Validating Real Time IP Services through Pre-Deployment Testing

Delay. Impair. Validate.

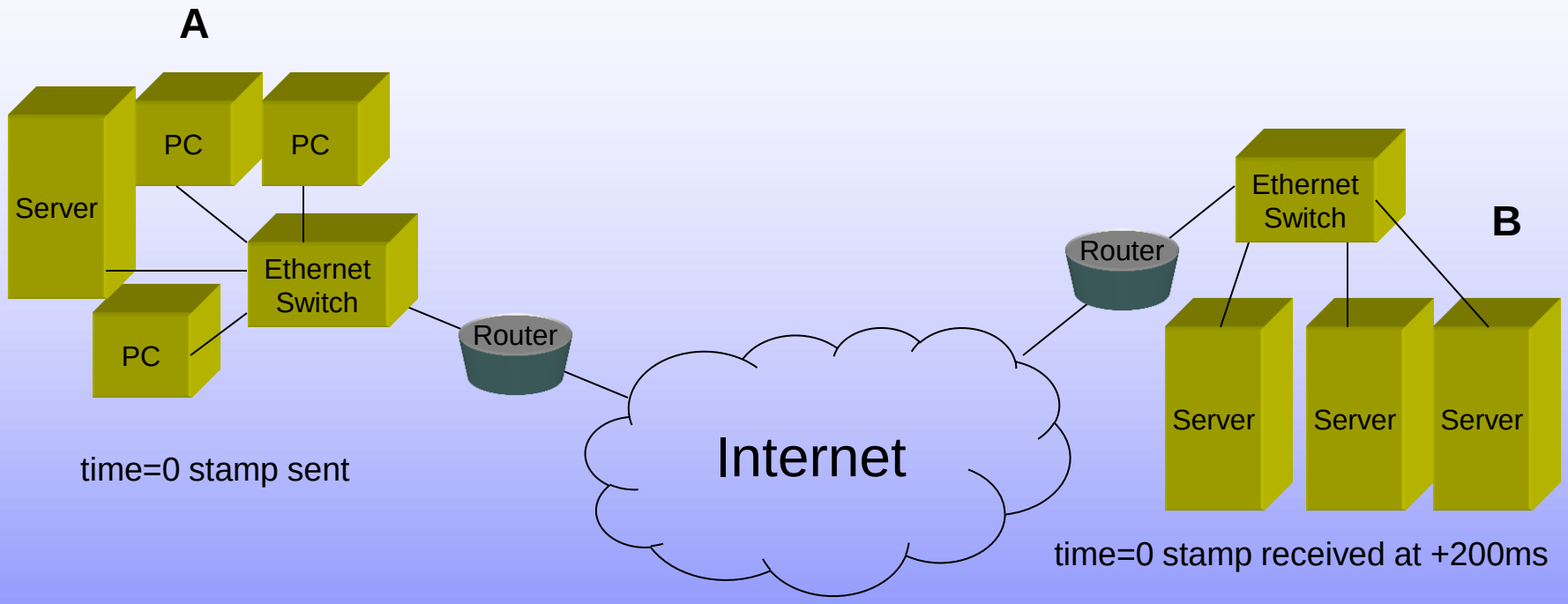
Kevin Przybocki, Anue Systems Inc.

www.AnueSystems.com

Sync is Important for:

- VoIP
- IPTV
- Wireless
- Interactive Gaming
- Networked Applications
- Satellite Communications
- Converged Network Testing
  - *Next Generation SONET/SDH*
  - *Circuit Emulation*
  - *MPLS Layer 2 and Layer 3*
  - *Metro Ethernet*
  - *QoS*

Delay Affects Sync



Key Points:

- Delay and changes in delay (i.e.,“Jitter”) impact Sync and therefore the real time application
- Without a timing source continuous symmetric Link at B is required for B to know time and timing information
- Phase recovery is harder than frequency recovery

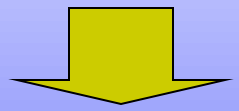
Impairments Affect Sync

- Line Bit Errors
- LOS / LOF Sync
- Jitter Delay (FDV)
- Frame/Packet Drop (Decimate)
- Re-order
- Policing
- Bandwidth Control (Throttle)
- Duplication
- Higher Layer Bit Errors
- Modification
- CRC Corruption

Targeted or Random
Precise Distribution
Single or Bursty
Maximum Accuracy

Important Pre-Deployment Testing

- Delays and Impairments
- Symmetric & Asymmetric
- At both the Layer 1 and Layer 2
- To validate phase recovery
- To ensure performance of network applications



Most efficient when done in an
“Emulated Network Environment”

Anue Creates Delay

- Network Emulators that test ***Applications***, ***Devices***, ***Solutions*** or ***Services***
  - Under 'Real World' **dynamic** delay and impairment conditions
  - With **true line rate** performance
  - With **precision** and accuracy for maximum repeatability
  - With an **"in-line"** testing approach
- We're ***Neutral***.
  - Sync carried in the packet stream, or
  - Sync carried by the physical layer

MAUI and HAWAII Series Emulators

MAUI

- OC3/STM1, OC12/STM4, OC48/STM64 Signal Delay and Path Delay
- G.709 OTU1 Signal Delay
- CPRI (614.4, 1,228.8 & 2,357.6 Mb/s)
- Fibre Channel 1x & 2x Signal Delay
- Gigabit Ethernet Signal Delay
- Advanced Fast Ethernet
- Advanced Gigabit Ethernet
- *Combine up to 7 firmware loads*

