



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)

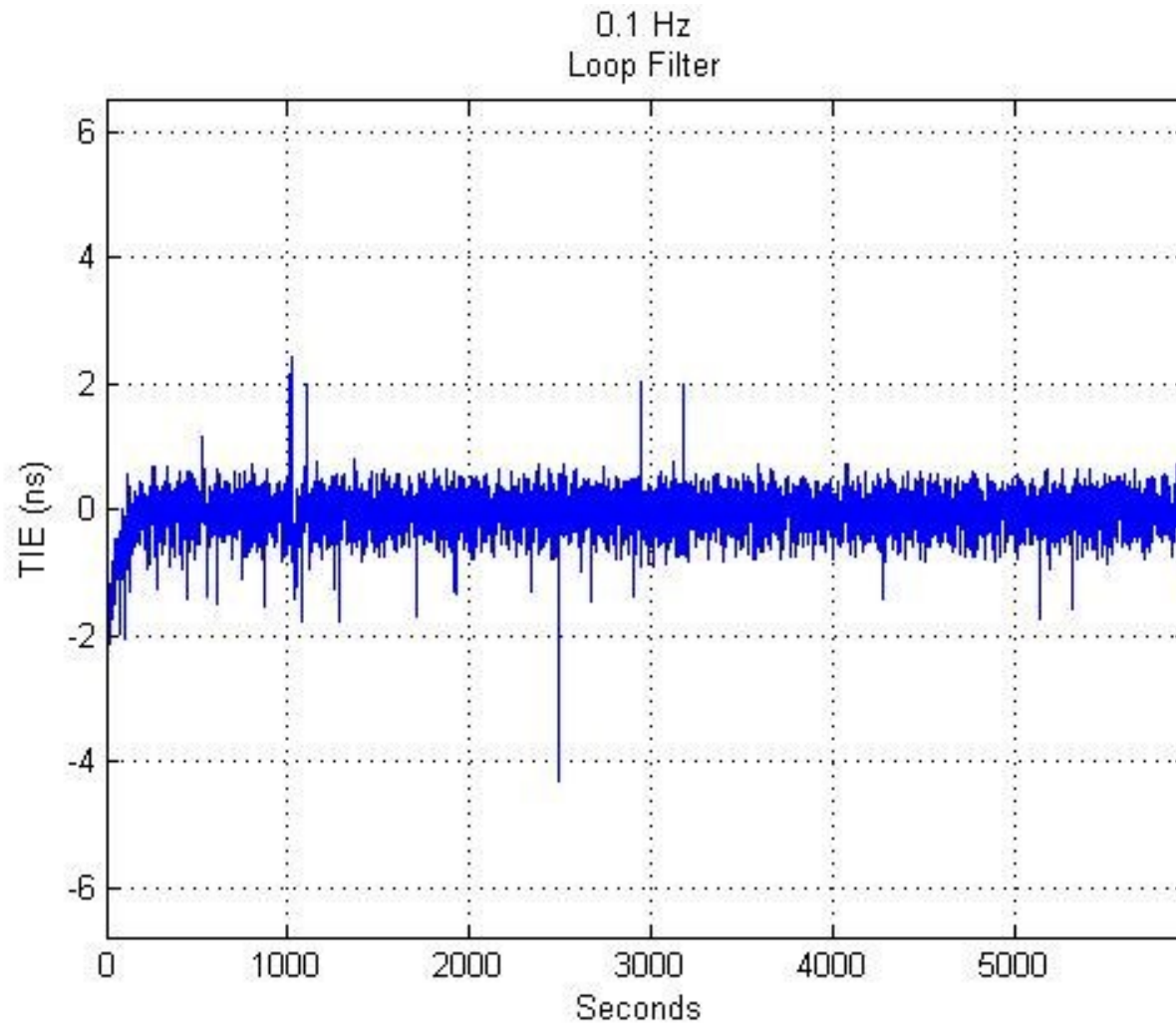
Clock metrics

- **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)

