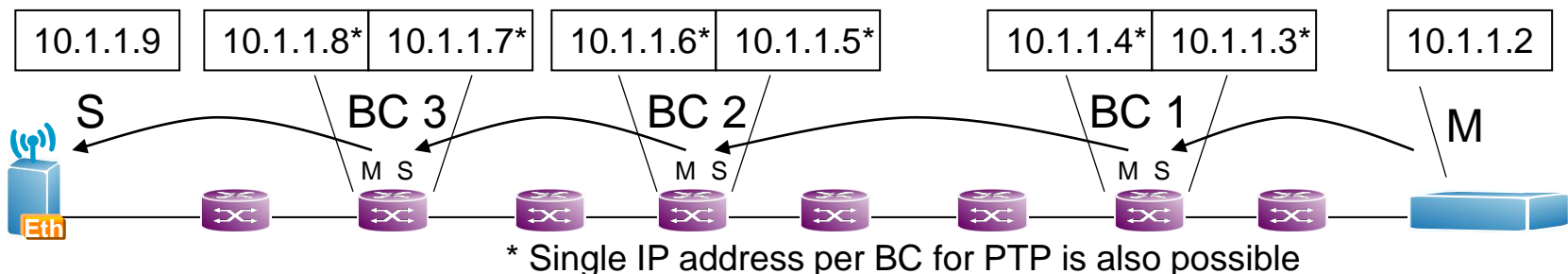
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Partial on-path support background

- The slower than expected spreading of Synchronous Ethernet indicates that building full on-path support for time synchronization might take long.
- Partial on-path support scheme might come to speed up the development.
- A contribution co-authored by several operators proposed to start development of a profile in ITU-T Q13. The proposal was accepted with certain conditions.
- Will probably utilize IEEE-1588 Annex A.9 or ITU Telecom frequency profile G.8265.1 supplemented with time traceability information.

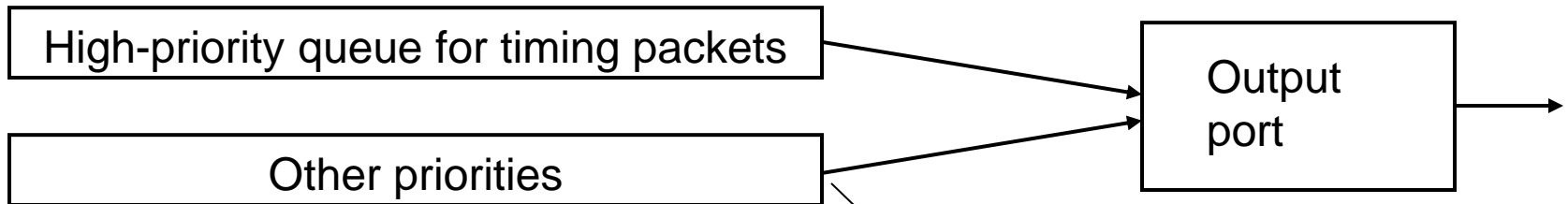


Conditions for partial on-path support

- Duration of a single full-length Ethernet frame is 12 μ s at 1-Gbit/s speed.
- Since the budget of the total path is in the order of 1 μ s, timing packets are useful only if they have not queued in any of the switches on the way. This means that even a fraction of an earlier packet still being sent out, is usually "fatal".

Satisfying the conditions

- Sending many and utilizing only the fastest timing packets.
- Depending on the number of PTP unaware hops between BCs, allowing only 70- 90-% load on links.
- If load would otherwise exceed allowed percentage, policing would be used:



Limit to maximum allowed fraction of port speed.