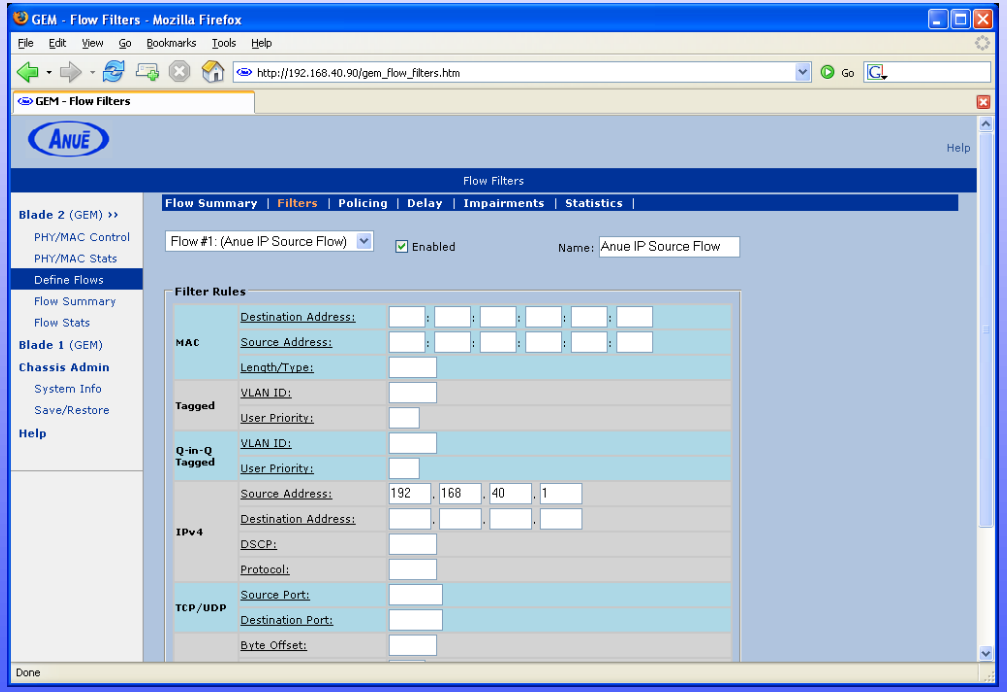
HAWAII

MAUI Series Loads plus:

- OC192/STM64 Signal and Path Delay
- G.709 OTU2 Signal Delay
- Fibre Channel 4x, 8X & 10x Signal Delay
- 10 Gigabit Ethernet Signal Delay:
  - WAN PHY (9.9532 Gb/s)
  - LAN PHY (10.3125 Gb/s)
  - LAN PHY with Digital Wrapper FEC (11.049 Gb/s)
  - LAN PHY with OTU2 FEC (11.095 Gb/s)
- *Combine up to 7 firmware loads*

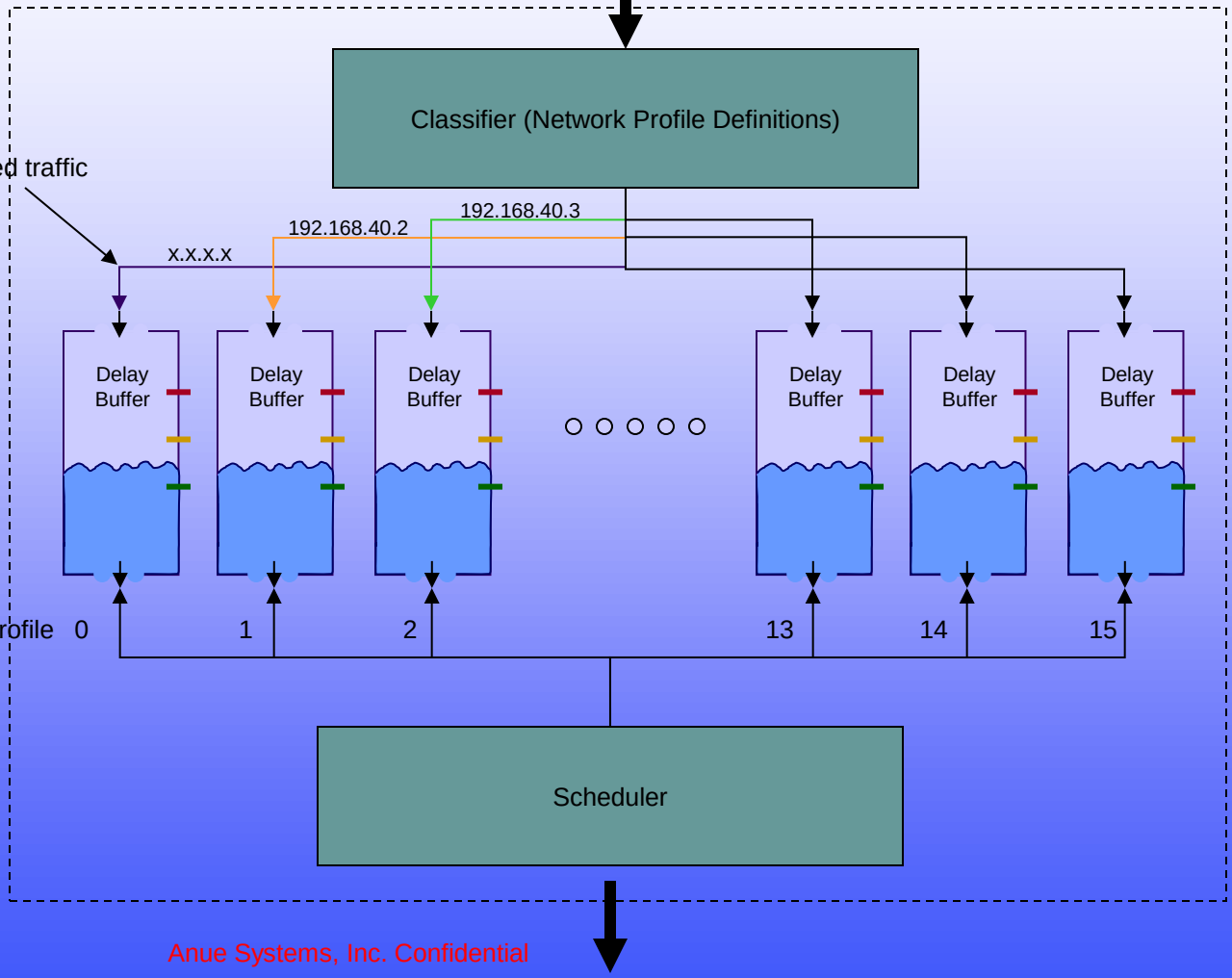
GEM

- 16 Network Flows per Blade (64 per 4-Blade MAUI)
  - Each with its own distinct delay, bandwidth & impairment profile
  - Defined by any combination of ***VLAN tag***, ***MPLS label***, ***MAC*** or ***IP address***, ***TCP port*** or ***any other field*** in the Ethernet, IP, TCP, UDP or RTP header as well as any other information up to 2,048 bytes deep within the Ethernet frame
- HTML Based GUI
  - Intuitive
  - No Client Software Installation Required
  - Platform Independent
- Layer 3 & 4 “aware”
  - Correct IP checksum
  - Correct TCP checksum
- TCL API
- Full Line Rate Support
- Dynamic Delay and Impairment Profile



