

# **End-to-end Synchronization using IEEE1588v2 over Fiber, Microwave and SHDSL IP Access Technologies**

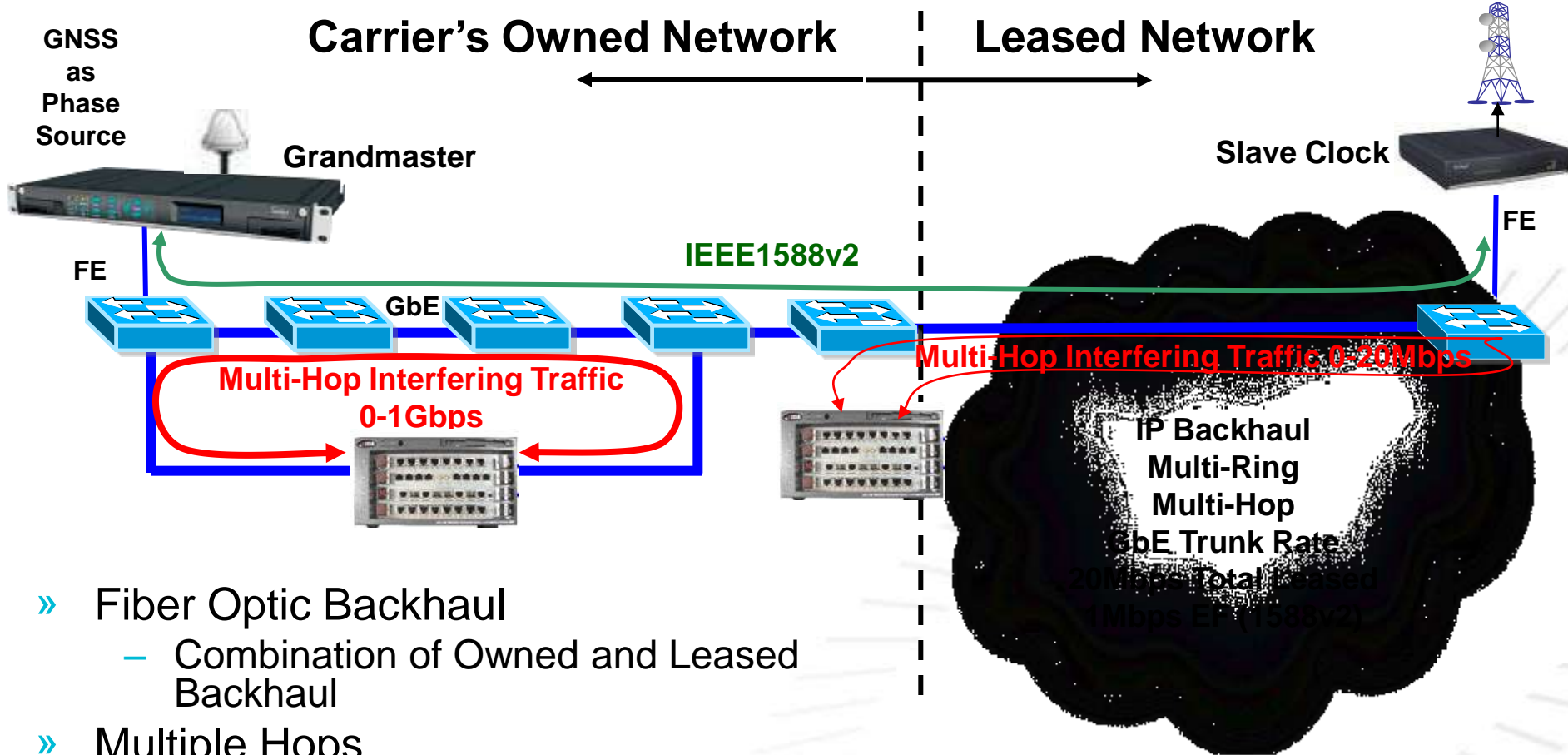
**Charles Barry, PhD  
Alan Shen**

The logo for Brilliant, featuring the word "brilliant" in a serif font. The letter "i" is white, while the other letters are black. A decorative graphic of thin, parallel lines forms a partial circle around the text.