Classification

Full on-path support

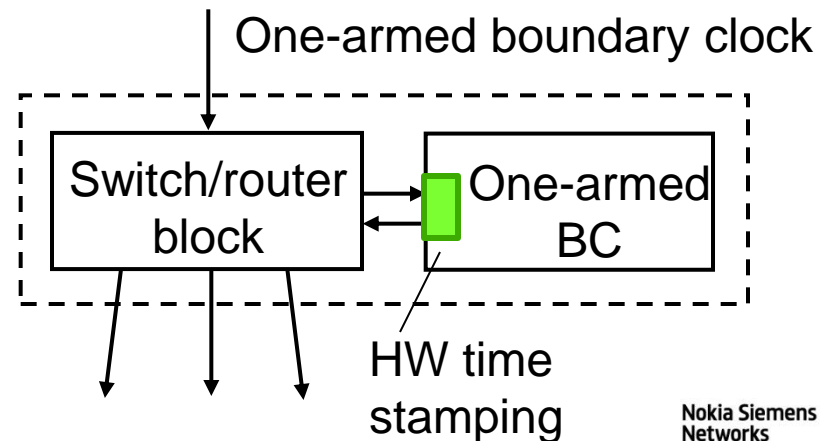
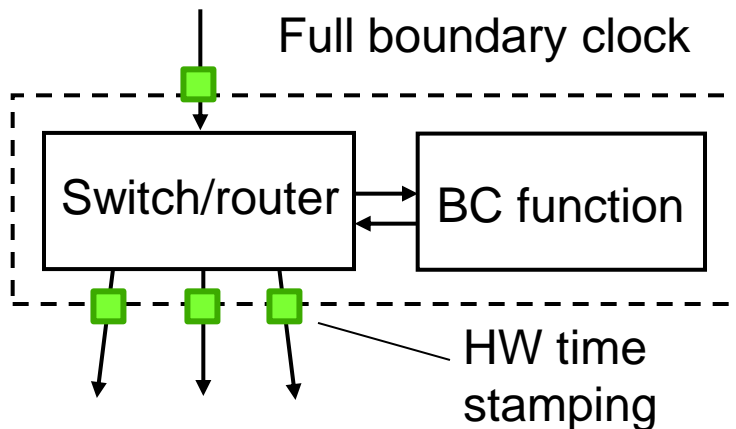
- Single-link multicast Ethernet for ease of configuring
- All timing packets are utilized for synchronization.
- Packet rate 16 pps

Partial on-path support

- Unicast IP for allowing multihop paths between PTP aware nodes
- Slow packets are filtered out. Possible for BCs and slaves but not for TCs
- Higher packet rate to allow filtering, for example 64 pps

