

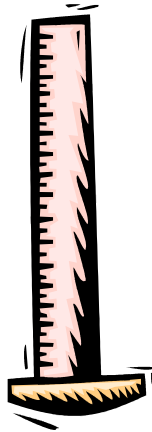


New PDV Measurement Approaches and the Application of Legacy Network Limits

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Example of Measurement, Metric and Limit

- Height of the doorways for this room
 - Measure the height of all the people in the room
 - Select the people who would use the room every day
 - Take the maximum of the remaining data
 - Set the door height to the maximum plus 10%
- Average or minimum would not be appropriate



Existing Network Limits

- Application based
- Supported by clock requirements
 - DS1, E1, SONET/SDH, OTN
- Network limits
 - ATIS 0900101, ATIS-0900105.03.2003(R2008)
 - ITU-T G.823 (ETSI), G.824 (ANSI)
 - ITU-T G.825 (SONET/SDH)
 - ITU-T G.8251 (OTN)

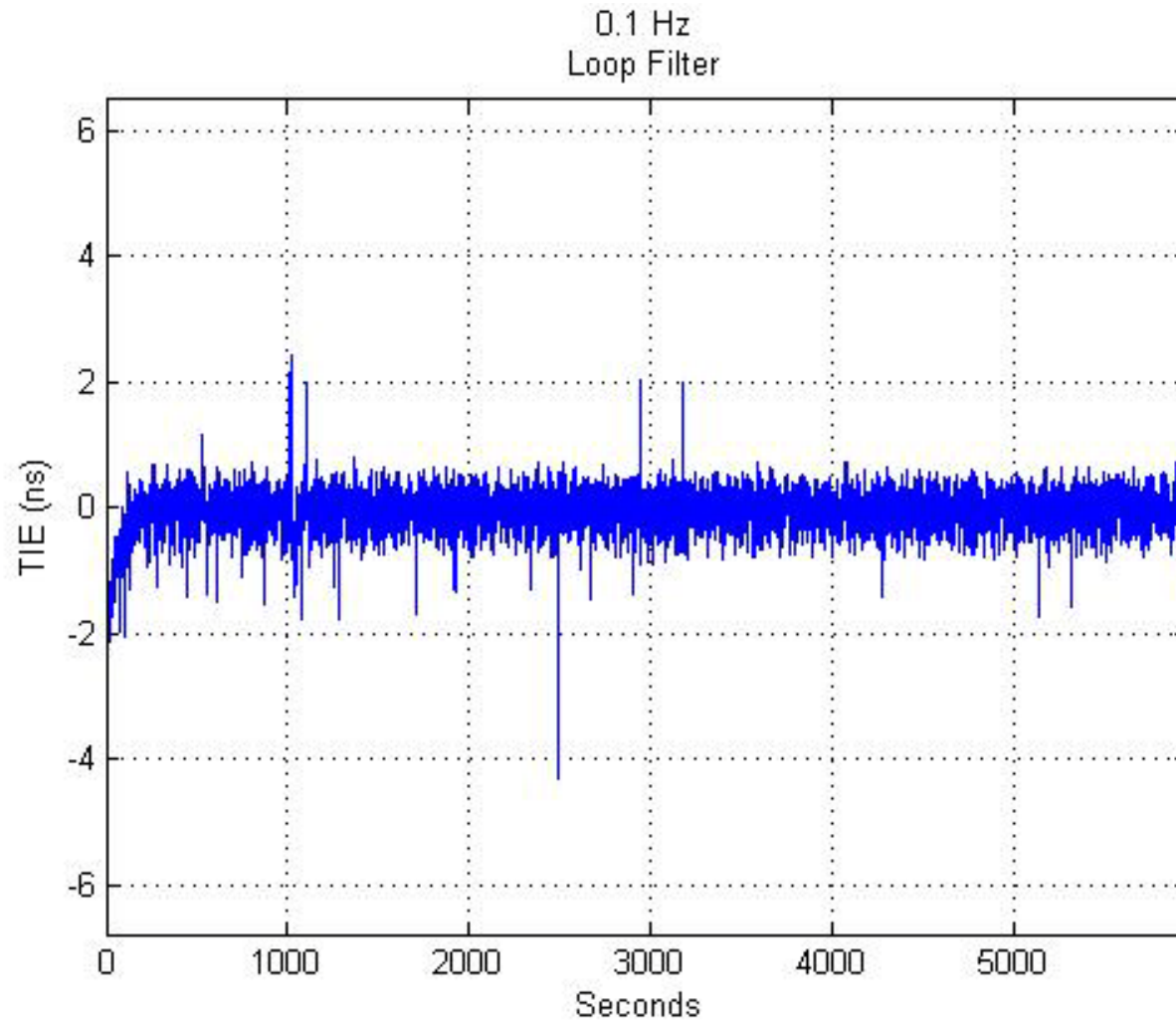
Clock metrics

- TIE – Time Interval Error
 - Seconds
- MTIE – Maximum Time Interval Error
 - Time domain measurement
 - Define maximum buffer sizes for error free transmission
 - Seconds
- TDEV – Time Deviation
 - Frequency domain measurement
 - Helps define PLL bandwidth used in systems
 - Magnitude measured in seconds
- FFO – Fractional Frequency Offset
 - Difference between signal and nominal frequency
 - Dimensionless measurement (seconds/seconds)

