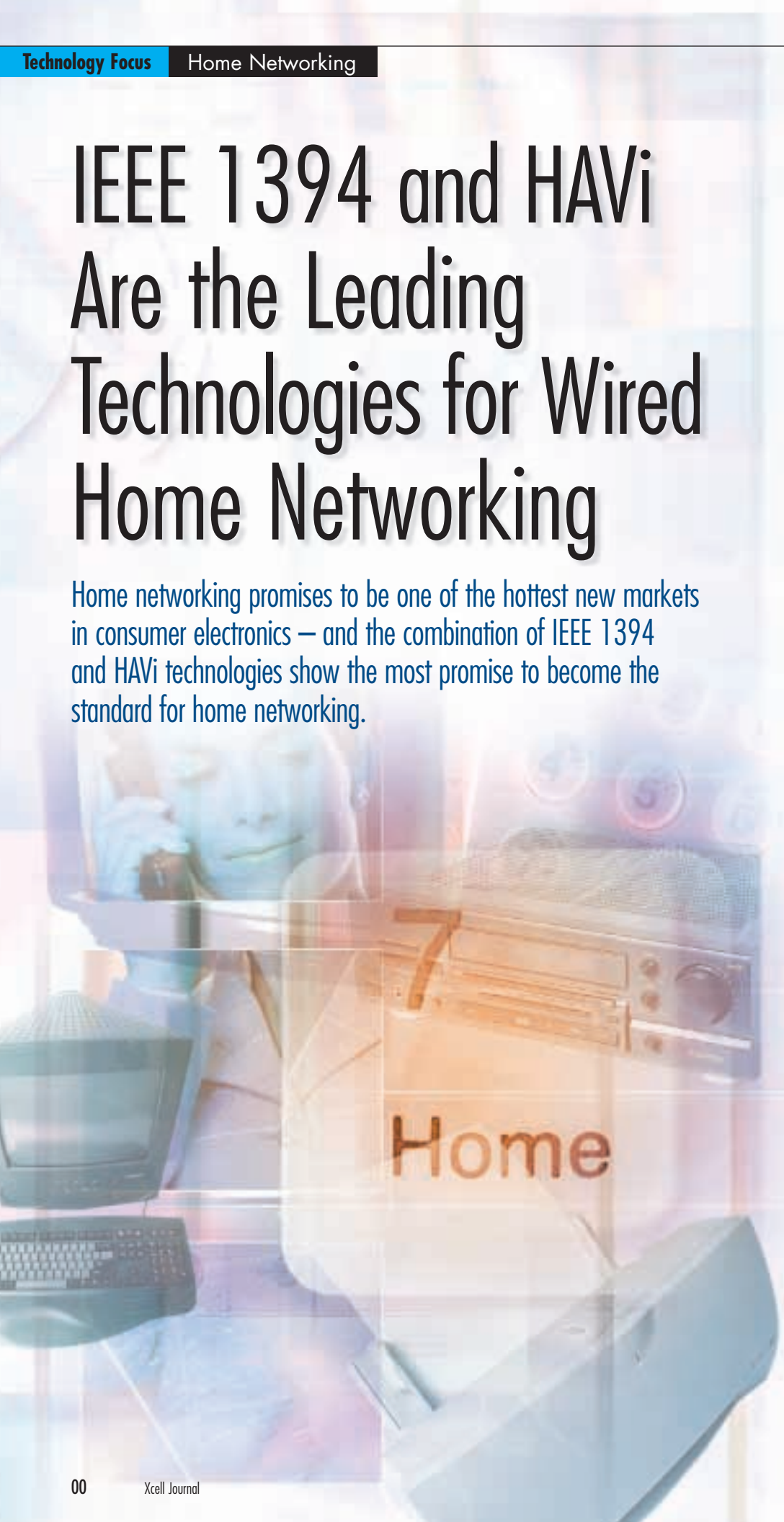
IEEE 1394 and HAVi Are the Leading Technologies for Wired Home Networking

Home networking promises to be one of the hottest new markets in consumer electronics – and the combination of IEEE 1394 and HAVi technologies show the most promise to become the standard for home networking.



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The consumer world is buzzing with news and standards to network home appliances, PCs, peripherals, and other consumer devices. A number of technologies are vying to be the next technology to network all appliances in the home. Some of these 22 technologies include HomeRF™, Bluetooth™, HiperLAN2, IEEE 802.11, Ethernet, HomePNA™, USB 2.0, and IEEE 1394.