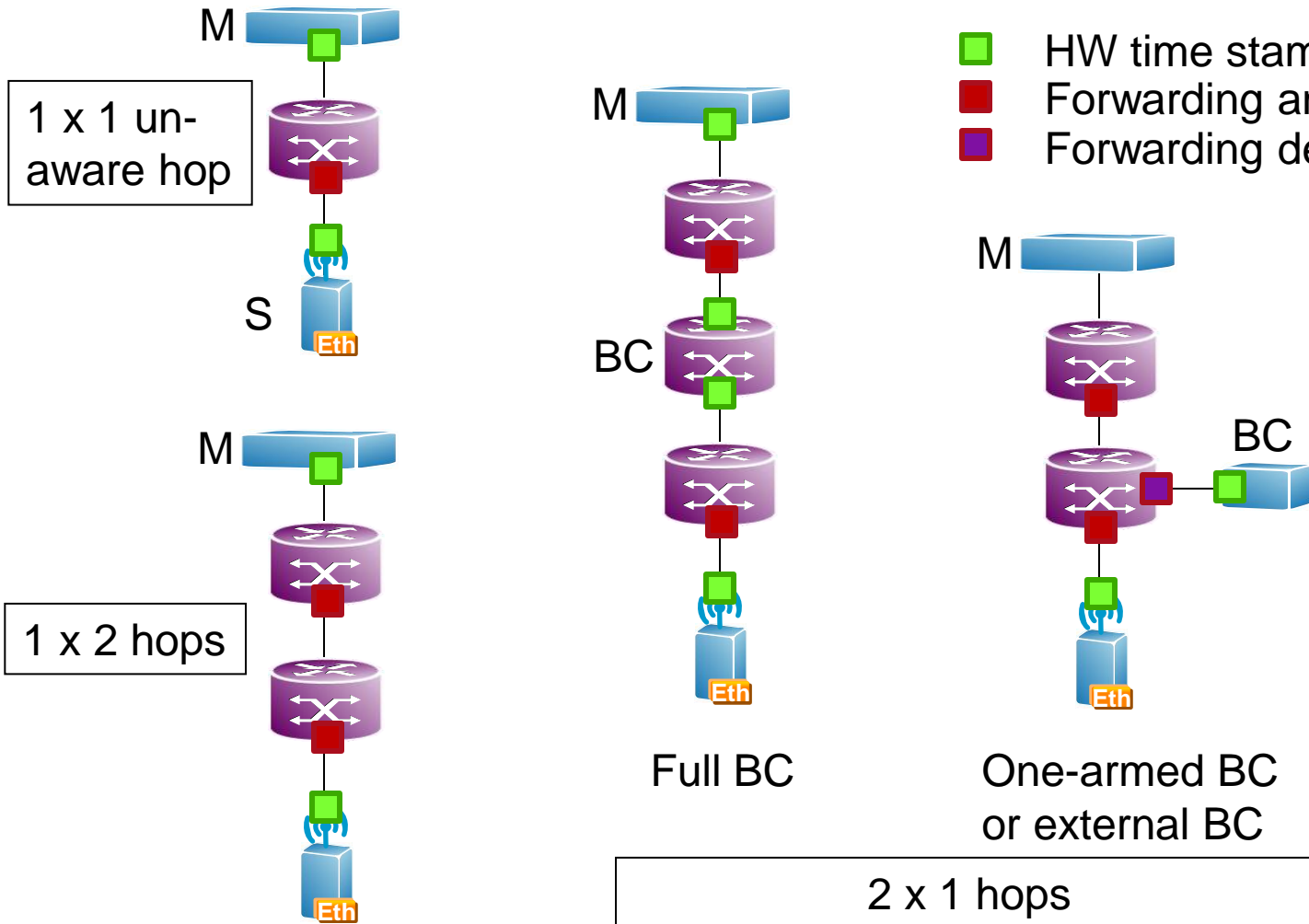
*TC: transparent clock

Implementation classes



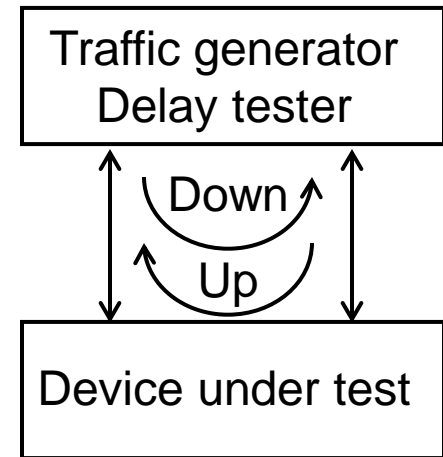
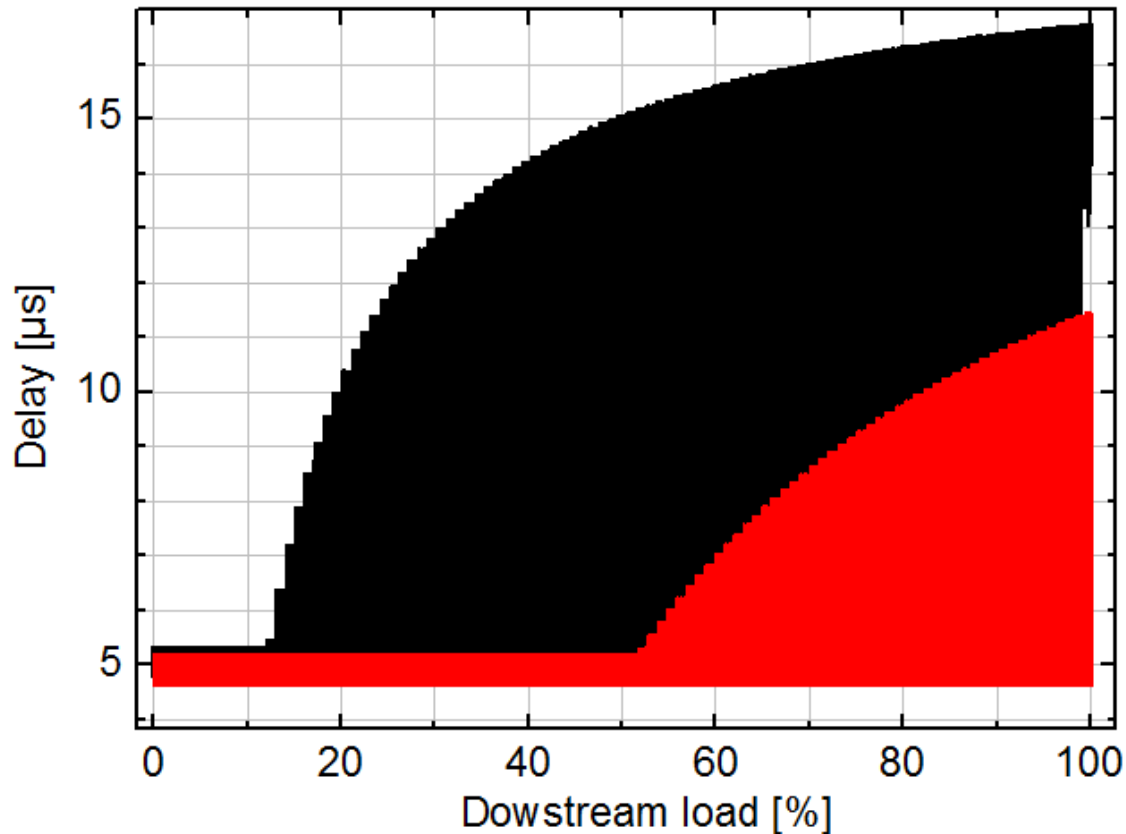
Counting PTP unaware hops