GEM – Network Profiles

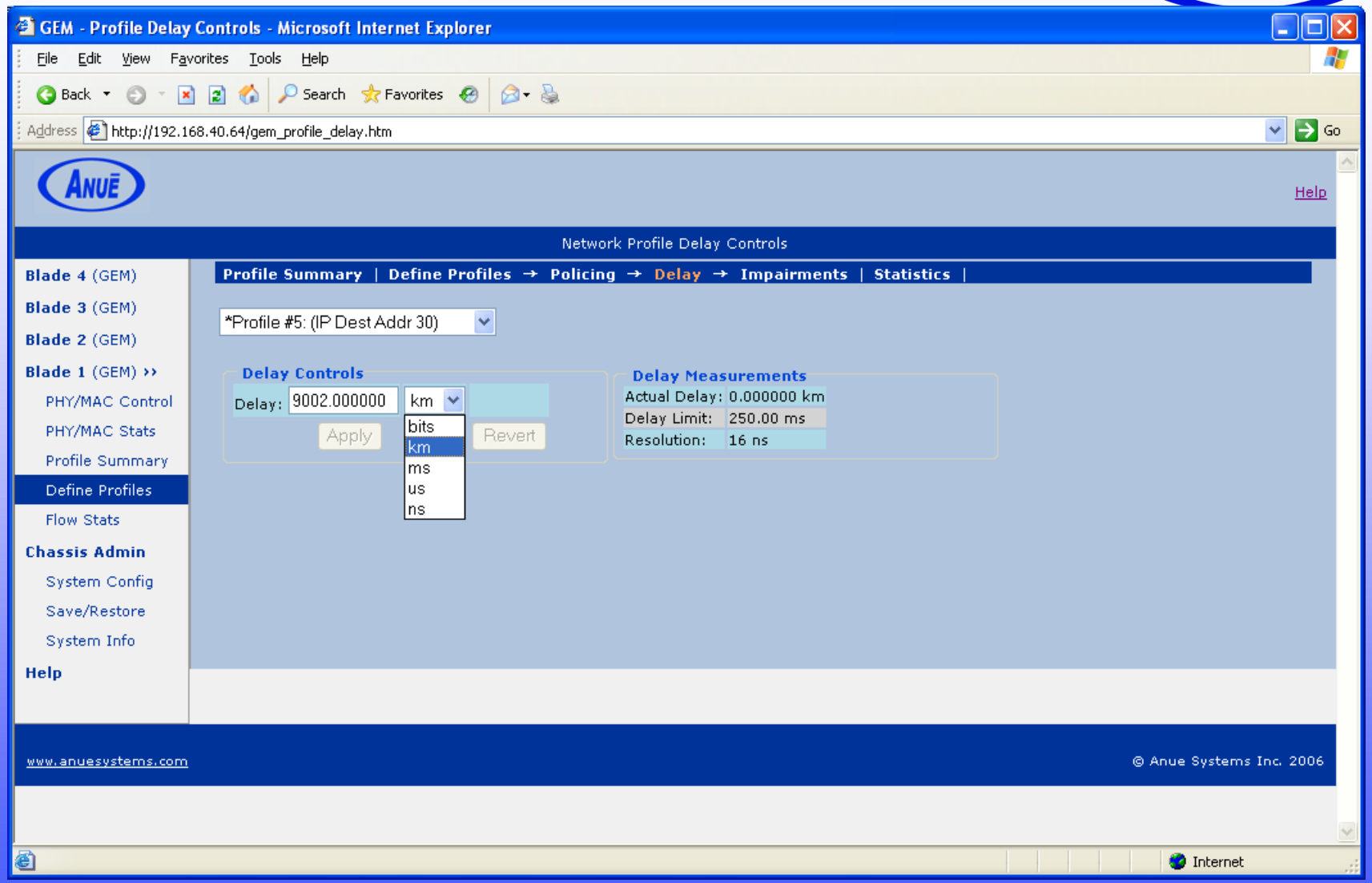
- Emulate Multiple Network Profiles



Defined Per Network Profile:

- Delay
- Policing (Bandwidth Control)
- Impairments
- Modification

GEM GUI


GEM - Profile Delay Controls - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address http://192.168.40.64/gem_profile_delay.htm
Go
Help
Network Profile Delay Controls
Blade 4 (GEM)
Blade 3 (GEM)
Blade 2 (GEM)
Blade 1 (GEM) ››
PHY/MAC Control
PHY/MAC Stats
Profile Summary
Define Profiles
Flow Stats
Chassis Admin
System Config
Save/Restore
System Info
Help
Profile Summary | Define Profiles → Policing → Delay → Impairments | Statistics |
*Profile #5: (IP Dest Addr 30)
Delay Controls
Delay: 9002.000000 km
bits
km
ms
us
ns
Apply
Revert
Delay Measurements
Actual Delay: 0.000000 km
Delay Limit: 250.00 ms
Resolution: 16 ns
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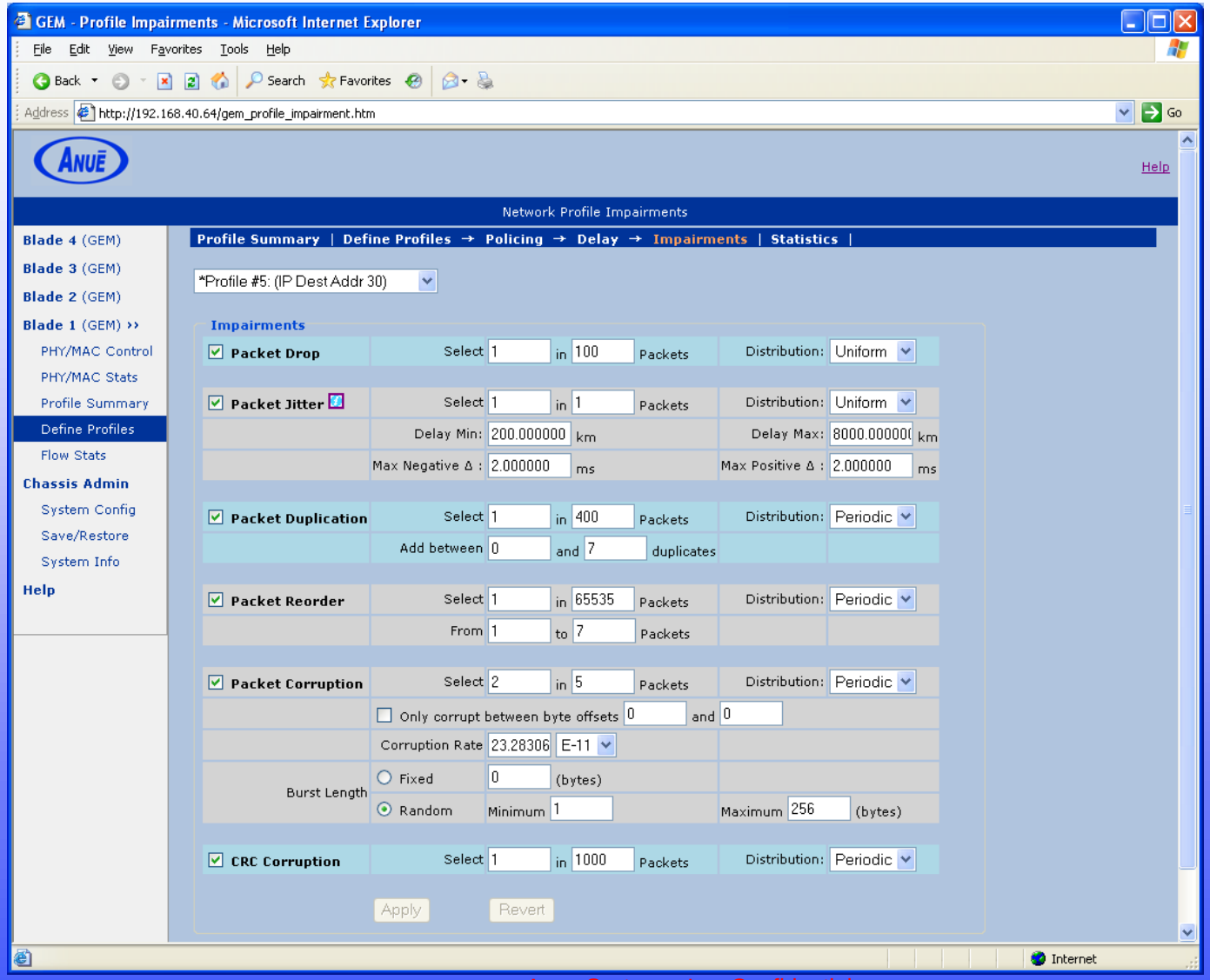
Internet