Although each technology presents unique pros and cons, the technologies that require wires do provide one critical capability – the ability to deliver reliable high-speed voice, data, and video transfer. Home networking is incomplete without the ability to transfer voice, data, and video together.

Ethernet, USB 1.1/2.0, and IEEE 1394 top the list of these "new wires" technologies:

- Ethernet is a low-cost technology, which uses a protocol ideal for data traffic.
- USB 1.1 and its more recent specification USB 2.0 are primarily PC-centric – networking PCs and PC peripherals.
- IEEE 1394 is the technology that holds the most promise to be the perfect home networking technology that will network audio, video, and PC equipment.

IEEE 1394 Backgrounder

The move from analog to digital technology has enabled the sharing of video, Internet, data, and audio. Consumers are constantly searching for faster, cheaper, more reliable, and easier ways of transferring and sharing information. While information sharing has been happening at the enterprise level for the last few years, the home is just seeing its introduction. This phenomenon, known as home networking, allows the interconnection of PCs, consumer equipment, and communications, and the distribution of infotainment among these appliances.

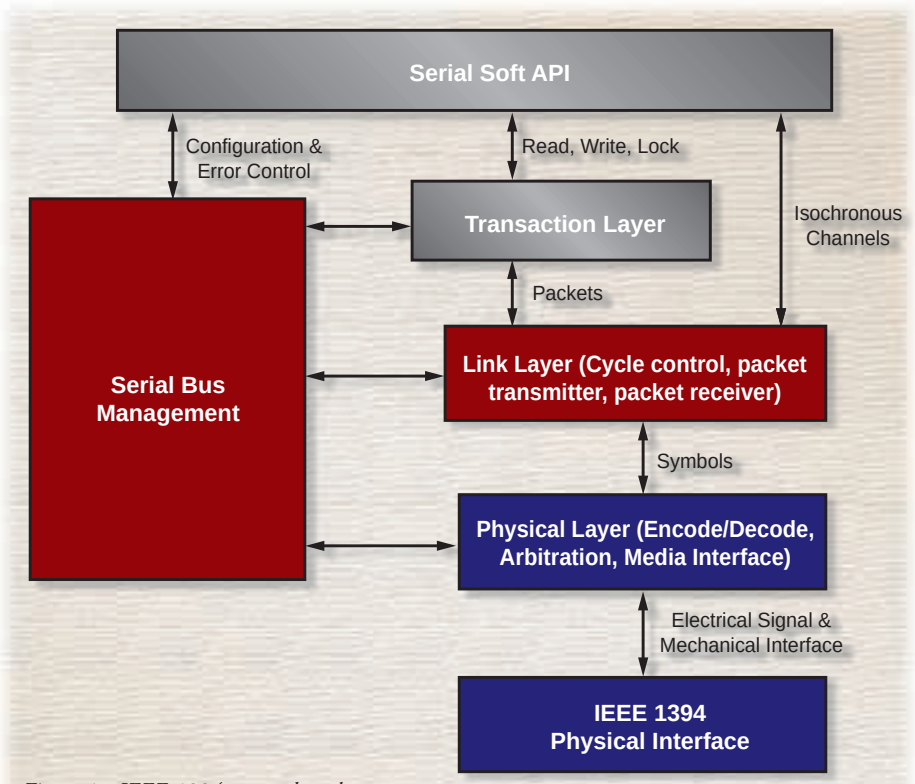

Figure 1 - IEEE 1394 protocol stack

The convergence of voice, data, and video in the home will happen only when seamless, high-speed communication becomes readily available. IEEE 1394 is one such interconnection technology that will enable connection of these devices throughout the home. IEEE 1394, also known as 1394, FireWire™ or iLink™, is a versatile, high-speed, and inexpensive method of interconnecting a variety of consumer electronic devices (such as digital TV, set-top boxes, and home theater equipment), PCs, and PC peripherals (such as scanners and printers).

The FireWire bus standard, originally created by Apple Computer, was born out of the need for a low cost, consumer-oriented connection between digital-video recorders and PCs. FireWire technology grew into a standard – called IEEE 1394 – for low cost, high data rate connections. In 1994, the 1394 Trade Association (1394ta) was formed to support and promote the adoption of the IEEE 1394 standard. In 1995, the 1394ta formally released the 1394 specification. Further revisions like 1394a in 1998 and 1394b in 1999, were introduced. The 1394b standard is fully backward compatible with the current 1394 and 1394a specifications. Each revision of 1394 has added features, performance, and capabilities.