- One-armed case could be used to make existing networks time capable.
- Each full BC brings an additional hop for “free” compared to one-armed.



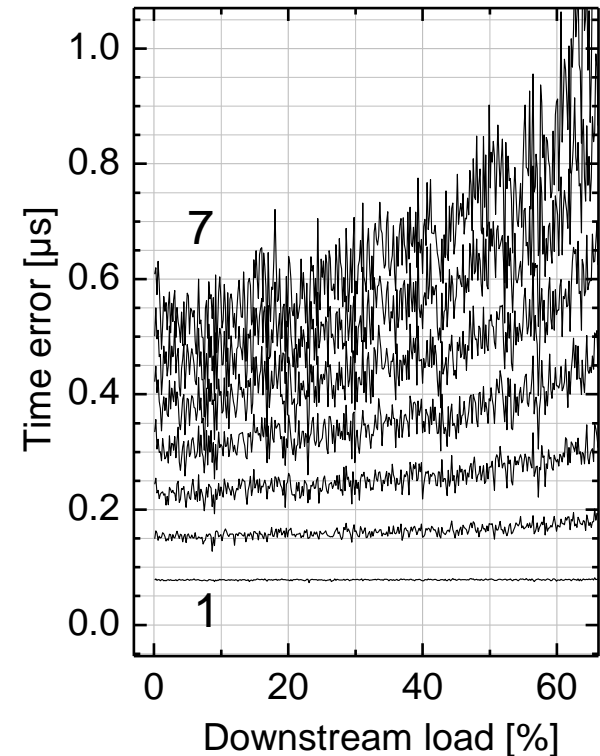
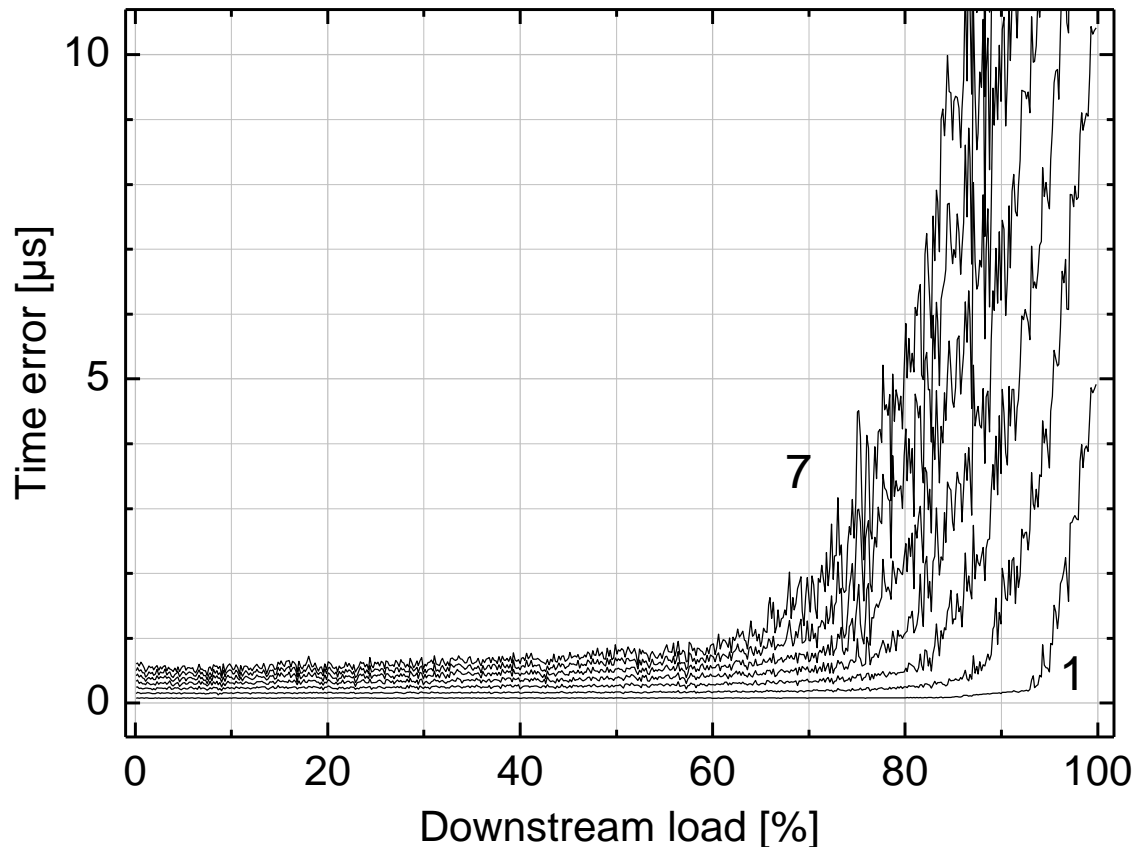
Delay measurements, cell site switch