TIE

- Time Interval Error
- Periodic difference between the “correct” time instant and the measured time instant
- Can be used with:
 - physical clocks via a time interval counter/analyzer, or
 - with packet methods via the difference between the protocol time stamp and the receive time stamp
- When collected in packet systems, can also be called PDV (Packet Delay Variation)

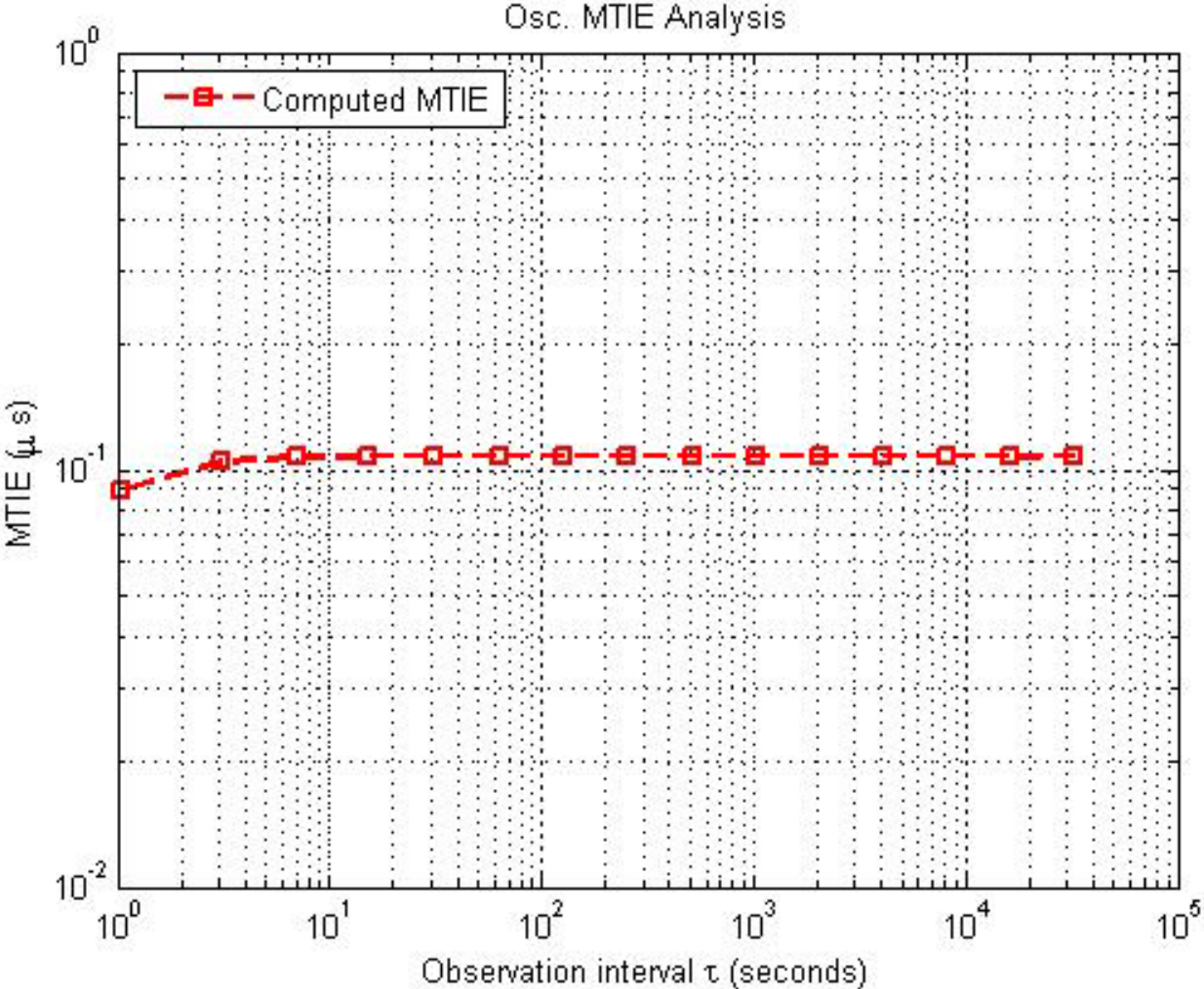
TIE - Example



MTIE

- Maximum Time Interval Error
- For various windows sizes, find the maximum and minimum relative values
- Difference is the value for this point