GEM GUI


GEM - Profile Impairments - Microsoft Internet Explorer
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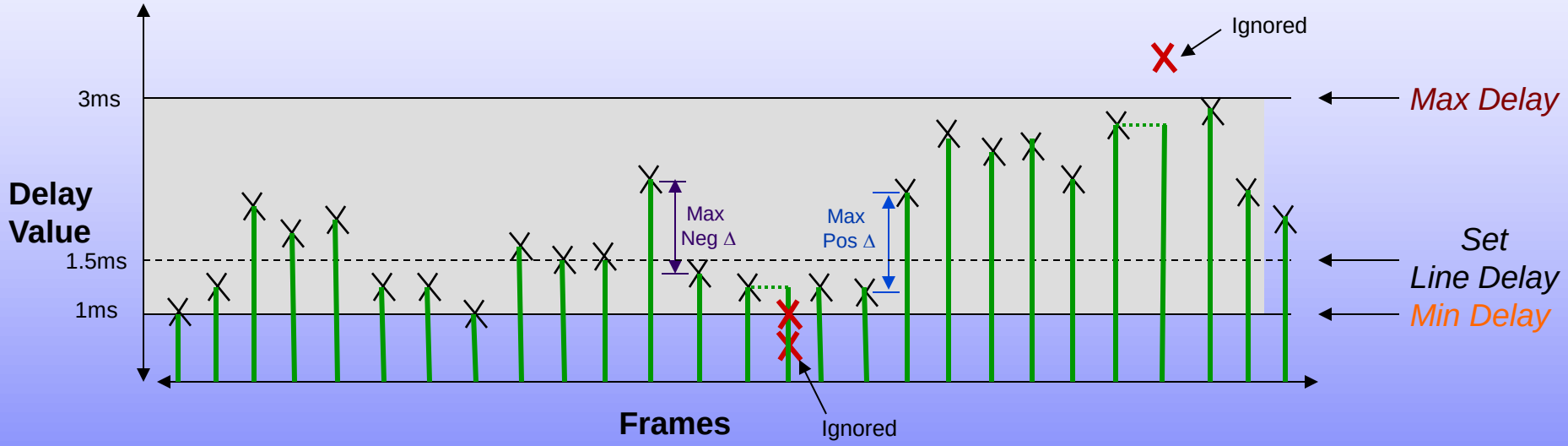
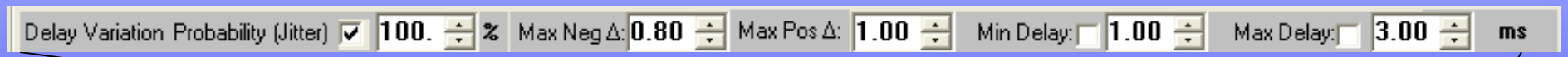
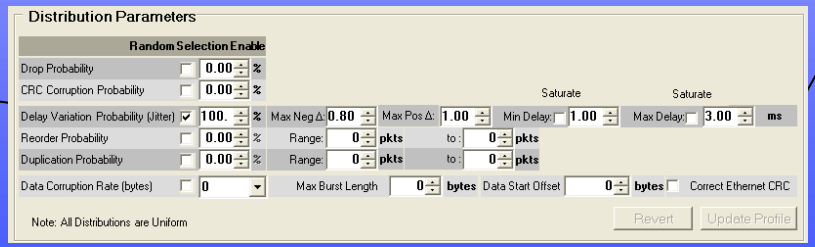
Save/Restore
System Info
Help
Profile Summary | Define Profiles → Policing → Delay → Impairments | Statistics |
*Profile #5: (IP Dest Addr 30)
Impairments
Packet Drop
Select 1 in 100 Packets
Distribution: Uniform
Packet Jitter
Select 1 in 1 Packets
Distribution: Uniform
Delay Min: 200.000000 km
Delay Max: 8000.000000 km
Max Negative Δ : 2.000000 ms
Max Positive Δ : 2.000000 ms
Packet Duplication
Select 1 in 400 Packets
Distribution: Periodic
Add between 0 and 7 duplicates
Packet Reorder
Select 1 in 65535 Packets
Distribution: Periodic
From 1 to 7 Packets
Packet Corruption
Select 2 in 5 Packets
Distribution: Periodic
Only corrupt between byte offsets 0 and 0
Corruption Rate 23.28306 E-11
Burst Length
Fixed 0 (bytes)
Random Minimum 1 Maximum 256 (bytes)
CRC Corruption
Select 1 in 1000 Packets
Distribution: Periodic
Apply
Revert
Internet

Delay Variation - Jitter

Min Delay - the absolute minimum delay a Frame can experience; signal delay can not be set below this value.
Max Delay - the maximum delay a frame can experience; signal delay can not be set above this value.
Max Neg Δ - the maximum amount of negative delay change possible when a Frame is selected for jitter.
Max Pos Δ - the maximum amount of positive delay change possible when a Frame is selected for jitter.