**brilliant**

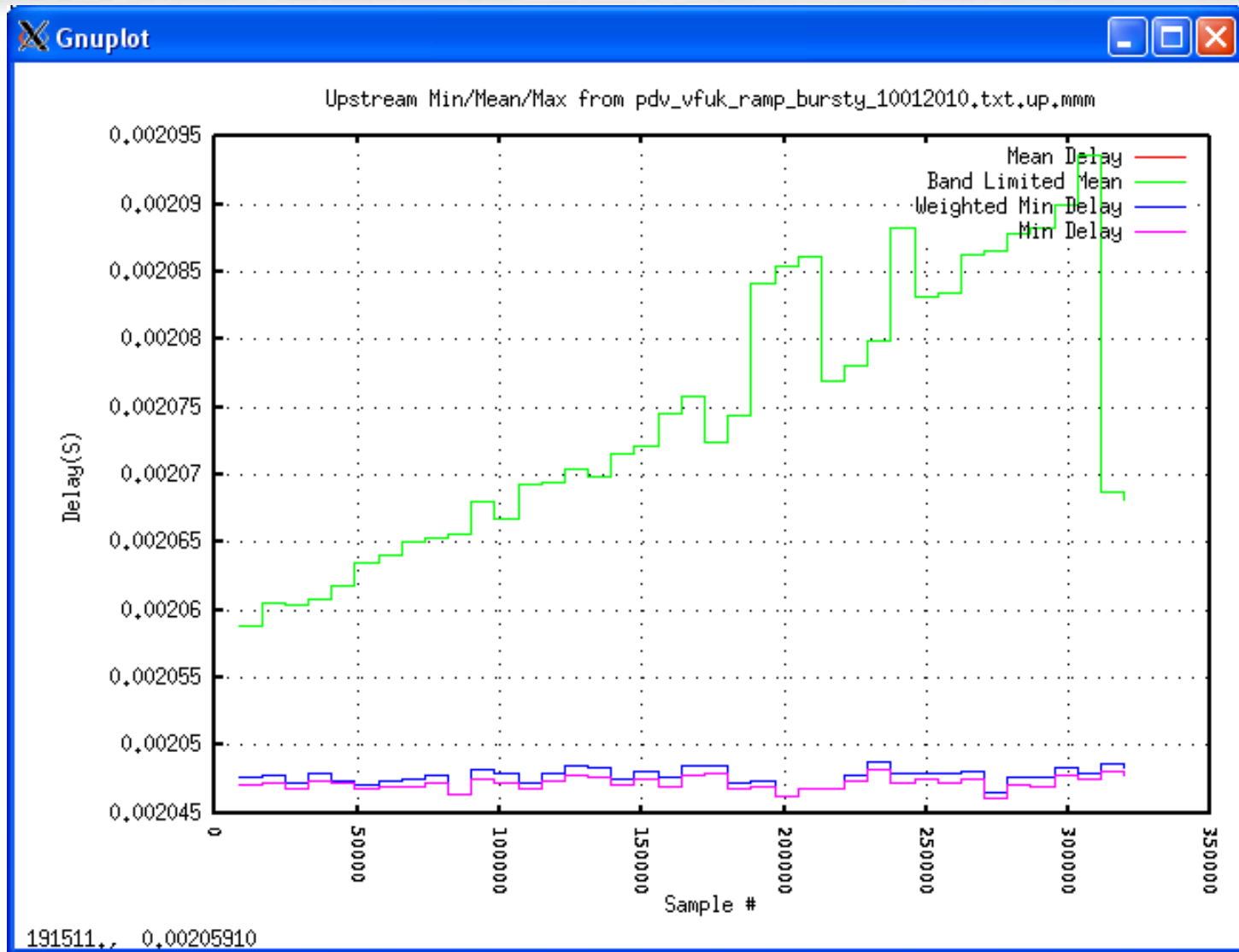
**ITSF 2010 - Time & Sync in Telecoms  
Nov 2nd - 4th, 2010 Dublin, Ireland**

