Audio/Video Bridging on Local Area Networks

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Outline

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Why AVB is needed?

- Designed for real-time streaming of audio and video data
- Common standard approved by joint group of manufacturers as part of *IEEE P802*
- Cost-effective cabling and hardware technology
- Simple to use and and set-up
- Robust operation achieved by a combination of specifically designed protocols

AVB addresses multiple market segments, including professional A/V and consumer entertainment.

Background Overview I

Point-to-Point Links:

- *MADI and AES/EBU*
- *SDI and HDMI*
- *OptoCore*
- *I2S and USB*
- *IEEE P1394*

Both audio and video manufacturers have already developed their own approaches to achieve similar capabilities and a number of standards exist using specific digital protocols with specialized cabling and hardware and cannot be combined with each other!

Background Overview II

Proprietary Solutions:

- *CobraNet*
- *EtherSound*
- *Aviom*
- *REAC*
- *AES50*

These audio networking systems are already using Ethernet. The approach is not uniformal and cross-compatibility of these systems is a major issue for audio engineers!

Background Overview III

- Networking protocols *(such as TCP, UDP and IP)*
  - do not implement time synchronization
  - were designed for more general data transmission
  - appied on a different scale of deployment
- It has been generally proven that
  Ethernet is capable to handle high definition A/V with reasonable quality of service (QoS)
- Some technologies listed above achived it with various approaches (mostly proprietary)

Background Overview IV

There certainly is a way of fine-tuning off-the-shelf networking equipment and software to provide reliable performance for streaming audio from one computer to another using cross-over *CAT5* connection or a single switch. Also applying a set of fine-tunned QoS and traffic shaping rules on commodity equipment may in theory provide reasonable performance in a larger LAN, assuming there is no other traffic.
Another set of approaches exists using RTP and RTSP combined with multicasting, however these are used for compressed and latency-tollerant media streaming in conferencing and entertainment.

How AVB uses the Ethernet network?

- No IP addresses and ports, use streams instead
- Distributed precise clocking hierarchy
- Pre-allocated resources for streams
- Monitoring of throutput and latency

Underlining Base Standards

IEEE 802.1 - Network Layer 1:

- `802.1Q` - *Virtual Bridged Local Area Network (VLAN)*
- `802.1Qav` - *Time-Sensitive Forwarding and Queuing*
- `802.1ak` - *Multiple Registration Protocol*
- `802.1Qat` - *Stream Reservation Protocol (SRP)*
- `802.1AS` - *Timing and Synchronization* `(P1588-2008)`
- `802.1BA` - *Audio Video Bridging Systems*

Network Layers 2 and 3:

- `P1723` - *Encapsulation Format for A/V Transport (AVBTP)*
- `P1733` - *Correlation of RTP timestamps with PTP*

Other:

- `P1588` - *Precision Time Protocol (PTP)*
- *. . . digital media format standards*

Clock Synchronization I

- *PTP version 2 is an IEEE standard* `P1588-2008`
- *For AVB use, a subset has been defined under* `802.1AS`
  Unlike other new protocols,
  PTP is already used in other application areas:
  - Industrial Control
  - Test and Measurement Equipment
  - A/V Streaming and Control
  - Telecommunications

Clock Synchronization II

PTP defines a number of algorithms to find the delay times on the network and adjust the clock on all devices to the same time base. This clock is then used to re-align audio and video frames received in data packets. This functionality needs to be implemented in physical layer hardware and sync precision of tens of nano seconds is achievable on a network that fully implements PTP in switches and end-points. A clock hierarchy of master and slave devices, including boundary and transparent clocks applies no such network.

Virtual Networks (VLANs)

802.1Q is a base for *Virtual Bridged Local Area Networks*. Fallowing two amendments were made for *A/V Bridging*:

- *802.Qat* - *Stream Reservation Protocol*
- *802.1Qav* - *Time-Sensitive Forwarding and Queuing*

Combination of this two protocols allows allows traffic with AVB tag to take 75% of total LAN bandwidth and also make sure the buffered packets are synchronized with PTP clock.

