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Why HANA chose 1394 (over Ethernet and HDMI) for home video networking

**The IEEE-1394 platform has several key advantages over both Ethernet and HDMI for home networking. And using ordinary CAT5/6 or even potentially power line connections, 1394 can be networked throughout the home without running any new wires.
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When HANA (High-Definition Audio-Video Network Alliance) chose IEEE-1394 as its recommended home network platform, it may have surprised some in the industry. Ethernet has won over the PC marketplace giving it a vast infrastructure base and economies of scale. In the consumer electronics world, HDMI already has taken a significant lead as the point-to-point connection of choice for moving video. With Ethernet's market dominance in PC networks, and HDMI's dominance in CE point-to-point connections, why didn't HANA select one of these technologies? So what compelling advantages does 1394 have that made it so appealing to HANA?

Bandwidth and quality of service

To transport a single, high-definition MPEG2 stream with audio typically requires anywhere between 20 to 30 Mbps of bandwidth, depending on the resolution for consumer applications. Although Ethernet, HDMI, and 1394 all have the bandwidth to transfer high-definition video content, each have their own pros and cons. Let's delve further into how each handles video.

In a perfect world, Ethernet at 100 Mbps would seem to be able to handle up to 5 HD streams. This assumes the minimum HD resolution, no overhead due to the protocol, each video stream has dedicated bandwidth, and there is no congestion with other devices on the network.

However, Ethernet IP networks provide only a best-effort packet delivery service, which means there is no guarantee that the network will not discard, duplicate, delay or mis-order the packets. This poses a major dilemma for clock reconstruction in MPEG2 transport streams, which is crucial for synchronizing video to audio (lipsync), multi-room audio and similar applications.

Due to the time sensitive nature of streaming video, you have two basic possibilities to improve the Quality of Service QoS in an IP system to prevent interruptions to the video: 1) reduce congestion by either increasing bandwidth or reducing the traffic on the network; and 2) add additional buffering to each display device.

In an attempt to improve QoS, the 802.1Q specification was created to offer a third alternative. Using a Tag Protocol ID (TPID), the 802.1Q spec creates a packet prioritization giving time sensitive data a greater chance of getting to the destination in time.

Although this frees the time-sensitive data from regular traffic, congestion may continue to be an issue as more and more time-sensitive products become integrated into our homes. HD video must compete with other HD streams, IPTV, VoIP, video conferencing, and gaming systems for packet priority.

NEXT: Advantages of 1394

The advantage of 1394 is its ability to transport up to eight simultaneous HD streams at 400 Mbps with 1394a. As more devices rollout with 1394b, speeds will double to 800 Mbps, enabling even more capabilities with the additional bandwidth. Where IP networks are ideally suited for latency tolerant file transfers, from the beginning 1394 was designed with video and QoS in mind.

To guarantee QoS, all bandwidth is divided into 125µs cycle periods (see *Figure 1*). Within each cycle period, up to 80 percent of the period is allocated to time-sensitive isochronous data. All other asynchronous traffic is sent during the remaining 20 percent of the cycle period. Should the asynchronous period be fully consumed, any remaining data will be transmitted in the next asynchronous period.

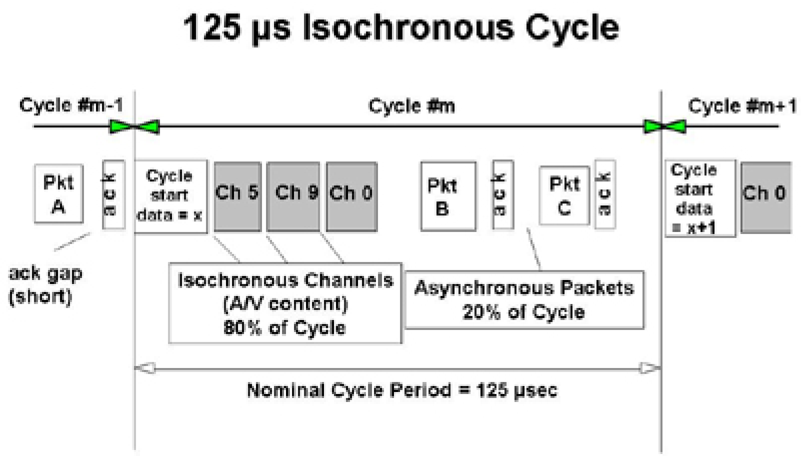

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Figure 1: Example of 1394 cycle period.