# Fiber Optic Backhaul



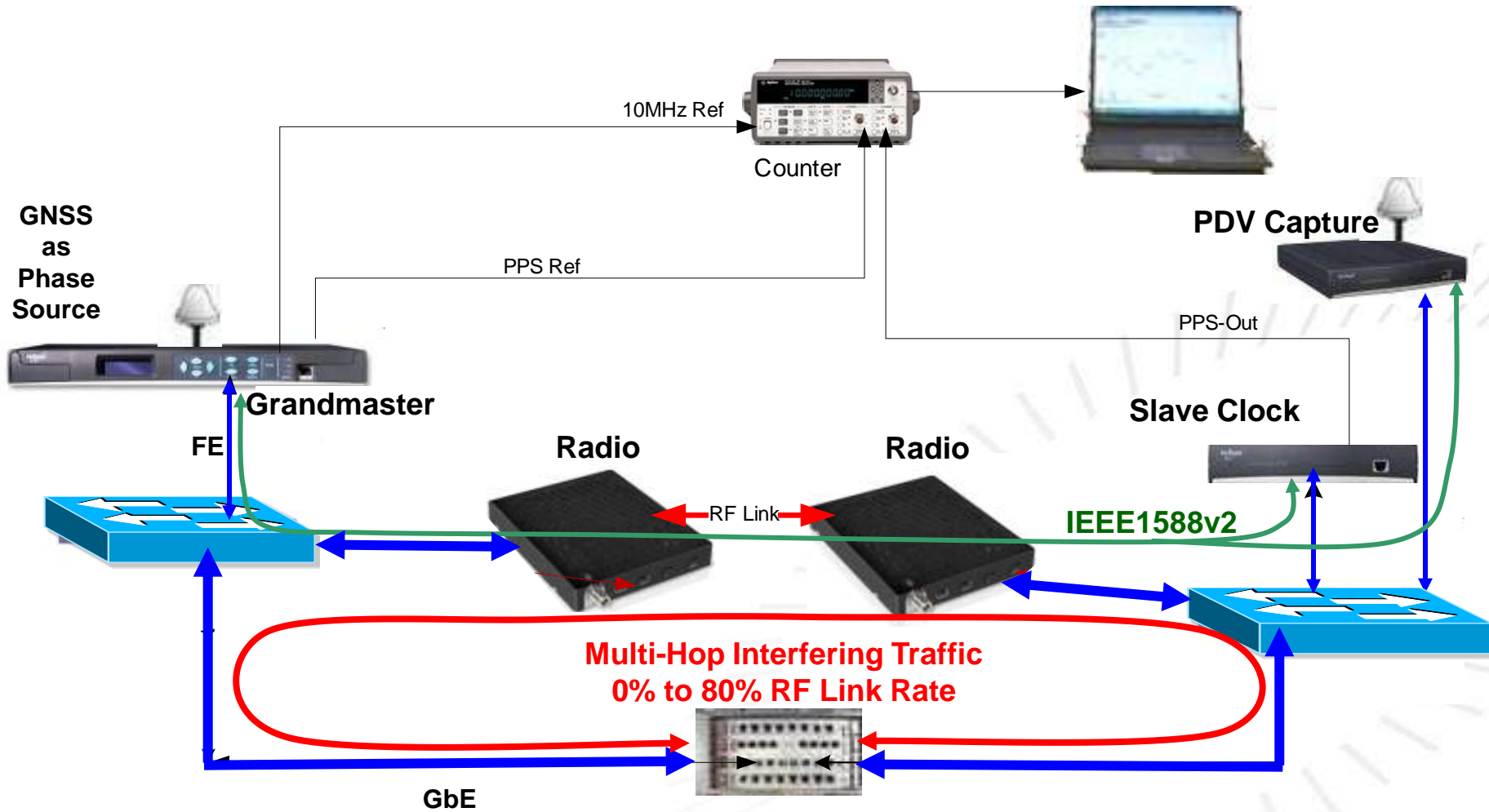
- » Fiber Optic Backhaul
  - Combination of Owned and Leased Backhaul
- » Multiple Hops
  - Store and Forward Jitter Dominates
  - QoS is Required