IEEE 1394 Architecture

The components that form a 1394-based home network include the actual protocol itself, the cabling system, and the architectural design of the network. Similar to other high-speed networking systems, IEEE 1394 adopts a layered approach to transmitting data across a physical medium. The four layers used by the IEEE 1394 protocol are shown in Figure 1.

Physical Layer

The physical layer provides the electrical and mechanical connection between the 1394 appliance (connector) and the cable itself. Besides the actual data transmission and reception tasks, the physical layer also provides arbitration to insure all devices have fair access to the bus. As its physical media, 1394 requires optical fiber or high-grade copper wiring between the appliances. The 1394 physical layer is physically point-to-point and logically a bus (each node is a repeater).

The physical layer transmits the unstructured, raw, bit stream over a physical medium, and describes the electrical, mechanical, and functional interface to the carrier. It provides the linking to the upper sessions via signaling and the initialization and arbitration services necessary to assure that only one node at a time is sending data. The physical layer of the 1394 protocol includes electrical signaling, mechanical connectors and cabling, arbitration mechanisms, serial coding and decoding of the data being transferred or received, and transfer speed detection.

Link Layer

The link layer takes the raw data from the physical layer and formats it into two types of recognizable 1394 packets – asynchronous and isochronous.

Asynchronous data transfer is the conventional transmit-acknowledgment protocol and puts the emphasis on guaranteed delivery of data, with less emphasis on guaranteed timing.

Isochronous data transfer is a real-time guaranteed-bandwidth protocol for just-in-time delivery of information. It puts the emphasis on the guaranteed timing of the data and less emphasis on delivery. Isochronous transfers are always broadcast in a one-to-one or one-to-many fashion. No error correction or retransmission is available for isochronous transfers.

Transaction Layer

The third layer in the IEEE 1394 protocol is called the transaction layer and is responsible for managing the commands that are executed across the home network. It supports the asynchronous protocol write, read, and lock commands. A write sends data from the originator to the receiver, and a read returns the data to the originator.

Serial Bus Management

The fourth and final logical grouping of functions is responsible for the overall configuration control of the serial bus. It controls the serial bus in the form of optimizing arbitration timing, guarantee of adequate electrical power for all devices on the bus, assignment of which 1394 device is the cycle master, assignment of isochronous channel ID, and basic notification of errors. The bus management is built upon IEEE 1212 standard register architecture.

Benefits of IEEE 1394

- Broad industry and standards bodies support
- Low cost
- High and scalable speeds
- Plug and play
- Nonproprietary.

IEEE 1394 is an enabling technology for connecting multimedia devices, such as:

- Digital camcorders and VCRs
- Satellite modems
- Set-top boxes
- Digital TV
- PCs
- DVD players
- Gaming consoles
- Home theater
- Musical synthesizers/samplers with digital audio capabilities
  - Digital audio tape (DAT) recorders
  - Mixers
  - Hard-disk recorders
- Video editors.

HAVi Backgrounder

HAVi (Home Audio/Video interoperability) is an industry initiative started by Sony and Philips in 1996. Since then six other companies have joined – Thomson, Hitachi, Toshiba, Matsushita, Sharp, and Grundig. HAVi adopted the IEEE1394 bus standard as the underlying network technology for the HAVi protocols and for the transport of real-time audio/video (A/V) streams. Using 1394 as the bus standard (shown in Figure 2) provides benefits, such as high-speed, flexible connectivity, and the ability to link up to 63 appliances together. No other interconnection technologies, such as wireless, HomePlug™, HomePNA, and USB, are capable of distributing high-speed video applications.

