Monitoring Timing Delivery Performance

QULSAR

OVERVIEW

- The Premise
  - The Datacenter operator provides "time as a service" from a few PTP Grandmaster devices and deploys "Monitoring" PTP TimeReceivers in each Datacenter
- Performance depends on the quality of the PTP TimeReceiver servo
  - Model for a servo in terms of bandwidth
- Experimental Set-up
- Analyzing time-error data reported by monitoring unit(s)

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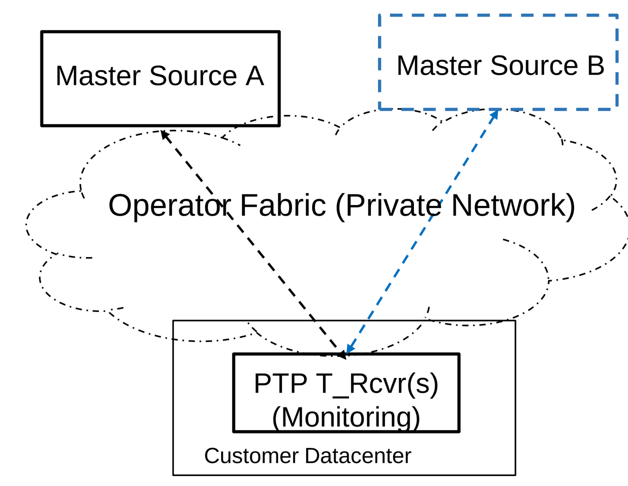
The Premise: Deploy PTP TimeReceivers in the Datacenter to estimate timing accuracy that can be provided to all customers in that Datacenter



Monitoring PTP TimeReceiver instrumented to report:
- Time error as estimated by the T_Rcvr
- One-way delay as estimated by the T_Rcvr
- Other useful metrics

Considerations:
- cannot detect asymmetry [*constant Time Error* (cTE)]
- The private network is well managed but unlikely to provide "Full Timing Support".

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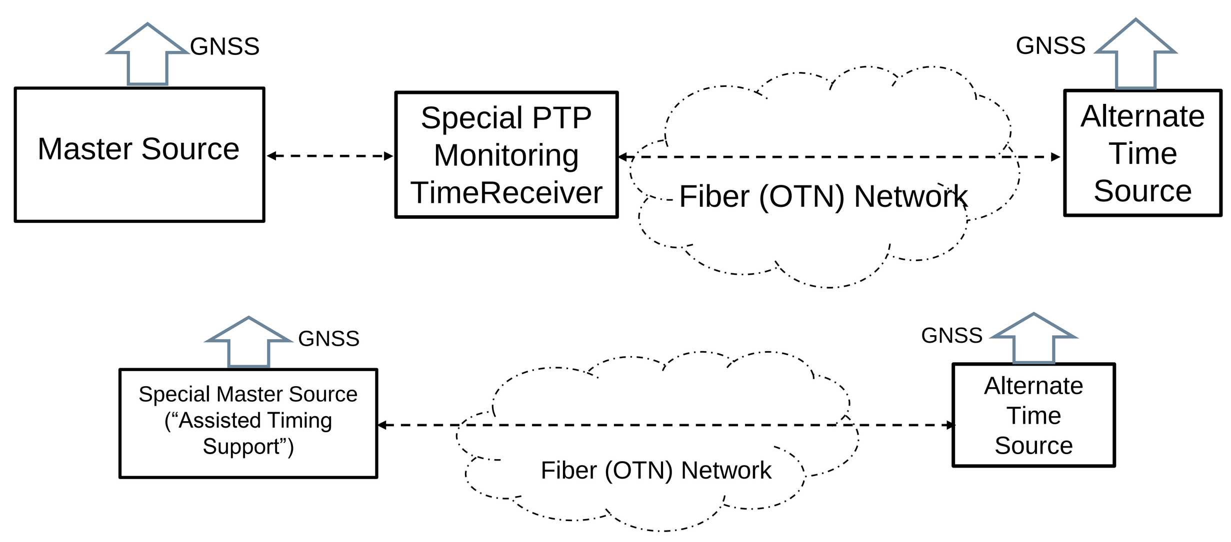
Master Timing Source can be monitored (or assisted) utilizing an alternate traceable reference PTP source with Ethernet over OTN