# Fiber Optic Backhaul

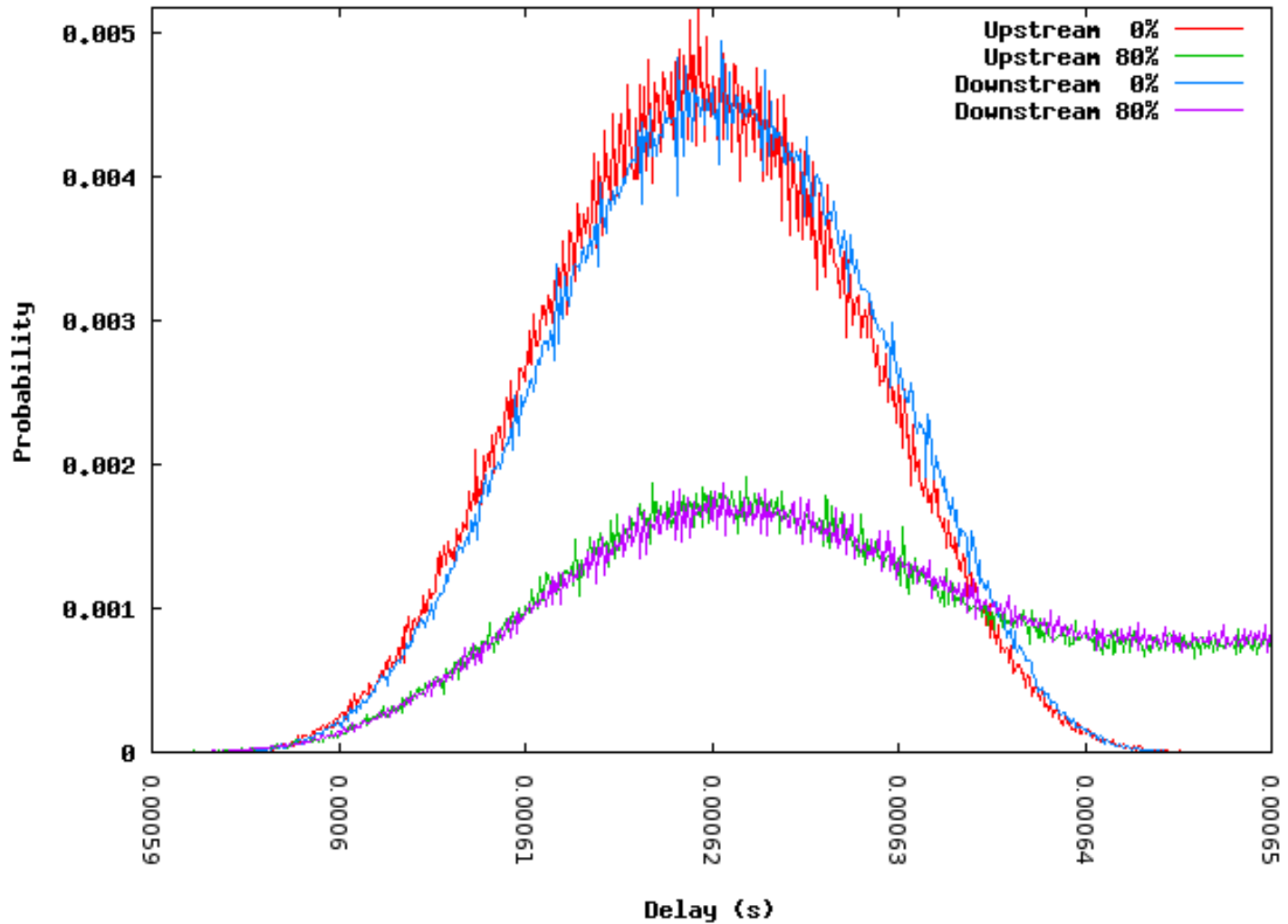


- » Fiber Optic Backhaul
  - Combination of Owned and Leased Backhaul
  - Multi-Hop Store and Forward dominates Jitter
  - QoS is Required
    - EF Queues with guaranteed BW for Timing Packets
  - Stable, accurate phase achieved within a sub-rate leased line over a GbE trunk network
- » Data Test Loads can be used to establish network behavior and suitability for deployment