When a device is attached, a bus reset is issued and all devices on the network exchange their network capabilities and requirements. For devices wishing to transmit isochronous content, an arbitration process takes place and one of the devices emerges as an "Isochronous Resource Manager" to ensure that devices wishing to transmit content are guaranteed the necessary bandwidth.

Mechanisms are built into the protocol to maintain the isochronous streams during a bus reset. This prevents disruptions to the audio or video as new devices are attached or removed from the network. Through this reservation-based system, bandwidths for audio and video content are guaranteed, providing robust QoS.

At 5 Gbps, HDMI is by far the speediest of the interfaces. Unlike Ethernet and 1394, HDMI transmits its video content uncompressed. Even with an uncompressed HD video stream, over half of the bandwidth remains available for future use. HDMI is strictly a single purpose, point-to-point interface that can only be used for a single AV stream. This is precisely what both HANA and DLNA strive to change.

Next: Topologies and Configurations

Topology and configuration
For decades, content was constrained, moving only from point-to-point. Networking is a revolution in our homes. No longer restrained to move strictly between two boxes, networking allows content to be viewed and shared by all boxes in the home.

Ethernet-IP and 1394 take two very different approaches to networking. IP-based networks must be configured in a star topology. Following a peer-to-host model, Ethernet networks rely on a central router to switch packets between devices. Each device must be either programmed to a static IP address, or configured through a DHCP server on the network. Although allowing for a virtually endless number of nodes on the network, the need for a router increases cost and requires additional boxes on the network.

In more of a free form topology, 1394 operates in a peer-to-peer model. A device can be plugged into any other device on the network with a free port. All configuration information is handled by each device and shared device-to-device via a "self-identification" process that takes place when the network first initializes. Although limited today to 63 nodes per cluster, future versions will support bridging between clusters, allowing multiple clusters to communicate with each other.

Development of the 1394b specification opened up a whole new range of cable media for its networks. Capable of operating over inexpensive unshielded twisted pair cables (CAT5/6), it can maintain 400 Mbps over 75 meters of cable and 200 Mbps up to 100 meters. By partnering with ultra wideband (UWB) technology, 1394 now can be bridged across coax cables without interfering with television and internet signals. Progress is being made even towards 1394 over power line. Through these developments, 1394 can be networked throughout the home today without running any new wires.

Security & storage
HDMI shines most in its copy protection. Data is encrypted under HDCP while the sheer speed of the interface poses a

dilemma to any would-be pirate development.

Decoding the content and sending it uncompressed is very difficult for any storage device to capture at gigabit speeds or the terabytes of data for a full-length movie. Only through costly encoders is it possible to store content on a hard disk or to burn a movie directly to disk.

Again, this is where the 1394 design has key advantages. By transporting content under MPEG compression, it allows for a much simpler and cost-effective network.

Next: 1394 Security

Content coming in from a STB or a DVD is already MPEG2 or MPEG4 encoded. Without any additional decoding or encoding in the STB, the MPEG is transported across the 1394 network to other boxes. Since the stream is already MPEG-compressed, a hard disk drive or DVD recorder-based DVR can save data directly without first decoding or encoding the data. Newer HD camcorders take advantage of 1394 as this content also is MPEG-compressed. The only decoder needed in the entire network is just in the display -- eliminating the need to place a decoder in every box (see *Figures 2 & 3*).

