High Definition on MPEG in Internet Protocol

Backbone and Access Network Considerations

D. Kelly Daniels

Taming Inter-Packet Jitter to 5 ns

Several IP Networks have struggled with Inter-packet Jitter in IP Networks at many routing points. The issue is often elusive and for years network operators have been chasing the next culprit. So far, most of the solutions have been easy to provide in MPEG-2 and Standard Definition networks. MPEG-4 and High Definition introduces more compression with better known requirements but fewer solutions. Solutions must address tighter tolerances for Jitter. The tighter tolerance has many companies avoiding the hard decisions. This presentation looks at the hard decisions in the network elements, operation support systems, telemetry networks and the cost of meeting the challenge.

MPEG 4 in Internet Protocol Transport

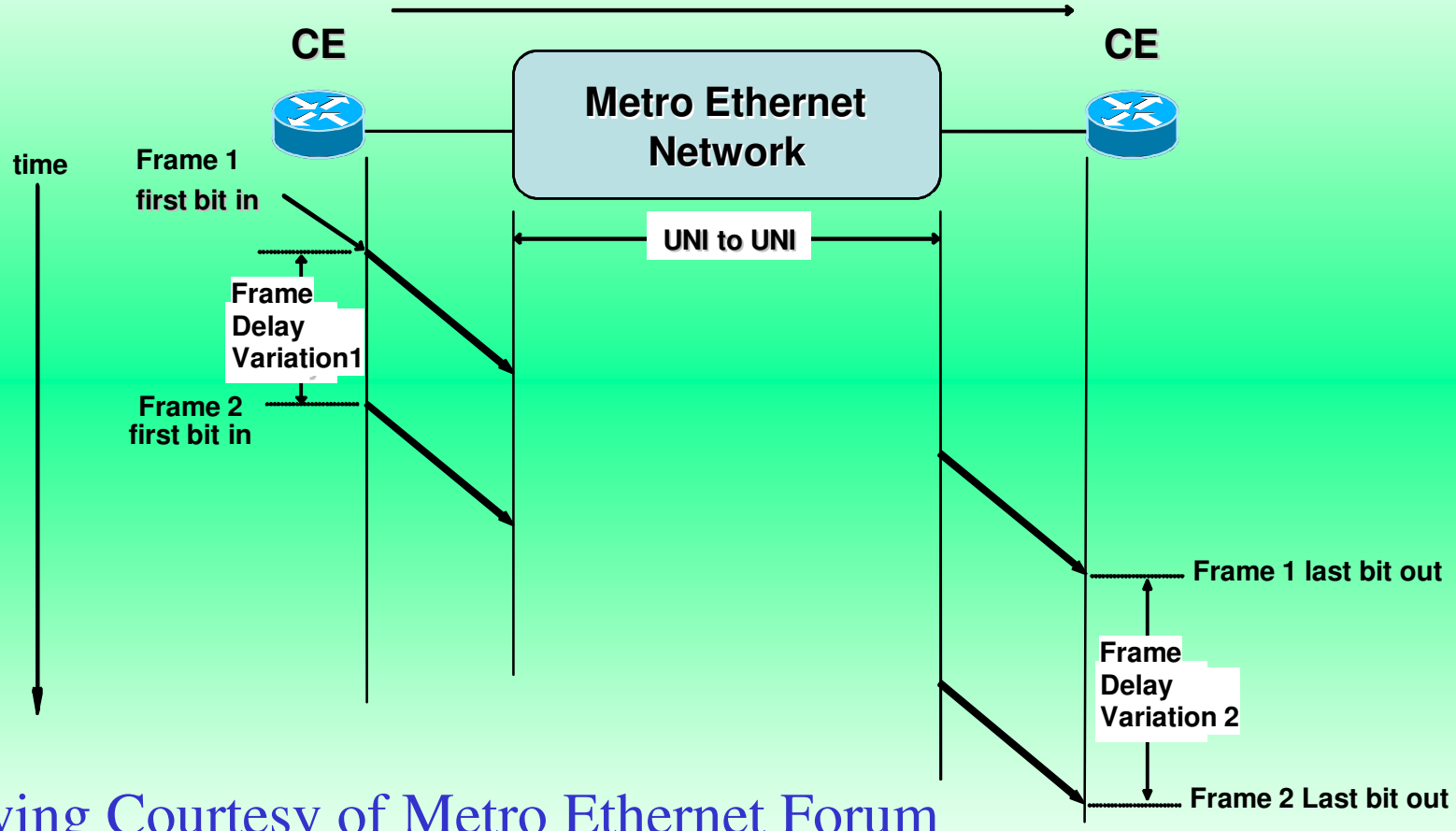
- As a Broadcaster, your architecture for network carriage have a direct impact on the program quality.
- As a Program Provider or Content Creator, your authorizations for network operators are impacted by the network operator.
- MPEG means Compression by removing content.
- Internet Protocol means transactional packet processing, a time sensitive proposition.