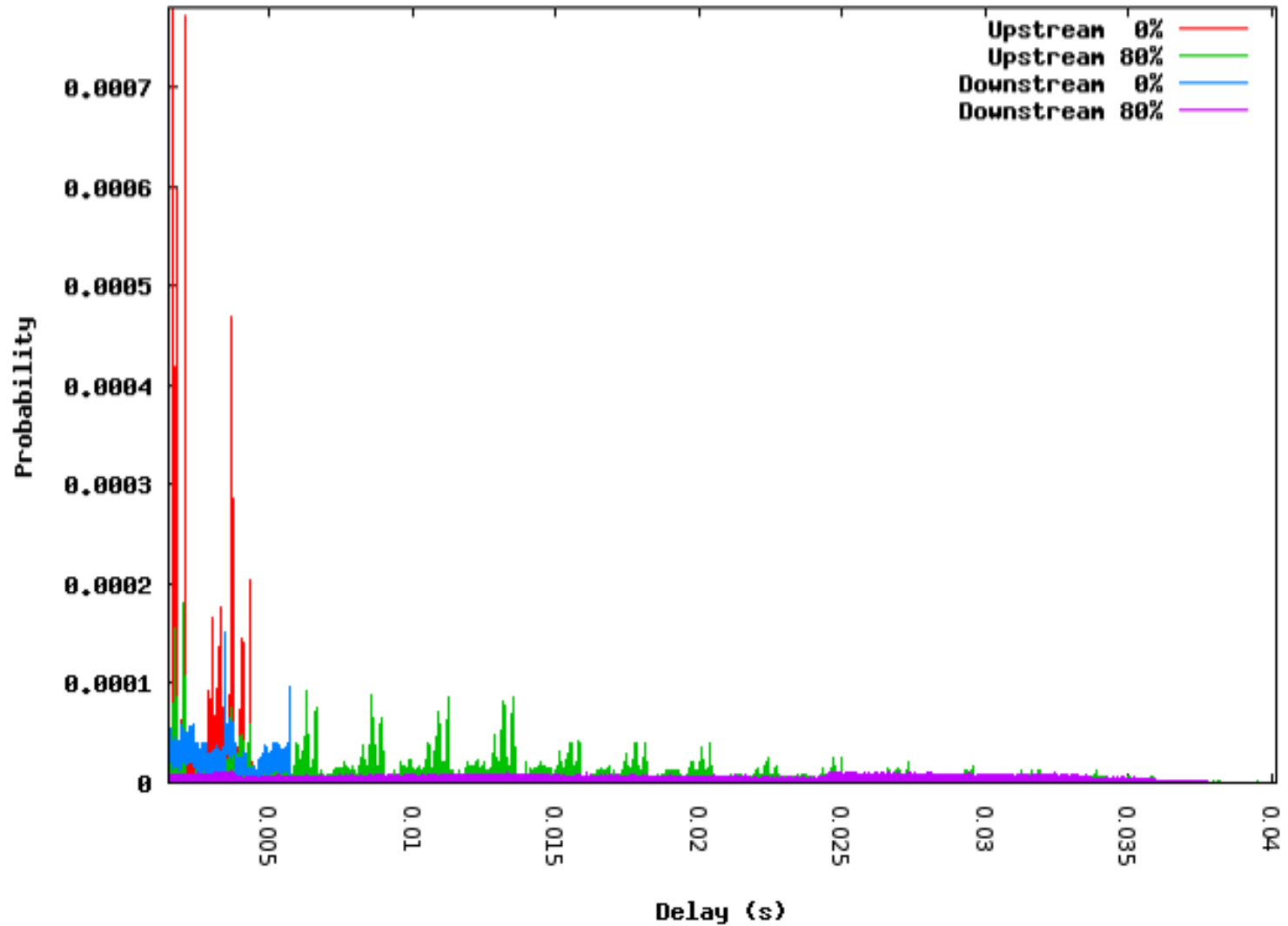
# Point-to-Point Microwave



# Point-to-Point Microwave - FDD



# Point-to-Point Microwave - TDD



## » FDD

### – Packet Delay Variation Histogram

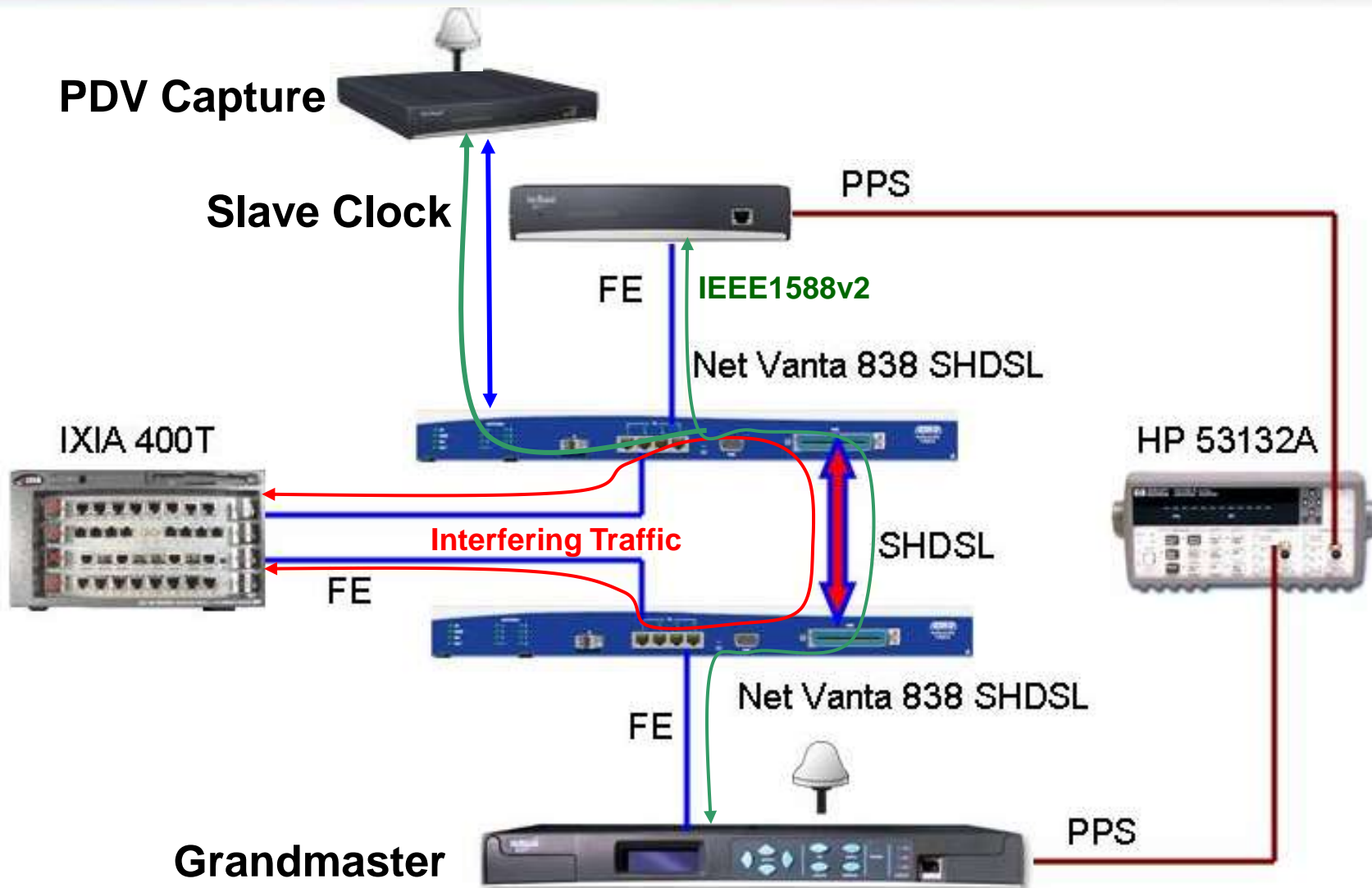
- Symmetric, Well-defined Minimums, Good behavior with load
- Phase Changes with Data and Code Rates
  - Can be automatically detected (or signaled out of band) and then corrected