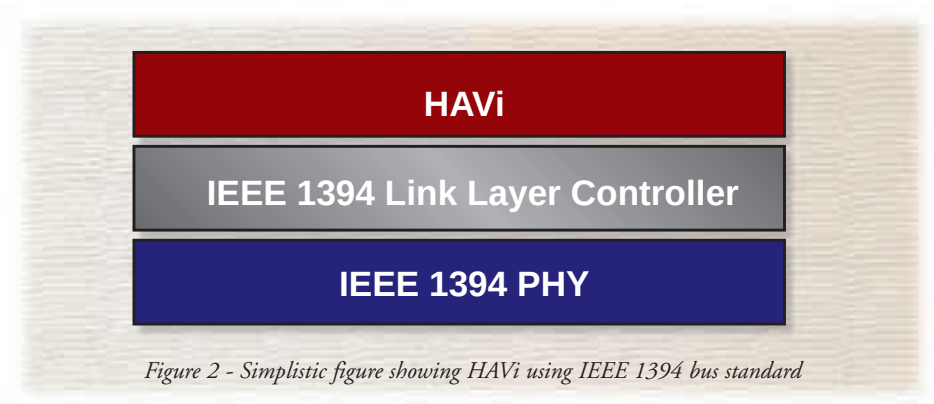

Figure 2 - Simplistic figure showing HAVi using IEEE 1394 bus standard

The HAVi middleware architecture is an open (nonproprietary), lightweight, and platform-independent specification that allows development of home networking applications. It does not, however, address home networking functions such as controlling the lights or monitoring the climate within the house. HAVi specifically focuses on the transfer of digital A/V content between in-home digital appliances, as well as the processing (rendering, recording, and playback) of this content by HAVi-enabled appliances.

The HAVi middleware system is independent of any particular operating system or CPU and can be implemented on a range of hardware platforms, including digital products such as cable modems, set-top boxes, integrated TVs, Internet TVs, or intelligent storage appliances for A/V content.

Today in the world of analog consumer electronic appliances, there exist a number of proprietary solutions for interoperability among appliances from one brand or vendor. In the upcoming world of digital technologies, HAVi extends this networking model by allowing communication among consumer electronic appliances from multiple brands in the home. The HAVi middleware architecture specifies a set of APIs (application programming interfaces) that allow consumer electronic manufacturers and software engineering companies to develop applications for IEEE 1394-based home networks.

One of the main reasons HAVi selected IEEE 1394 over other transmission protocols is because of its support for isochronous communications. HAVi comprises software elements that facilitate the interoperability among different brands of entertainment appliances within the house. Interoperability is an industry term that refers to the ability of an application running on an in-home appliance to detect and use the functionality of other appliances that are connected to the home network.

The underlying structure for a home network based on HAVi technologies is a peer-to-peer network, where all appliances can talk to and interact with each other. HAVi has been designed to allow the incremental addition of new appliances, which will most likely result in a number of interconnected clusters of appliances. Typically, there will be several clusters of networks in the home, with one per floor or per room. Over time these clusters will be connected with technologies such as 1394 long or wireless 1394.

Benefits of HAVi

A HAVi-compliant appliance offers a number of advantages, which include:

- Automatic detection
- Automatic registration of added appliance to the HAVi network
- Automatic software upgrades
- Manageability
- Brand independence
- Hot plug-and-play
- Legacy appliance support.

Xilinx Programmable Solutions Enable IEEE 1394/HAVi Products

The IEEE 1394 technology consists of a physical layer for encoding-decoding, arbitration, a medium interface, and provides an electrical signal and mechanical interface. The link layer provides cycle control, packet transmits, packet receives, CRC, and provides the host and application interface.

As shown in Figure 3, programmable logic solutions provide complete link layer functionality with the ability to connect to multiple interfaces such as PCI, USB, and proprietary audio-video buses. The advantage of programmability is realized when there is a proprietary application interface. However, in an IEEE 1394 system, the Spartan™-II FPGA provides system interface and other ASSP functionalities.

With the 1394 specification still continuing to evolve, having the link layer controller programmed in a FPGA provides the ability to reprogram the FPGA with the latest 1394 revision.

Supporting different products requires the support and interface to different interfaces. For example, using 1394 in a PC requires an interface to PCI, PCMCIA, and other proprietary interfaces. Programmable solutions are ideal for providing this interface, because developing ASSPs for these applications is relatively expensive. Also, the decreasing cost of programmable logic solutions makes them ideal for IEEE 1394 and HAVi-based products.

Conclusion

The digital home continues to evolve and smarter appliances continue to populate the home. These smarter appliances and the need for sharing broadband data, voice, and video are pushing the need for home networking. Although several technologies exist, the technology that provides high-speed and reliable delivery of voice, data, and video will win.