- Downstream load varies from 0...1 Gbit/s (port speed).
- For creating load based asymmetry, upstream is $\frac{1}{4}$ of the downstream load.
- Multiple-hop configurations were created by adding the same measurement up after uncorrelation by shifting $nx100$ samples



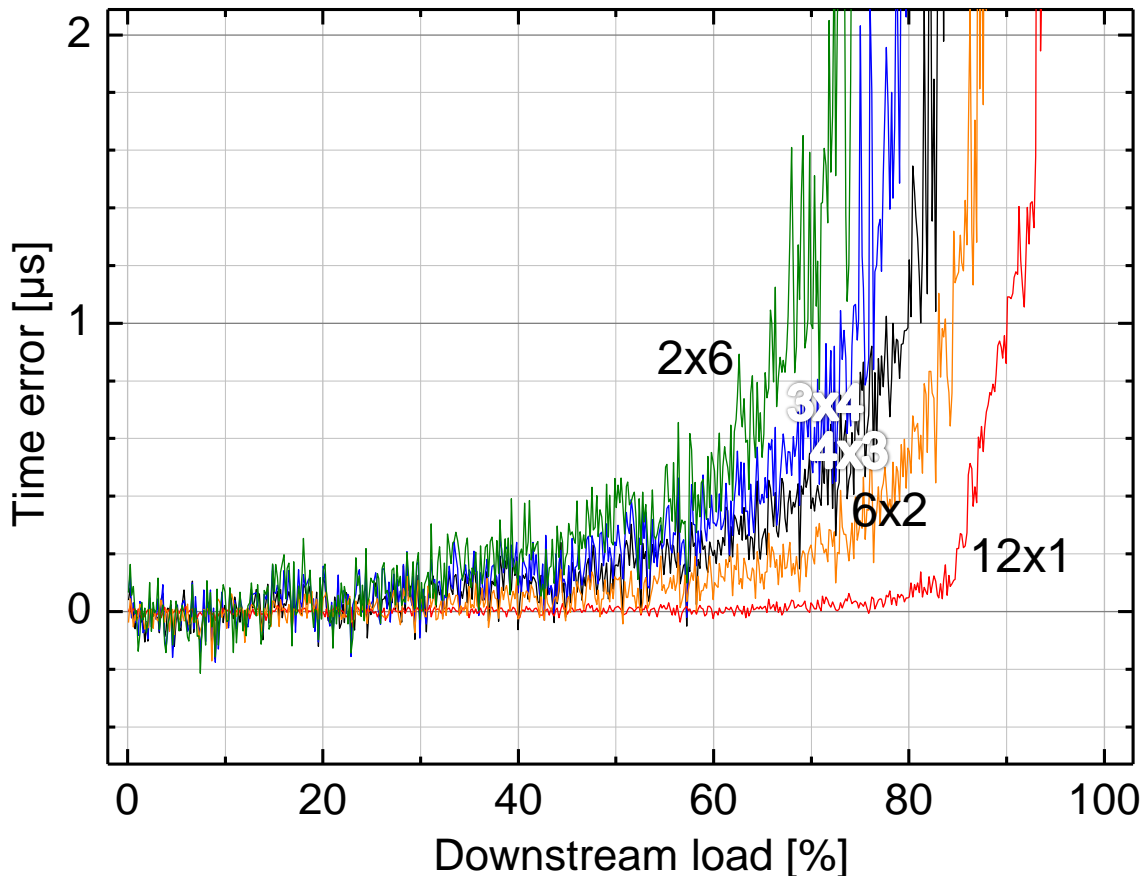
Time error estimate, cell site switch

- Error calculated as $(1\% \text{ Downstream delay} - 1\% \text{ Upstream delay})/2$
- Hop counts from 1 to 7, i.e. 1x1-hop to 1x7-hop configurations, see p. 5.
- A load-independent asymmetry of $150\text{-}\mu\text{s}$ causes a $75\text{-}\mu\text{s}$ time error that adds up linearly as hop count increases. May be caused by copper interf.