MTIE - Example



TDEV

- Frequency (spectrum) measurement of the time differences (errors)
- Typically used to define filter or PLL bandwidths
- Can also highlight highly periodic updates in the signal
- Note that frequency is the rate of change of phase
 - The TDEV is related to the slope of the phase plot

Packet Metrics

- Metrics based on traditional frequency signals
 - Packet TIE – Use the input PDV of the packet timing system to define a TIE
 - Process the packet TIE similar for TIE
 - Produce MTIE, TDEV and FFO
- Fixed bandwidth
 - selection, filter PLL
- Dynamic Bandwidth
 - Matie, Mafe
 - Changes bandwidth via calculation used
 - Change number of samples over which the measurement is averaged
 - Integrated TDEV
 - Adds selection to TDEV measurement

Selection and Metrics

- Packet timing clients do not use all packets
 - Started by eliminating outliers
 - Now try to find the “best packets”
- Trade off between less available packets for timing solution, but packets are closer to the minimum delay of the network
- Selection types
 - time (cluster) or % based (band or percentile)
 - minimum/floor or ceiling or median

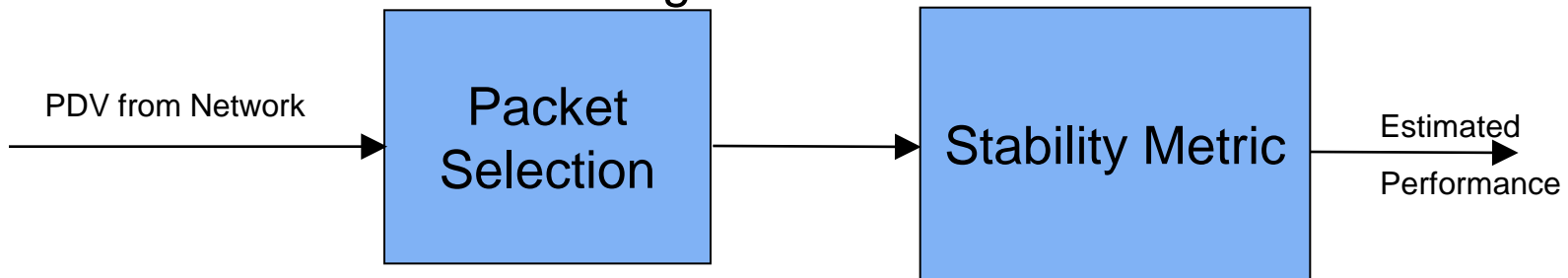


Figure based on I.3/G.8260 draft

TDEV with selection - MinTDEV

- Selection definitions:
 - Cluster range – the value for selection packets based on a long term minimum and maximum values of the signal
 - Window interval – time over which the range is calculated
- Run the TDEV metric over the data after discarding certain “outlier” points
- MinTDEV – Use for calculating the characteristics of the delay floor for a certain network
- Minimum packets are less impacted by queuing delays
- Used for characterizing the best possible packet timing performance

TDEV with selection - BandTDEV

- BandTDEV – Like MinTDEV but use a certain range of the packets to get the characteristics
 - May be used where there is too few minimum packets
 - Band is defined by sorting the delays in a windows and selection from a% to b% of the packets
 - Also called percentageTDEV when selecting from 0% to x% of the sorted packets

TDEV with selection - ClusterTDEV

- Can select a group of packets away from the floor (minimum)
- Superset of other TDEV with selection methods
- Can define the length of sorted data for section depending on the noise processes in the system

MATIE

- Maximum Average Time Interval Error
- Averages the difference between points a specific windows size apart over the data file
- Like MTIE but with an averaging filter to simulate the effect of large time constant (or small bandwidth) filters
- Can use packet selection before running MATIE calculation
 - Can use the same selection mechanisms as TDEV

MAFE

- Maximum Average Frequency Error
- For each point in MATIE calculation divide by window length
- Good for measuring frequency offsets

Metrics to Limits

- Define Hypothetical Reference Model (HRM)
 - Number of types of network element in maximum sized network
- Measure the statistics of a real network setup as in the HRM
- Must be repeatable between labs and test equipments
 - Can translate into a PDV sequence for ease in testing
- Pick from the metrics to best define the PDV from the HRM
- Network limits will be defined based on the results masks