Jitter as a Culprit

- Jitter is – the disruption of time between packets/frames/datagrams caused by uncorrected time/distance or errors in transmission.
- Jitter tolerance is moving from 50 MS to 10 NS
- Internet Protocol (IP) Jitter is in router protocol encoding (RT vs UDP and Multicast vs Streaming).
- Ethernet Jitter is in Router performance known as wire-speed causing Frame Delay or Frame Delay Deviation.
- MPEG Jitter is in the PCR performance measured in TR101.290.
- Jitter weighting can be measured in ITU calculations for Media Delivery Index or V-Factor formulas.

Frame Delay Variation Defined

- The difference in delay of two service frames.



Drawing Courtesy of Metro Ethernet Forum MEF 3

Jitter in Protocol

The five-layer TCP/IP model
5. Application layer
DHCP · **DNS** · **FTP** · **Gopher** · **HTTP** · **IMAP4** · **IRC** · **NNTP** · **XMPP** · **POP3** · **SIP** · **SMTP** · **SNMP** · **SSH** · **TELNET** · **RPC** · **RTCP** · **RTSP** · **TLS** · **SDP** · **SOAP** · **GTP** · **STUN** · **NTP** · (more)
4. Transport layer
TCP · UDP · DCCP · SCTP · RTP · RSVP · IGMP · (more)
3. Network/Internet layer
IP (IPv4 · IPv6) · OSPF · IS-IS · BGP · IPsec · ARP · RARP · RIP · ICMP · ICMPv6 · (more)
2. Data link layer
802.11 (WLAN) · 802.16 · Wi-Fi · WiMAX · ATM · DTM · Token ring · Ethernet · FDDI · Frame Relay · GPRS · EVDO · HSPA · HDLC · PPP · PPTP · L2TP · ISDN · ARCnet · (more)
1. Physical layer
Ethernet physical layer · Modems · PLC · SONET/SDH · G.709 · Optical fiber · Coaxial cable · Twisted pair · (more)

The Seven-layer OSI Model
7. Application layer
NNTP · SIP · SSI · DNS · FTP · Gopher · HTTP · NFS · NTP · SMPP · SMTP · SNMP · Telnet
6. Presentation layer
MIME · XDR · SSL · TLS
5. Session layer
Named Pipes · NetBIOS · SAP · SDP · Sockets Session establishment in TCP · SIP.
4. Transport layer
TCP · UDP · IPsec · PPTP · L2TP
3. Network layer
IP · ARP · ICMP · DHCP · RIP · OSPF· BGP · IGMP · IS-IS · IGRP · EIGRP
2. Data Link layer
PPP · SLIP
1. Physical layer
RS-232 · V.35· V.34· I.430· I.431· T1· E1· 10BASE-T· 100BASE-TX· POTS· SONET· DSL· 802.11a/b/g/n PHY

- Ethernet
- SONET
- QAM
- DVB or Digicipher
- Internet Protocol
- MPEG
- Broadcast
  - Multi-cast
  - Real-time and Near Real-time
- Streaming
  - Real-time and Near Real-time

Transport Protocols

- MPEG(2 or 4) in Internet Protocol in Ethernet inside of SONET/SDH carrier
- MPEG in IP inside of Ethernet as the carrier
- MPEG in QAM/RF Carrier
- MPEG in DVB (S/S.2) in QAM modulation
- Carrier as QAM/RF, ASI, SDI, on media like Satellite, Fiber, Twisted Pair, Coax.

Internet Protocol Jitter

- Currently no Standard for MPEG Transport although ATIS is specifying QoS Performance expectations.
- Solutions are in the works for one which I have been promoting Carrier Grade.
  - SNTP Reference 8 decimals to the right stamping
  - Use of time stamps in the Router.
  - ITU 1588 'Grand Master Clock' to feed DATA and TDM based Stratum clocks.
- A few equipment manufactures have adopted reference and requirements to SNTP.
- Others equipment manufactures rely on router performance.
- The decision to use Carrier Class SNTP impacts
  - the cache/wire-speed capabilities of the silicon
  - the transaction decisions of Firmware in ASIC or FPGA
  - Implementation in Element Managers
  - Improvements in manufacturing of Quartz for Oscillators

MPEG Jitter Control

- PCR.
- Shared PCR.
- References to PCR Correction.
- Network Element Oscillator Taming.