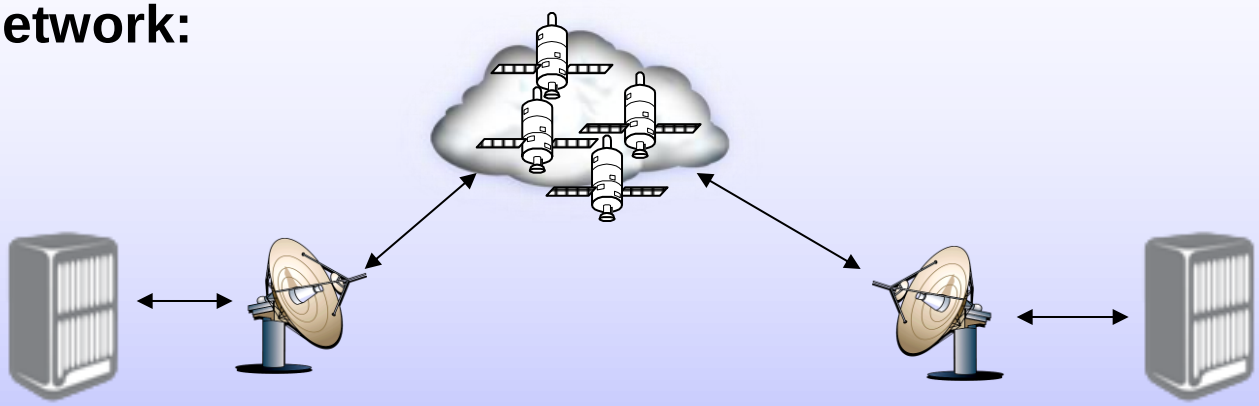




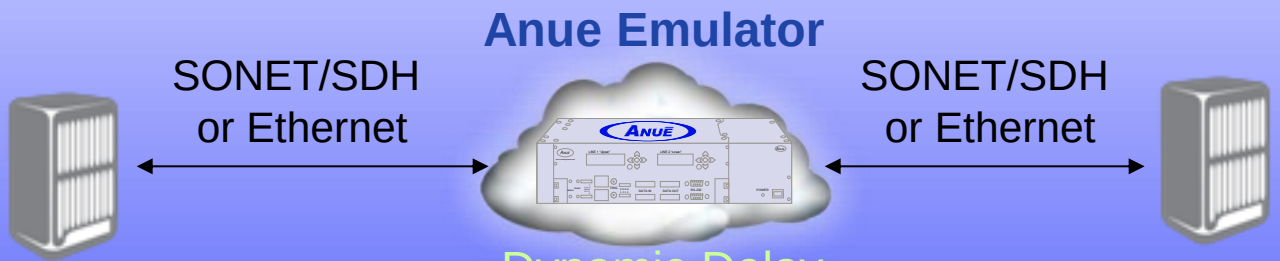


Doppler/Wander Delay Variation

Actual Network:



Emulation Setup:



Dynamic Delay

(Doppler Shift or Random Delay Variation)

Bit Errors, LOS, Frame Drop

GEL2 also provides: bandwidth throttling and focused Layer 2+ impairments

Case Study

Circuit Emulation

- Multinational NEM in Portugal
- Circuit Emulation Services over Packet Switched Network
- Emulated an IP Network using Anue GEM Ethernet Network Emulator
- Required highly accurate and repeatable impairment emulation
  - Maintain time base for PHD CESoP within $1x10^{-9}$ of the original signal
- Testing failure recovery scenarios
  - Looking at application performance
  - Testing response time to failures
  - Tested for optimal buffer sizes, correction of packet sequence errors and handling of lost packets

Anue Advantages

- **Flexible FPGA Based** Architecture
- Supports **100% Line Rate** Processing up to 11.3 Gb/s
- **Precise** and **Repeatable** Signal Delay Emulation
- **Dynamic Control** over Delay and Impairments
- Emulate both **Physical** and **Packet** Layer Delays without introducing timing issues
- Create multiple "**Profiles**" to emulate different links on the network
- Controlled **Layer 1** – **Layer 4** Impairments
- Managed by **easy to use** GUI, TCL API and/or front panel access
- **Integrated** Multi-protocol Solutions
  - IP, Ethernet, SONET/SDH, Fibre Channel, OTN, CPRI in one emulator
- Real Time Statistics and Alarm Monitoring

Anue Systems Overview

- Market and Technology Leader in **Network Delay** and **Impairment** Emulation
- Founded in December, **2002**
- Headquarters in **Austin** Texas USA
- Over **100** Customers Worldwide
- Over **250** Systems Sold
- Self Funded and Profitable
- **SONET/SDH**, **Ethernet** and **Fibre Channel** Expertise

Thank You

Anue Systems is a technology leader in Next Generation data communications testing. Anue's products help network equipment manufacturers, semiconductor companies, service providers and large enterprises test optical networks, devices and applications. Headquartered in Austin Texas, Anue Systems has built a team of world-class engineers with expertise in optical data networking and testing.

For more information about our products and solutions, visit Anue's website at **www.anuesystems.com**, email **info@anuesystems.com**, or call **+1-512-527-0453**.

