Ethernet AV™ summary

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April, 2006
Agenda

• What is Ethernet AV?
• Why is it needed?
• Where will it be used?
• How does it work?
• How will Broadcom support it?
• Beyond?
What is Ethernet AV?

• Simple enhancement to IEEE 802.1 bridges to support streaming QoS
  - 2 ms guaranteed latency through 7 Ethernet bridges
  - Admission controls (reservations) for guaranteed bandwidth
  - Precise timing and synchronization services for timestamps and media coordination
    - < 1µs absolute synchronization between devices
    - Jitter less than 100ns, filterable down to 100ps

• Trade group to provide trademark “enforcement” of otherwise optional features
  - Require useful bridge performance, network management, PoE management, auto-configuration features
Why is it needed? (1)

- Common IT-oriented networks have inadequate QoS controls
  - All use 802.1 “priority” (actually, “traffic class”)
- Ethernet is the best
  - … but it’s easy for the customer to misconfigure or overload
  - … no guarantees
- Wireless has inadequate bandwidth and excessive delays for whole-home coverage
  - … 802.11n and UWB work for non-critical applications, or short range
  - … latencies through multiple A/Ps may be too much for interactive applications
  - … no guarantees
  - … and we still need a backbone for the wireless attachment points
Why is it needed? (2)

- Proposed CE-based networks need new media or are expensive
  - MoCA requires coax everywhere, and is not cheap, and does not carry power, and has modest performance
    … but it’s part of the solution
  - Power line is not cheap, has modest performance, is susceptible to interference, and is blocked by protection circuits
    … but it’s part of the solution
  - 1394b/c long distance has limited developer base & infrastructure, is not cheap
    … but even this is part of the solution
Where will Ethernet AV be used?

• Backbone for home
  - The “Gold Standard”
    • Highest quality/lowest cost way to interconnect wireless A/Ps
    • “Perfect” QoS, requires the least customer interaction

• Within the entertainment cluster
  - Trivial wiring, no configuration, guaranteed 100/1G/2.5G+ per device, not just per room or per house
  - PoE for speakers, extra storage (HD/optical), wireless A/Ps, other lower-power devices
  - Ideal long-term replacement for 1394

• Numerous non-“residential” applications
  - Professional audio/video studios, industrial automation, test and measurement
Proposed architecture

• Changes to both IEEE 802.1Q and IEEE 802.3
  - 802.1Q - bridges/switches - most of work
  - 802.3 - Ethernet MAC/PHY - small change to MAC

• Three basic additions to 802.3/802.1
  - Traffic shaping and prioritizing,
  - Admission controls, and
  - Precise synchronization
Streaming QoS only guaranteed in AV cloud

Peer device not AV capable

Device outside of AV cloud still communicate with all other devices using legacy "best effort" QoS

Filtering/retagging active

AV "cloud" (defended network)
Establishing the AV cloud

• IEEE Std 802.1AB defines “LLDP”: Logical Link Discovery Protocol
  - Allows link peers to determine each other’s characteristics

• Will be enhanced with P802.1as service that gives a relatively precise round trip delay to a peer
  - Allows link peers to discover if any unmanaged bridges or other buffering devices are present on link
Traffic Shaping and Priorities

• Endpoints of Ethernet AV network must “shape traffic”
  - Schedule transmissions of streaming data to prevent bunching, which causes overloading of network resources (mainly switch buffers)
  - Shaping by limiting transmission to “x bytes in cycle n” where the cycle length is 125 µs or 1ms depending on traffic class
  - Traffic shaping in bridges will provide scalability
    • without it, all bridges need worst case buffers

• Mapping between traffic class and priorities
Traffic Class?

- **802.1p introduced 8 different traffic classes**
  - Usually implemented as strict priorities
    - tagged frames, priority field as “PCP”
  - Highest (6 & 7) reserved for network management
    - low utilization, for emergencies
  - Next two for streaming (4 & 5)
  - Lowest four for “best effort”

- **AV bridging:**
  - Class 5 is for lowest latency streaming
    - Roughly 250 usec per bridge hop: interactive audio/video
  - Class 4 is for moderate latency streaming
    - Perhaps 1ms per bridge hop: voice over IP, movies
Admission controls

• Streaming priority mechanism can reliably deliver data with a deterministic low latency and low jitter
  - but only if the network resources (bandwidth, in particular) are available along the entire path from the talker to the listener(s).

• For AV streams it is the listener’s responsibility to guarantee the path is available and to reserve the resources.