IEEE 1394 is one such home networking technology that provides both high-speed and reliable delivery. The proliferation of 1394 as the A/V standard will be accelerated through the use of HAVi as its middleware solution to connect disparate devices, thus providing a complete solution to the consumer.

However, the specification continues to evolve and 1394 products need to coexist with other home networking and system interface technologies, thus requiring products that interface between these technologies. With the continuing reduction in prices of programmable logic solutions, these are ideal solutions to provide interfaces between 1394 and other technologies such as PCI, USB, PCI-X, SCSI, and HomePNA.

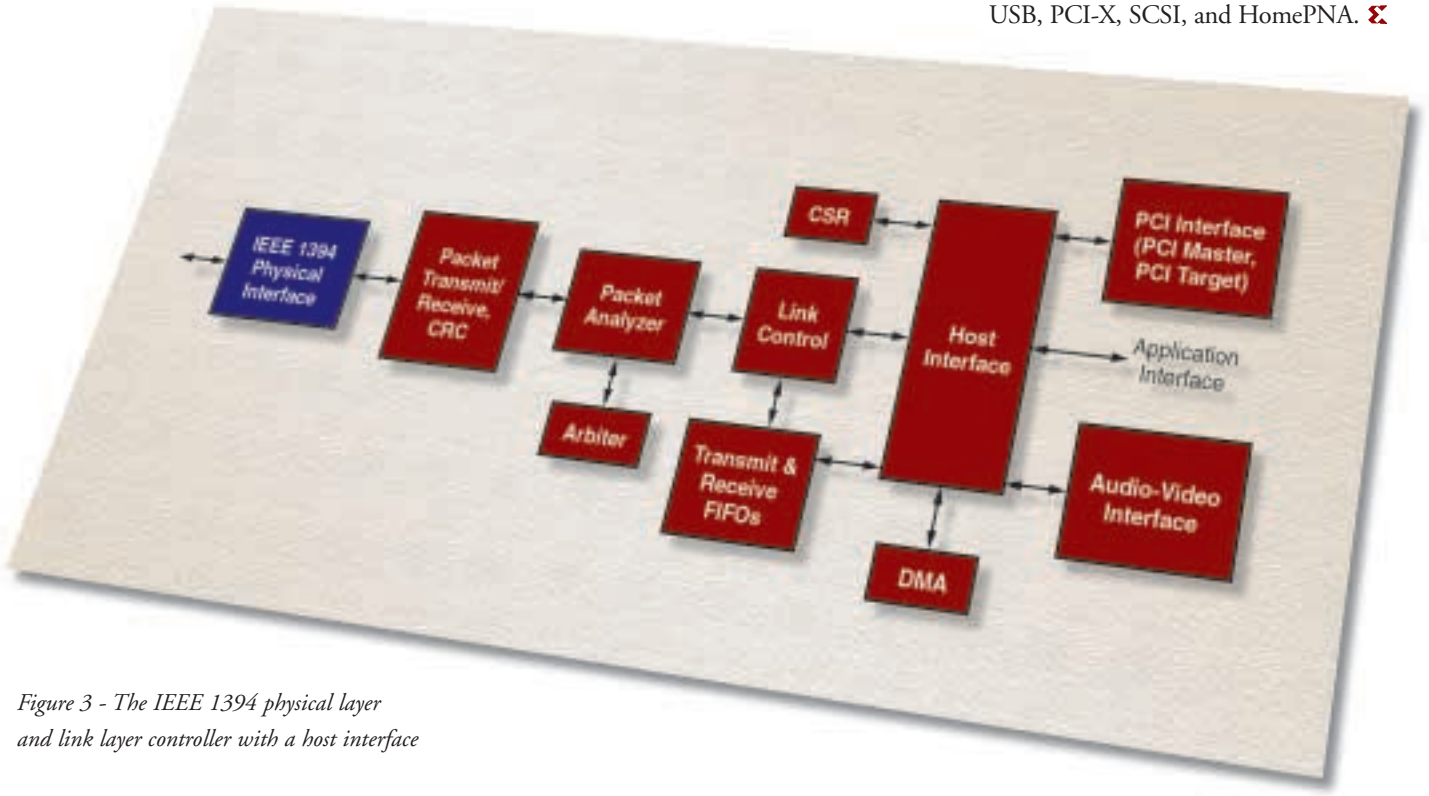

Figure 3 - The IEEE 1394 physical layer and link layer controller with a host interface