## » TDD

- Asymmetric, weak minimums, periodic, poor behavior with load
- Time Stamp Unit (TSU) at Ethernet ingress and post framing is proposed as a modified Transparent Clock to achieve stable, accurate phase.

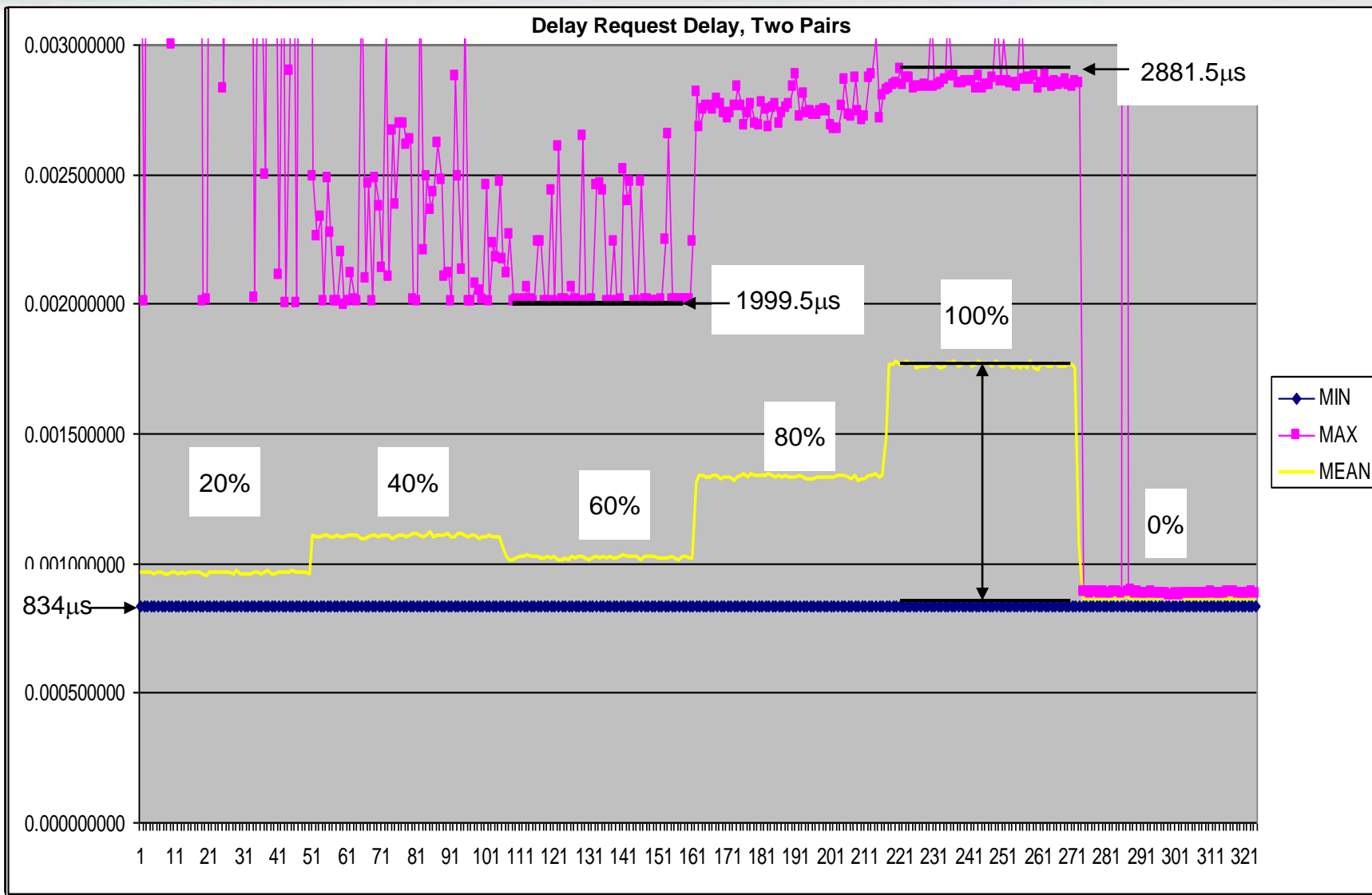


# SHDSL



## » SHDSL:

- Single-pair High-speed Digital Subscriber Line
  - Symmetric Rates in Upstream and Downstream
- Large variety of Variants defined in Annexes, e.g.,
  - Annex A – North America; Annex B Europe; Annex F – Higher rates
- Supports Payload rates from 0192kbps to 5.696Mbps per pair
  - $64000 * n; 3 \leq n \leq 89$
- Supports pair bonding up to 8 pairs
  - 2=> 11.392Mbps; 8=>45.568Mbps
  - When bonded, data is striped across pairs
- Supports many Multiplexing Modes, most important is ATM
  - IP Packets are mapped into ATM cells
    - IETF RFC 2225, Classical IP and ARP over ATM
- Rate determination can be fixed or adaptive
  - When adaptive, used BER, SNR, ranging monitoring to determine rate
    - Rates can be limited to a range  $n_{\min} \leq n_{\text{current}} \leq n_{\max}$



## » Packet Delay Variation Statistics:

- Asymmetric Upstream/Downstream but with Well-defined Minimum Phase
- Minimum Phase Changes with Number of Pairs, SNR
  - SHDSL can change rate based on fluctuations in SNR, Twisted pair failures, etc.
  - Can be automatically detected (or signaled out of band) and then corrected, or
  - TSU at Ethernet ingress(egress) coupled with TSU at SHDSL egress(ingress) is proposed as a modified Transparent Clock to achieve stable, accurate phase regardless of data rate to avoid need for detection or signaling.

## » Fiber Optic Backhaul

### – Combination of Owned and Leased Backhaul

- End-to-End QoS is required for phase accuracy and stability
- Asymmetry not significant  $<0.5\mu\text{s}$
- Stable, Accurate phase under all load conditions
- Introduction of in-band test loads can be used to detect suitability of end-to-end network and detect if QoS is enabled properly

## » Point-to-Point Microwave

### – FDD Radio works well, even with AMR, if

- QoS implemented, Rate detected or signaled

### – TDD Radio will require TSU/Distributed TC at/after framing

## » SHDSL

### – Stable Phase Achievable

- Upstream/Downstream Asymmetry requires compensation/calibration
- Requires Rate detection or signaled, and
- EF QoS for Timing Packets

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**Thank You**

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The logo for Brilliant Telecom features the word "brilliant" in a serif font. Behind the text is a stylized graphic consisting of two curved, parallel lines made of small dashes, resembling a signal or a stylized 'B'.

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