• Done via a new 802.1ak “Multiple Registration Protocol” application: SRP (“Stream Registration Protocol”)
  - Registers streams as multicast address/bandwidth/traffic class needed tuples
  - Perhaps other information useful for stream management such as path availability
• With MSRP registration, the talker and intermediate bridges know where are potential listeners and how to get to them

• Assume in the above figure, B3/B4 have learnt the talker’s address, and B1/B2 haven’t, then:
  - MSRP floods the registration if the talker’s address is not in the bridge FDB (eg. B1, B2)
  - MSRP relays the registration through specific outbound port if the talker’s address is known by the bridge FDB (eg. B3, B4)
Admission Control (2)  
(successful reservation)

- RESV signaling triggers admission control operations in intermediate bridges. It also locks resources and updates isochronous filtering database if the admission control is successful.
- In this example, admission control is successful along the whole path. RESV signaling servers as the end-to-end explicit ACK signaling to listener.
In this example, admission control is failed at B2. The SI (Status Indication) bit of RESV signaling will be set to FAILED.

The RESV is still forwarded to the listener. However, downstream bridges (i.e., B1, B2) will not lock resources for the RESV signaling whose SI is set to FAILED.

Listener is noted of the failure since RESV with FAILED SI serves as an end-to-end explicit NACK.
Precise synchronization

- AV devices will periodically exchange timing information
  - both devices synchronize their time-of-day clock very precisely.
- This precise synchronization has two purposes:
  - to enable streaming traffic shaping and
  - provide a common time base for sampling data streams at a source device and presenting those streams at the destination device with the same relative timing
- Very similar to IEEE 1588, but much simpler
  - likely to be a part of new IEEE 1588v2
• There is a single device within an Ethernet AV “cloud” that provides a master timing signal.
  - All other devices synchronize their clocks with this master.
Master clock selection

• Selection of the master is largely arbitrary (all AV devices will be master-capable), but can be overridden if the network is used in an environment that already has a “house clock”.
  - Professional A/V studios
  - Homes with provider time-synchronization service
Changes to Ethernet NIC

• MAC changes
  - Frame Timer – Accurately note time of RX/TX Ctrl Frame
    • Not really a change to “MAC”, but to buffers for the MAC

• Queuing/DMA
  - Separate queues and DMA for class 4/5 frames to provide appropriate traffic
    shaping (scheduling)
    • One extra queue/DMA channel possible

• Admission Control (driver firmware)
  - Bandwidth allocation database associated with filtering database
  - Management using same methods (MRP) used for multicast addressing

• Real-time clock module
  - Master clock generator
  - Time Sync correction method
Changes to Ethernet Switch

• MAC changes
  - Frame Timer – Accurately note time of RX/TX Ctrl Frame

• Bridging
  - Ingress filtering/shaping at edge of network to ensure proper traffic shaping for class 4/5 (streaming) frames
  - Egress filtering to ensure that streaming CoS not over-utilized

• Admission Control
  - Bandwidth allocation database associated with filtering database
  - Management using same methods (MRP) used for multicast addressing

• Real-time clock module
  - Master clock generator
  - Time Sync correction engine per port - only if wanted to reduce switch CPU processing

• Reasonable Microprocessor Cycles
  - Scales with # of ports similarly.
When will Ethernet AV be available?

- IEEE standardization process started
  - Originally an 802.3 study group, moved to 802.1 in November 2005 as “Audio/Video Bridging Task Group”
  - Early drafts already available
  - Expect technical closure in 2006, final standard in 2007

- First hardware/software soon after stabilization
  - Possibly a number of “pre standard” iterations

- Later editions support uncompressed HD video
  - “multiGigabit” NIC/Switch (“Ethernet HD”)
Example EnetAV NIC

- PHY is Fast Ethernet or better
  - 1G for backbone, 2.5G/10G for uncompressed video
- CPU interface is PCI-E
  - Streaming frames on PCI-E use virtual channel
  - Perhaps parallel PCI for CE?
- Streaming I/O?
  - MPEG-TS 10-signal I/F?
  - I2S 3-signal for audio?
  - DVI for uncompressed video?
Example EnetAV bridge

- PHYs are Fast Ethernet or better
  - 1G/5 port for first versions
- Separate CPU at first, but moving to integrated processor ASAP
**Example multiport Enet AV NIC**

- **Best product for TVs, STBs, home gateways, media PCs**
- **Anything that is a “hub” in the cluster**
Beyond Ethernet AV

• Ethernet HD™
  - Multi-gigabit Ethernet with AV QoS

• Multi-gigabit?
  - Supports uncompressed HD video at 1.4+Gbit/sec plus
    multiple compressed streams and regular best-effort traffic

• Higher layer protocols
  - Streaming protocol adaption layer using IEC 61883 (for non-
    routable streams) or RTP (for IP-routable streams)
  - DTCP, DTCP-IP, and/or HDCP for content protection
  - UPnP, CEA-2027 or simplified RSVP for stream establishment
  •
Why uncompressed HD?

• “Video Rich Navigation”
  - User interface information generated locally (STB/gateway)
  - Compression adds significant cost

• Professional usage
  - Studios/performance

• Games
  - Compression adds significant cost …
  - And much more importantly …

Latency!
Summary

• Ethernet AV will be the standard interconnect for uncompromised quality of service
  - soon!

• There will be growth in both technology (speeds and feeds) and infrastructure (switches, ICs, intellectual property)
  - The first providers set the real standards, the interoperability requirements.
Thank you