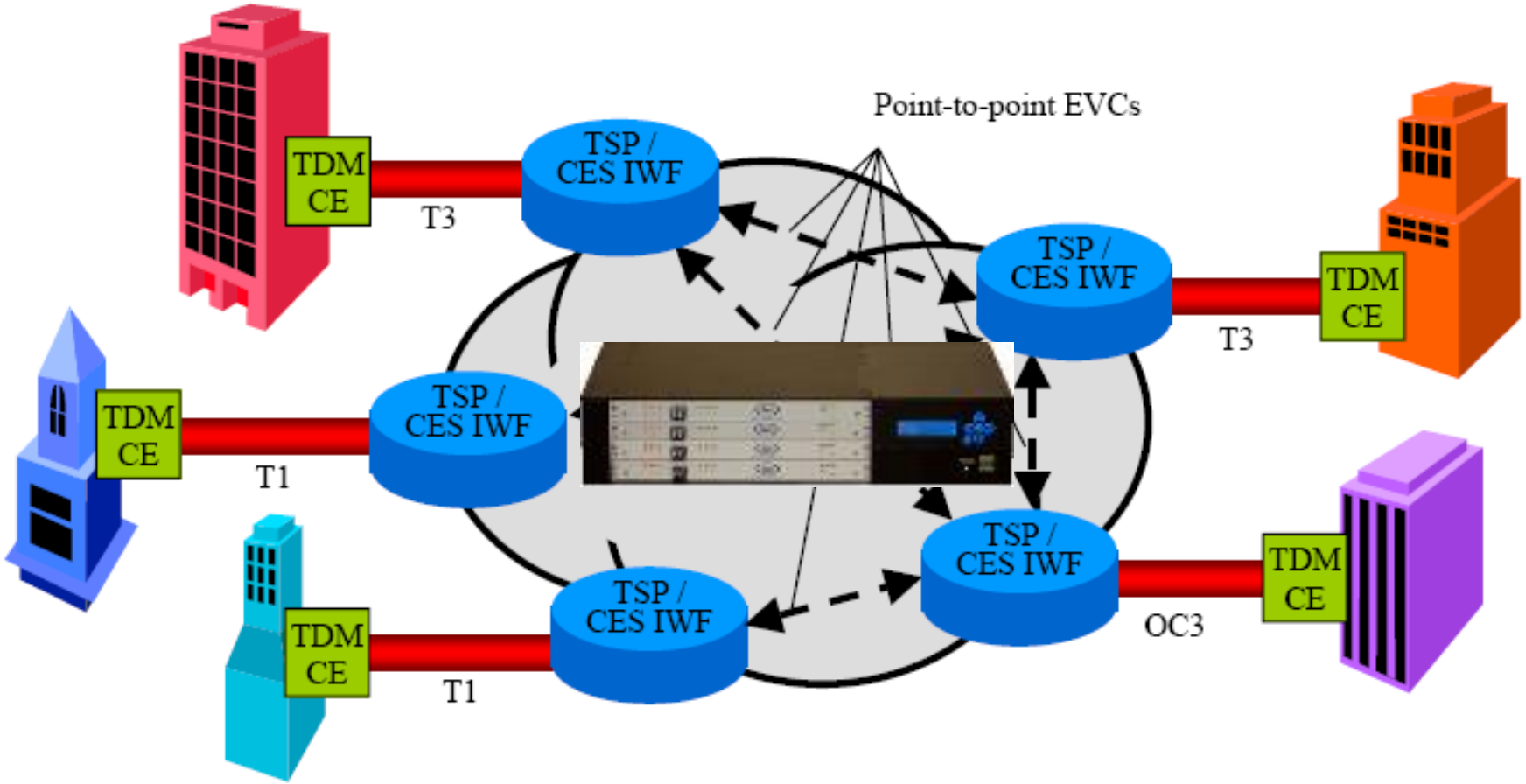
Reference Slides

Advanced Ethernet Impairments

- Support for **Targeted** or **Random** Impairments
- Targeted Impairments defined by any combination of ***VLAN tag***, ***MPLS label***, ***MAC*** or ***IP address***, ***TCP port*** or ***any other field*** in the Ethernet, IP, TCP, UDP or RTP header as well as any other information up to 2,048 bytes deep within the Ethernet frame
- Random Impairments are based upon any of the following distributions:
  - *Periodic*
  - *Poisson*
  - *Gaussian*
  - *Uniform*
- Impairment Types:
  - **Drop** – frames are dropped based upon a user specified probability
  - **CRC Corruption** – the Ethernet CRC of frames is corrupted based upon a user specified probability
  - **Jitter** – Ethernet frames are variably delayed around the line or network flow delay based upon a user defined probability and the following:
    - *Max Delay* – maximum value of delay
    - *Min Delay* – minimum value of delay
    - *Max Positive* Δ - the maximum positive change of delay
    - *Max Negative* Δ - the maximum negative change of delay
  - **Reorder** – up to 7 Ethernet frames can be reordered
  - **Duplication** – up to 7 Ethernet frames can be duplicated
  - **Data Corruption** – any burst of bytes (up to 2,048) within the Ethernet frame may be corrupted based upon a user specified offset from the start of the Ethernet frame and a user-defined error rate (1E-12 to 1E-2).
  - **Modification** – any burst of bytes (up to 2,048) may be modified based upon a user specified offset.

Circuit Emulation Solution

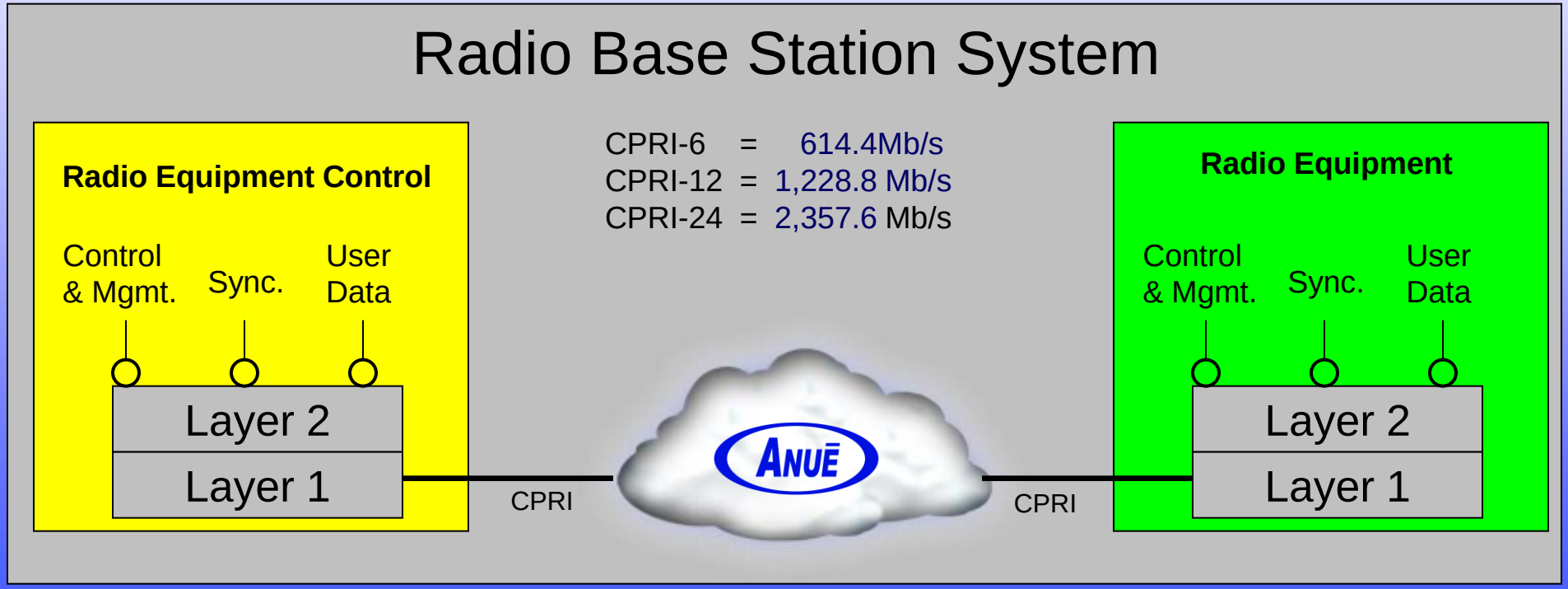
This diagram was taken
from an MEF spec.