Stream Reservation and Traffic Shaping I

802.1Qat and *802.1Qav* introduce the concepts of

- *streams* and *slots* or *channels*
- *talkers* and *listeners*

- Provide special *admission control* and *priority tagging*
- Talkers advertise their stream
  - *(64-bit ID) = (48-bit MAC address) + (16-bit stream ID)*
  - *QoS requirements*
- Listeners request to register for streams
- *802.1Qat* is a software protocol

Stream Reservation and Traffic Shaping II

`802.1Qav` is designed to:

- prevent packet loss in buffers
- synchronize queued packets with PTP clock

It defines flow control algorithms to provide:

- predictable latency of the path and lower the jitter
- synchronized forwarding of buffer queues
- prevention of packet "bunching"

Stream Reservation and Traffic Shaping III

- All *A/V Bridges* are required to
  - *verify the bandwidth availability (between the end-points)*
  - *propagate the advertise message (to and from end-points)*
- If the bandwidth is insufficient
  $\longrightarrow$ the failure is reported
- When a listener registers a stream
  $\longrightarrow$ the resources are locked down
- The resources are unlocked when it de-registers

Channels and Devices I

On AVB network end-point devices are classified as

- `talkers` - advertise streams
- `listeners` - suscribe to recieve streams

Then the set of protocol ensure

- best-effort traffic throughoutput
- synchronization in transmission and on the end-points

Channels and Devices II

- Audio channels are grouped into *streams*
- Video or audio channels are refered to as *slots*
- Stream originates from *one talker* and shares *one clock*
- Routed on second layer in *unicast* or *multicast* mode
- The channels are not split out of the stream in the network
- From the network level only the *unique stream ID* is known
- Higher channel count in one stream reduces the bandwidth

Media Formats and Control

AVBTP - the Transport Protocol (P1722)

- Various media formats can be used
  (such as MPEG/ISO, PCM or AM824 and others)
- Allows for bridging of `P802` and `P1394` networks
- Compatibility with IP streaming is facilitated by `P1733`

DECC - the higher layer protocol (P1722.1)

- Discovery
- Enumeration
- Connection
- Control

Design Solutions

- National Semiconductors DP83640 Ethernet Physical Layer Chip with P1588
- XMOS AVB Reference Design Software for XS1 Processor Architecture
- Marvell Kirwood ARM SoC and 88E0000 Yukon & LinkStreet Ethernet ICs
- Freescale MPC831X PPC SoC
- Lab-X and Xilinx FPGA cores

Peformance Metrics

Source: XMOS reference design documentation

- Network: 100MB Ethernet
  - Channels: 32x32 and 16x16
  - Audio Quality: 48kHz/24-bit and 96kHz/24-bit
- Network: 1GB Ethernet
  - Channels: 72x72 and 36x36
  - Audio Quality: 48kHz/24-bit and 96kHz/24-bit

Source: Harman product presentation

- Network: 1GB Ethernet
- Latency: <2ms
- Channels: 300 x 300
- Audio Quality: 48kHz/24-bit

More Data : Bandwidth of channels per stream

Table: *Source: XMOS reference design documentation*

$\frac{kHz}{Mbps}$	*48*	*96*	*192*
7.81	2 or 1	-	-
10.88	4	2 or 1	-
17.02	8	4	2 or 1
29.31	16	8	4
53.89	32	16	8

On-line Reference

AVnu Alliance

Homepage:

http://avnu.org/

IEEE Task Group

Homepage:

http://ieee802.org/1/pages/avbridges.html

Xilinx Ethernet AVB Endpoint IP LogiCORE

Product Page:

http://xilinx.com/products/ipcenter/DO-DI-EAVB-EPT.htm

XMOS AVB Refferece Desgin

Application Design for XS1 Processor:

http://xmos.com/applications/avb