Technology

MPEG	INTERNET PROTOCOL	ETHERNET	CARRIER
PCR	Time of Day responsibility	10 MHz clock	Stratum
27/54 MHz clock	IETF Tic-Toc committee work on 1588 clocks	Sequencing and best calculated routes.	GPS
	No requirement to reference	No requirement to reference.	DOCSIS Timing Interface
	NTPv4/SNTP incorporating Carrier Grade	MEF-22 for wireless adopts Carrier Grade	

PCR verse Stratum

- There is a resolution mis-match in the quality of 27 MHz Clock verse a 10 MHz Clock.
- Ever so slight, the difference is analogous to the ability to achieve 50 ms jitter with 10 MHz verse 10 ns jitter with 1588 Grand Master Clock.

Jitter in the Modulation & Transport

- MPEG relies on PCR timestamp resolving by both the encoder and the decoder at a technically superior reference.
- IP routing solutions include an appropriate wires-speed router with balanced port to processor mapping.
- New solutions incorporate SNTP server referenced to GPS Stratum 1 and a packet time stamp 8 places to the right of decimal.
- Newer solutions reference the SNTP and Stratum 1 to a ITU 1588 - Grand Master Clock.

MPEG Jitter 50 MS or 10 NS

- Low and High Definition at MPEG 2 has tested reasonably well. 50 MS jitter on High Definition in MPEG 2 is very much at the high-side of threshold.
- When using MPEG 4, High Definition becomes un-usable with 15 ns inter-packet jitter on the Ethernet affecting the IP packets cannot be corrected.

Packet Testing at Layers

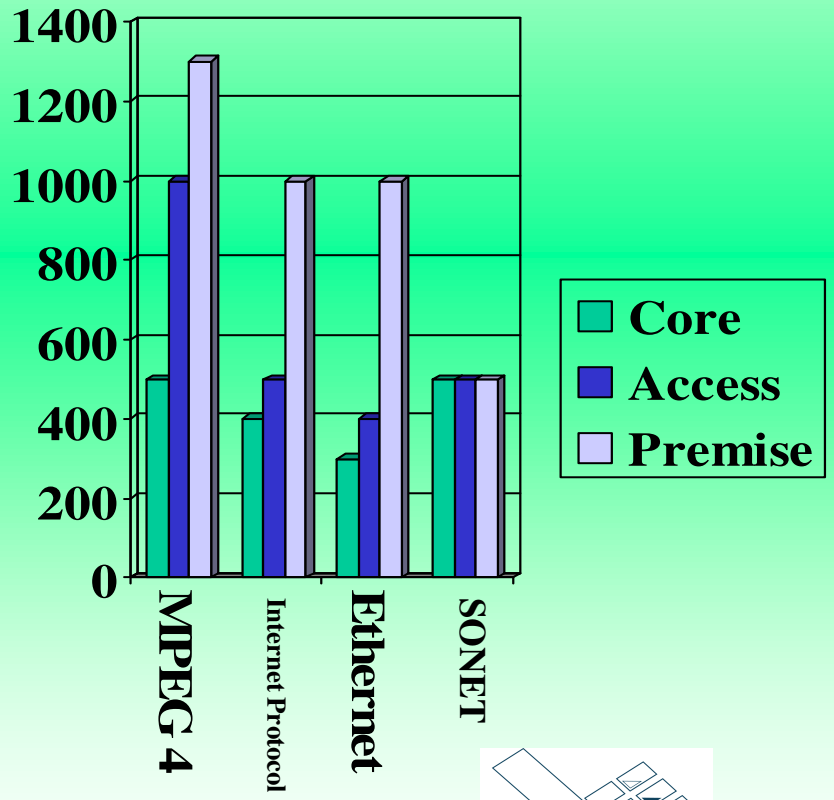
- Measuring IP Jitter by time-stamping packets has been defacto standardized by use of the Tektronix MTM-400 and Tektronix MTS-430 in conjunction with tools available to measure MDI or V-Factor (Media Delivery Index and Video Factor are both ITU test cases for converged content protocols using IP on Ethernet, TR101.290 measures at the MPEG Layer).
- The important factor is to measure the sequential Packet Variation along with Inter-packet Deviation.

Video Streaming Verse Broadcast

- Content Delivery Network
- Internet by Technology
  - Broadband
  - T-Carrier
- Program
- VOD
- CATV, Telco

Network Elements

- Middle-Ware
- Encoders
- Encryptors
- Core Routers
- Applications
- Edge Routers
- Application Devices
  - STB
  - PCs
  - Servers
  - Wireless/Wired Routers
  - NIDs



Standards and Specifications

Active work in these committees help manufactures and carriers.

- Standards Organizations
  - MPEG
  - ITU
  - MEF
  - IETF
  - DVB
- Specifications Organizations
  - OpenCable Labs
  - ATIS
  - IPMPLS
  - OpenTV
  - TMForum

Any Questions ?

Thank-you