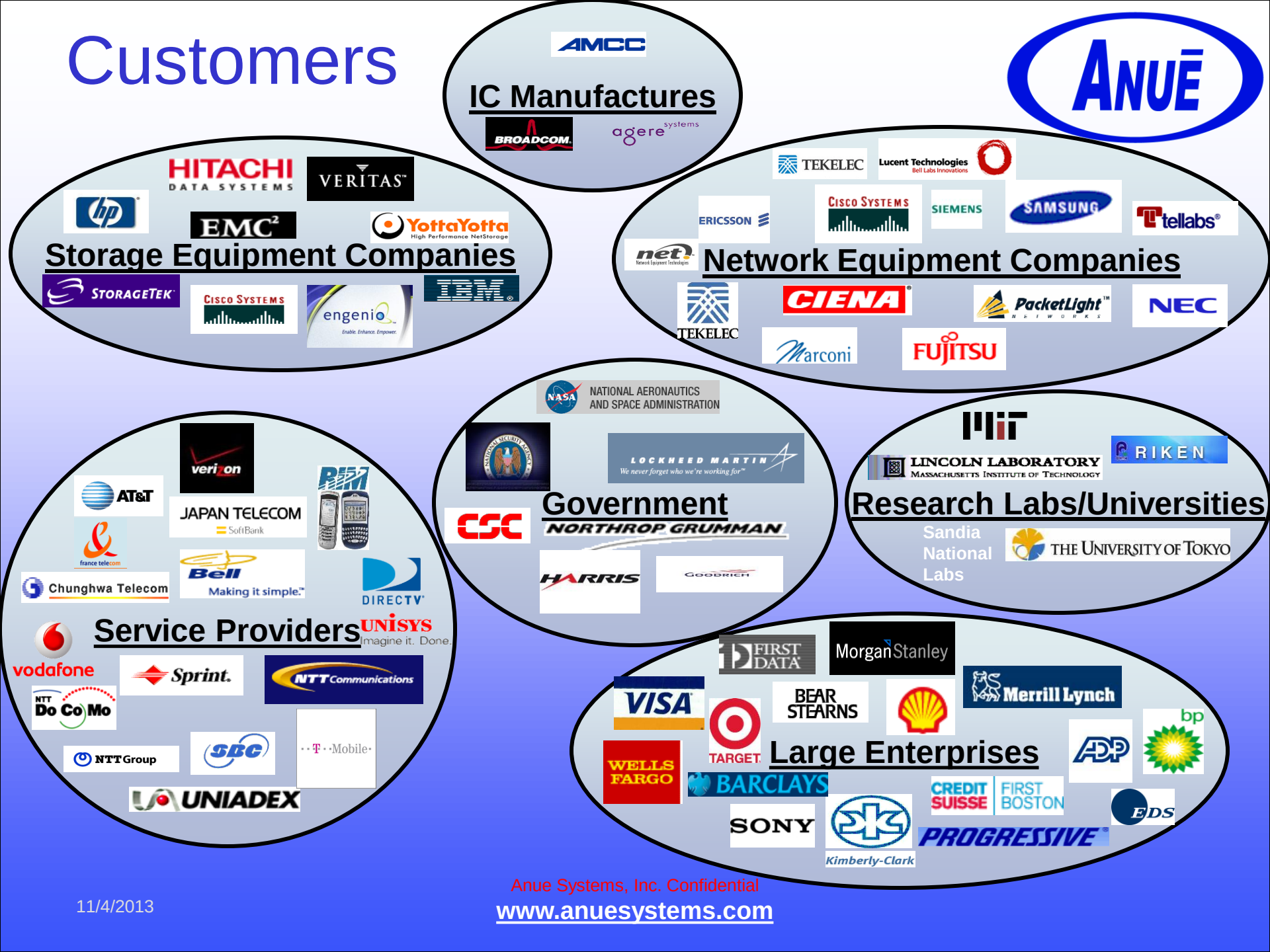
Common Packet Radio Interface

Emulate:

- Cable Length
- Multiple Hops
- Round Trip Cable Delay
- Round Trip Delay Accuracy
- Loss of Signal
- Loss of Frame
- BER



Customers


IC Manufactures
AMCC
BROADCOM
agere systems
Storage Equipment Companies
HITACHI DATA SYSTEMS
VERITAS
hp
EMC²
YottaYotta
High Performance NetStorage
STORAGETEK
Cisco Systems
engenio
Enable. Enhance. Empower.
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TEKELEC
Lucent Technologies
Bell Labs Innovations
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Sprint.
NTT Communications
NTT DoCoMo
NTT Group
SBC
T-Mobile
UNIADEX
Large Enterprises
FIRST DATA
Morgan Stanley
VISA
BEAR STEARNS
Merrill Lynch
TARGET
WELLS FARGO
BARCLAYS
ADP
bp
CREDIT SUISSE
FIRST BOSTON
EDS
SONY
Kimberly-Clark
PROGRESSIVE

GEM - Classifier

Network Profile Classifier

- MAC or IP Source Address
- MAC or IP Destination Address
- VLAN
- MPLS
- IP ToS
- TCP or UDP Source or Destination Port Numbers
- DiffServ
- Other Protocols (Layer 3 through 7)
- ANY piece of information or bit pattern up to 1000 bytes deep