12-hop time error with different BC- vs. unaware-node configurations, cell site switch

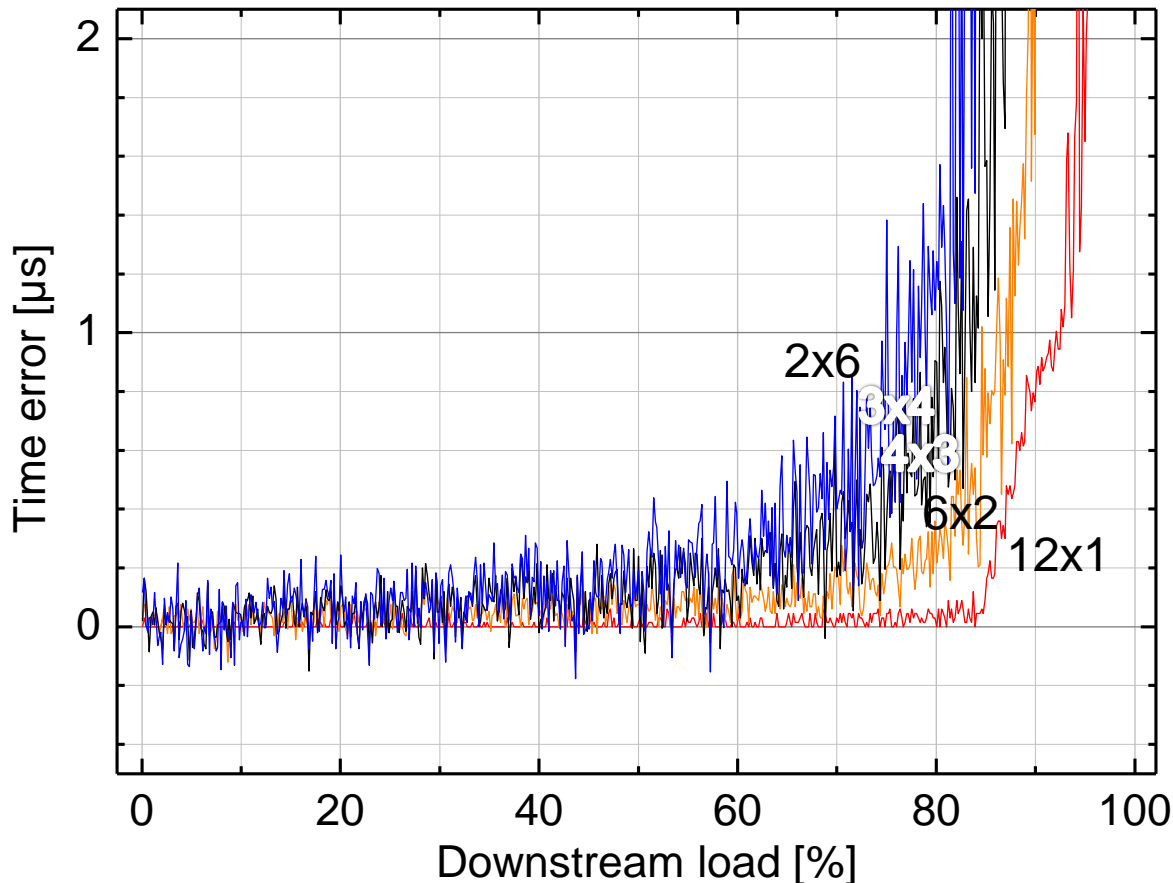
- The fixed asymmetry was removed for determining load-based asymmetry effects.