Piracy is thwarted in 1394 through the use of digital transmission content protection (DTCP -- also known as 5C) content protection licensed by the Digital Transmission Licensing Administrator (DTLA). This encryption scheme has proven itself to be robust over the years. Approved by the Motion Picture Association of America (MPAA), it is required by the Open Cable specification for HD cable set-top boxes.

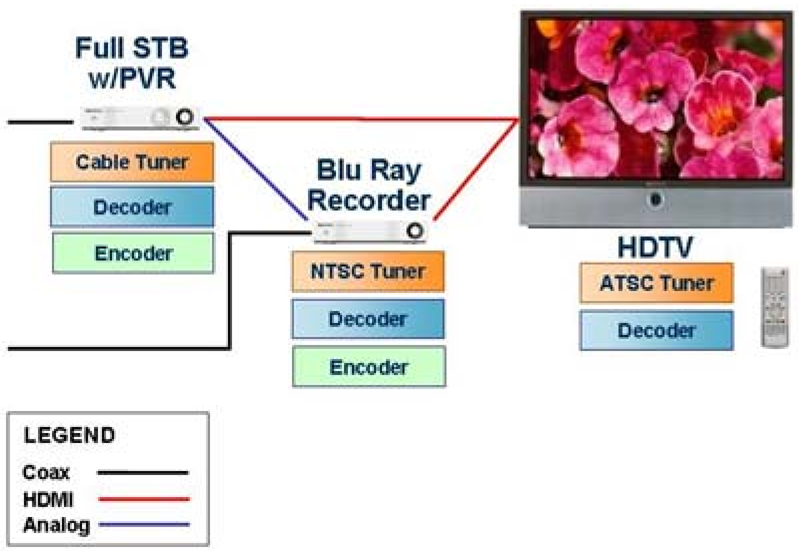

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Figure 2: HDMI and Analog Implementation.

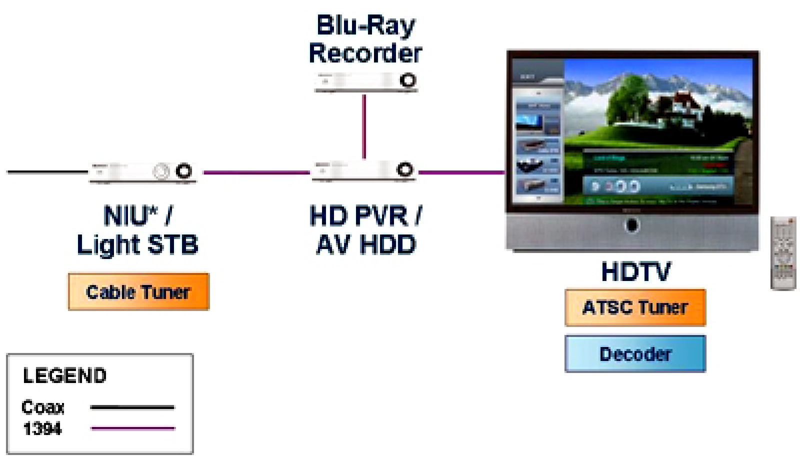

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Figure 3: 1394 Implementation

DTCP is not digital rights management (DRM), i.e., it does not manage the digital rights. Instead, it protects the content during transfer. Each device has its own unique certificate and key. So if one key is ever broken, only that key is broken. The broken key can not be used by other devices to crack the encryption.

IP networks also have gone to the Digital Transmission Licensing Administrator (DTLA) for a way to encrypt content. The result is DTCP-IP, a variation of DTCP for IP networks. For HANA, however, this security is still too developmental and can not readily be implemented into products. Additionally, DTCP-IP has not been approved by CableLabs for transmission of premium cable content.

Summary
For HANA, 1394 is the clear choice. HANA needed a network interface that is simple to install throughout the home, self-configuring with the ability to transport multiple HD streams with robust QoS. This network needed to transfer and store content with a security method that is proven and approved by the content providers. Only 1394 meets the needs of HANA today and well into the future. For more information, visit www.HANAalliance.org.

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