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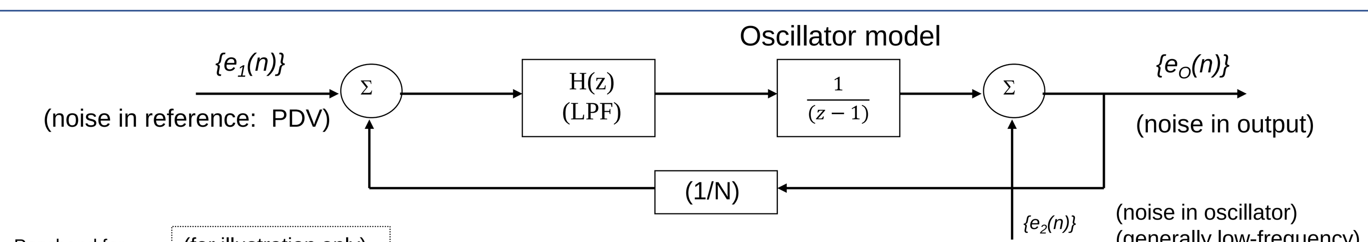

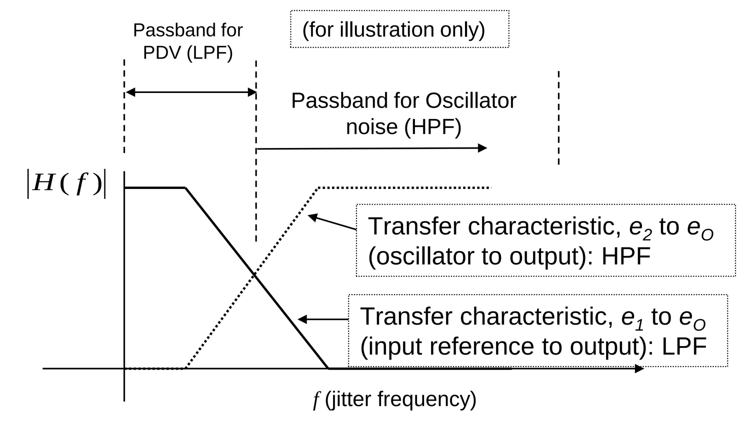

- High-freq. noise (jitter) in output originates in the oscillator
- Low-freq. jitter (wander) originates in network induced packet delay variation (PDV).
- Bandwidth tradeoff: Narrow-band (LPF) implies strong filtering of PDV but lax filtering of oscillator noise.
- Narrow-band implies e_o from oscillator; wide-band implies e_o from network

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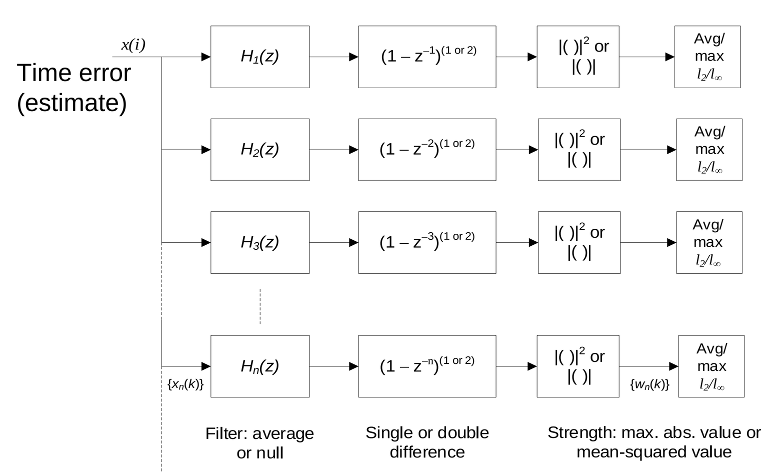
Metrics - Computation



Signal Averaging Filter

$$H_n(z) = \frac{\sum_{m=0}^{m=(n-1)} z^{-m}}{n}$$

Metric Avg. calc. over K points

$$V_n(N) = \frac{\sum_{m=(N-K+1)}^{m=N} (w_n(m))}{K}$$

Metric Avg. Recursive calculation

$$VR_n(k) = \alpha \cdot VR_n(k-1) + (1-\alpha) \cdot w_n(k) \quad [\alpha < 1]$$

- MTIE calculation does not fit neatly into this model
- Boundary points need to be handled with care when data set is finite

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Useful Metrics

Metric	Strength calc.	Signal Avg. Filter	Difference level	Comments
MATIE (MAFE)	maximum	yes	First difference	Identifies frequency offset
TIE_{rms}	(root) mean-square	none	First difference	Power of dynamic time error
TEDEV (TEVAR)	(root) mean-square	yes	First difference	Power of time error
TDEV (TVAR)	(root) mean-square	yes	Second difference	Power of time error
ADEV (AVAR)	(root) mean-square	none	Second difference	Power of time error (indirect)
MDEV (MVAR)	(root) mean-square	yes	Second difference	Power of time error (indirect)