Configuration	Load at 1- μ s error
12 x 1 hops	90 %
6 x 2 hops	83 %
4 x 3 hops	80 %
3 x 4 hops	73 %
2 x 6 hops	65 %

Same as previous slide but selection percentage dropped from 1 % to 0.2 %

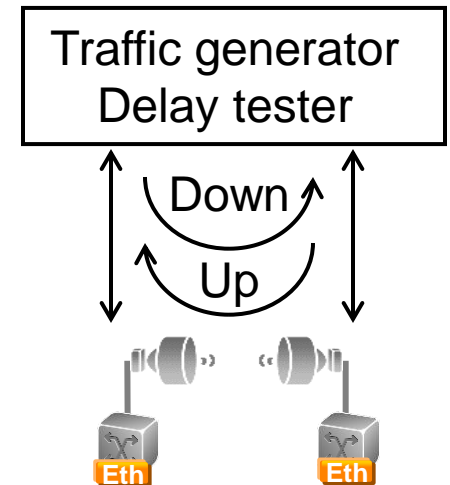
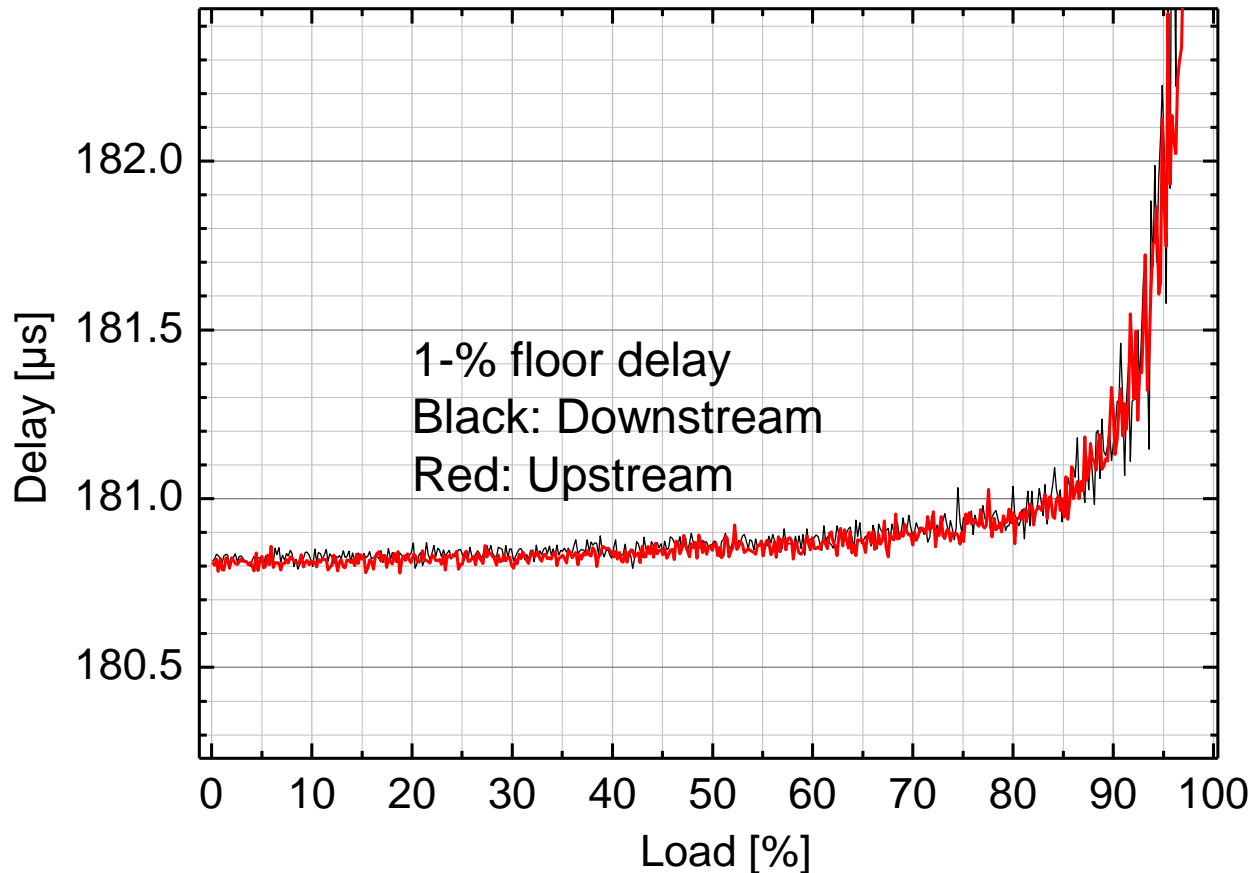
- Improvement compared with 1-% case is surprisingly small.
- 0.2 % selection percentage yields only one packet every 8 seconds. Further dropping of selection percentage may be difficult.