XGEM

- 4 Network Flows per Blade (8 per 2-Blade HAWAII)
  - Each with its own distinct delay, bandwidth & impairment profile
  - Defined by any combination of ***VLAN tag***, ***MPLS label***, ***MAC*** or ***IP address***, ***TCP port*** or ***any other field*** in the Ethernet, IP, TCP, UDP or RTP header as well as any other information up to 2,048 bytes deep within the Ethernet frame
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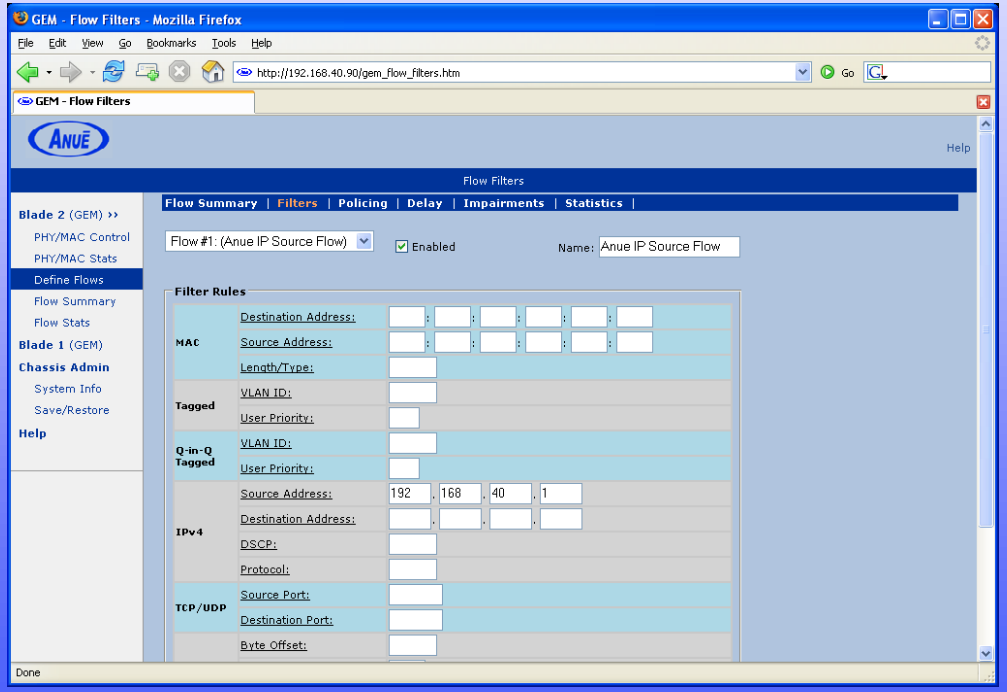


SONET/SDH Path Delay

SONET/SDH

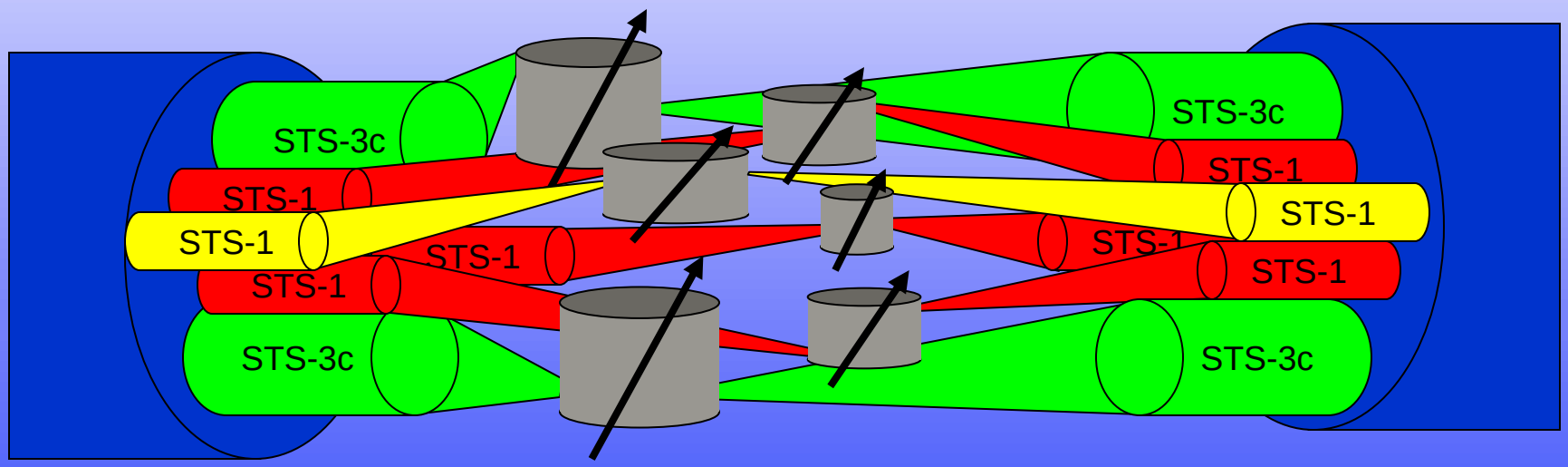
- Differential Delay
  - Delay each path from 0ms to 320ms
  - 154.32ns increments (1 pointer position)
- Dynamic Differential Delay Testing
  - Dynamic Pointer adjustment control
  - Dynamically increase or decrease delay
  - Simulates payload mapping jitter
  - Stress test for VCAT alignment hardware
  - Can reliably control outgoing pointers on a per path basis
- Inject controlled Path layer BER
  - True error injection throughout the SPE (POH plus Payload)
- All TOH/reserved/stuff bytes transparently passed through the MSPD (except B1, B2, H1, H2)
- Loss of Signal and Loss of Frame
- AIS-P – per path
- UNEQ-P – per path

Next Generation Networking Technologies

Virtual Concatenation (VCAT), LCAS, GFP

“PD”

- **Anue Emulators can create a programmed amount of delay for each SONET path/tributary for Differential Delay Testing**
  - Setting different delays for different paths allows the user to simulate transmission delays encountered by diverse routing



SONET Signal Delay

- OC-192 – 0.1ns to 400ms delay
- OC-48 – 0.4ns to 800ms delay (250ms on M Series)
- OC-12 – 1.7ns to 3.2seconds delay (1sec on M Series)
- OC-3 – 6.4ns to 12.8seconds delay (4sec on M Series)
- Adjust delay in bit increments
- Loss of Signal, Loss of SONET/SDH framing
- BER - 10^{-12} to 10^{-2}

‘Real World Networks’

All networks have Impairments and Delay

Impairment	Cause
Frame/Packet Loss	Noise, Dirty fiber/connector, Congestion (overflow), Protection Switches, Failed Hardware, Human Error, Hard/Software Bugs
Corruption/Errors	Noise, Dirt, Congestion, Hard/Software Bugs
Reorder	Protection Switches, Changing routing and switch tables, Jitter
Duplication	Protection Switches, Hard/Software Bugs
Failures (LOS,LOF)	Human Error, Excessive Noise (corruption), Hardware Failure
Delay	**Cause**
Static Delay	Propagation (distance), Congestion, Queuing, Processing
Delay Variation	*Packet Jitter* - Congestion, Queuing Algorithms, Processing *Doppler* – Dynamic delay due to moving TX and RX devices *Differential* – SONET/SDH diversely routed VCAT Networks