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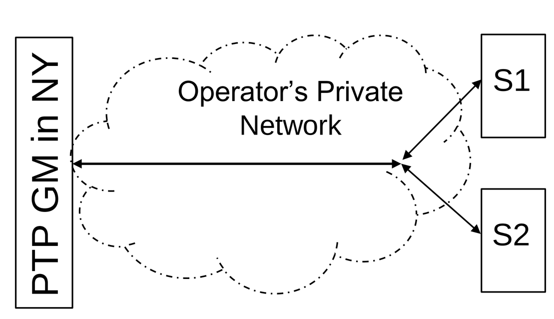
Experimental Set-Up

- Two TimeReceiver devices (S1 and S2) in San Jose (California) synchronize to PTP GM in New York over the Operator's managed, private, network
- Both S1 and S2 report estimated time error (Offset from Master); data collected in 3-hour blocks for post processing



TimeReceiver S1: bandwidth "unknown"

TimeReceiver S2: 3 separate bandwidth settings (~7mHz, ~2mHz, ~1mHz)

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Experimental Results

- Three 3-hour collections for three different choices of bandwidth for S2
- Observations:
  - The max|TE| as estimated by S1 is significantly greater than that by S2
  - The max|TE| as estimated by S2 decreases with reduction of bandwidth (stronger PDV reduction)

	S1	S2 (~7mHz)	S2 (~2mHz)	S2 (~1mHz)
Delay	35.7ms	35.7ms	35.7ms	35.7ms
Max|TE|	50us, 41us, 35us	27us	10us	9us
TDEV shape	peculiar	normal	normal	normal
Spectrum shape	peculiar	normal	normal	normal
Amplitude histogram shape	normal	normal	normal	normal

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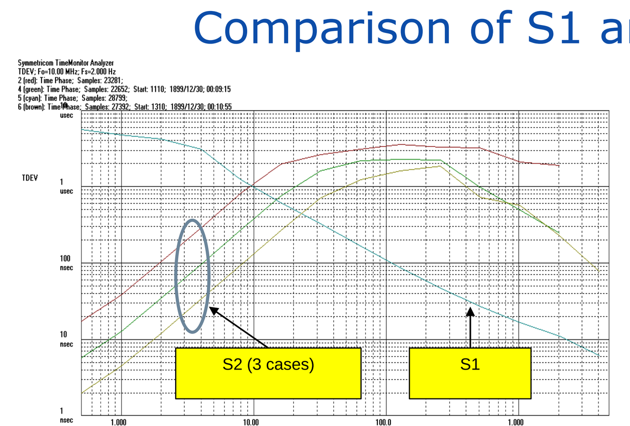
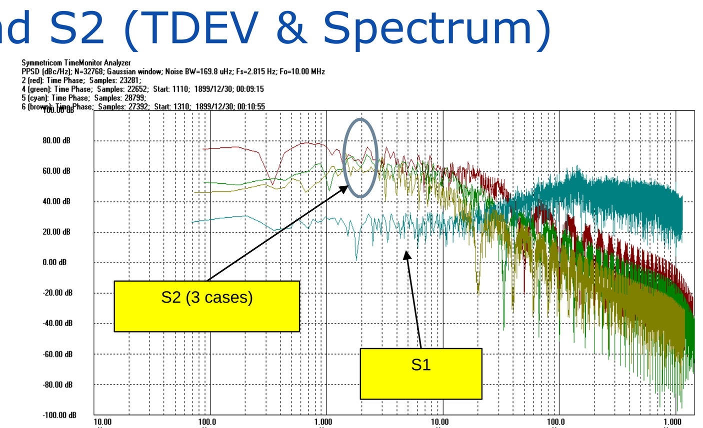
Comparison of S1 and S2 (TDEV & Spectrum)





- It can be concluded that the S1 implementation provides an estimate of performance that is more pessimistic. The S2 implementation provides results much better than those of S1, improving with reduction of bandwidth.
- Looking at the ancillary metrics of TDEV and power spectrum, it appears that the S1 servo behavior is suspect and appears to have significant high-frequency content.

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Concluding Remarks

- Datacenter operators can provide time ("as a service") by deploying a few GrandMaster devices and employing their own (existing) private network interconnecting datacenters
  - Monitoring the GrandMaster achieved using a special monitoring TimeReceiver that connects to the GM as well as another trusted reference source over a trusted medium (e.g., OTN).
- Monitoring performance achievable by a (customer deployed) PTP TimeReceiver in a datacenter can be estimated by deploying a monitoring PTP TimeReceiver synchronizing to the (same) GM
  - Wide-band version of monitoring PTP TimeReceiver provides guidance on PDV introduced by network; narrow-band version provides guidance on the achievable synchronization performance
  - Constant time error introduced by network asymmetry is not visible and must be estimated by different methods

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Questions? Comments? Suggestions?
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