Configuration	Load at 1- μ s error
12 x 1 hops	92 %
6 x 2 hops	85 %
4 x 3 hops	82 %
3 x 4 hops	74 %
2 x 6 hops	70 %

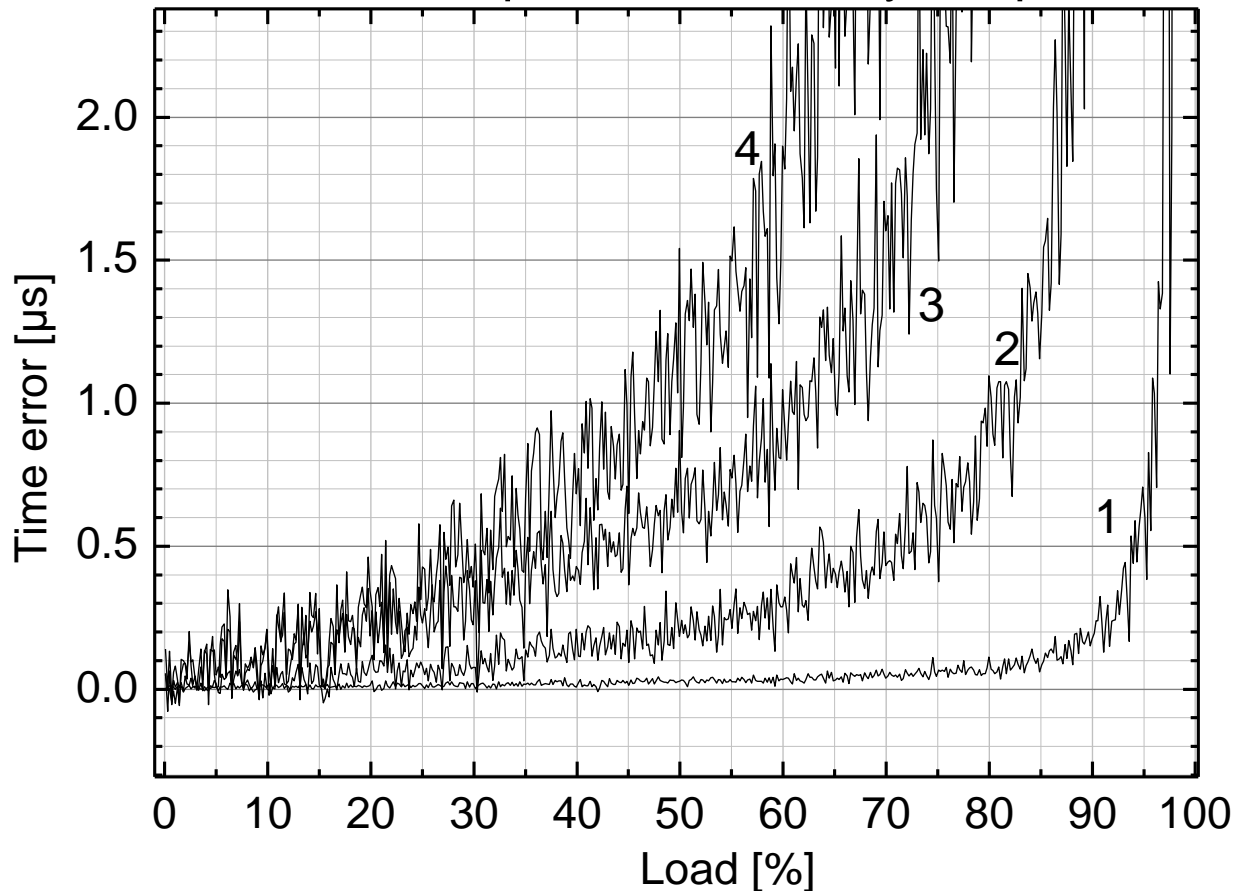
Microwave radio link

- Delay is extremely symmetric
- However, the delay starts to increase from low utilizations, which does not promise excellent chaining performance.



Microwave radio link chaining

- Delay was measured with symmetric load so error is estimated based on half of downstream delay increase as a function of load.
- Error increases clearly more rapidly as a function of hop count compared with the cell site switch case.
- 2 hops with 70 % load corresponds still to only 0.5 μs error.



Conclusions

- Partial on-path support seems to be feasible if it is possible to limit maximum short-time average traffic to 70-90 % of bandwidth depending on BC configuration.
- Bursts reaching 100 % and lasting few seconds at a time could be still allowed.
- A network with 4x3 Gbit/s links and 1x2 microwave links could be chained together if the short-time average utilization would be limited to 70 %.