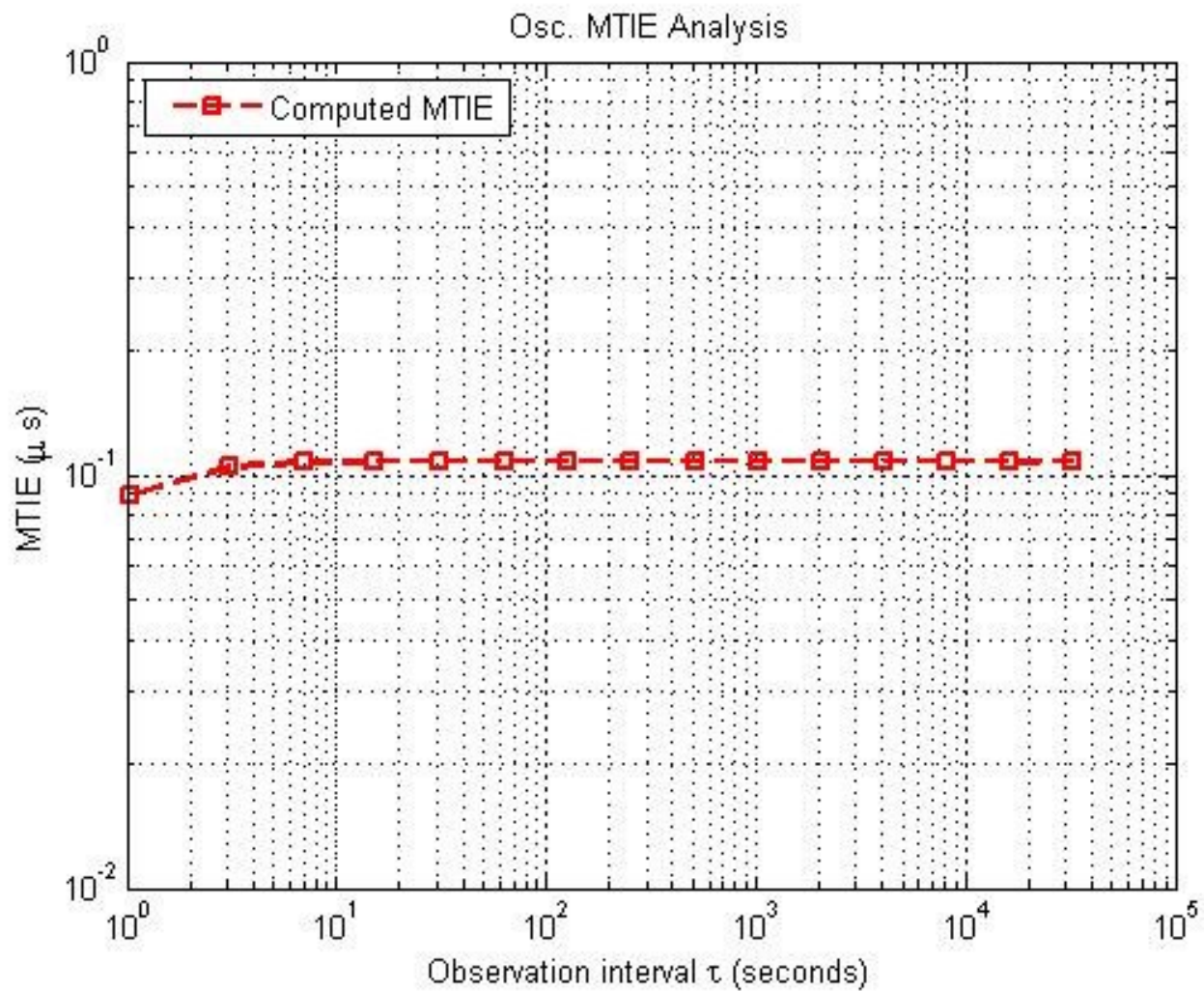
TIE - Example



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

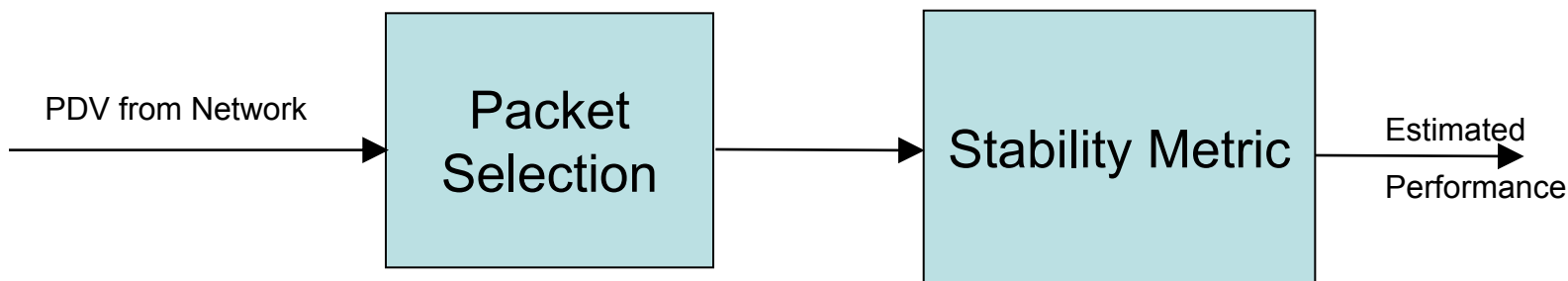


Figure based on I.3/G.8260 draft

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**