# TECHNICAL BACKGROUND

# HAVi,
# the A/V digital network
# revolution

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## HAVi and Home Networking

HAVi (Home Audio Video interoperability) provides a home networking standard for seamless interoperability between digital audio and video consumer devices. In other words, all audio and video appliances within the network will interact with each other and allow functions on one or more appliances to be controlled from another appliance, regardless of the network configuration and appliance manufacturer.

The spirit of HAVi is to extend the capabilities of consumer audio and video systems while decreasing the complexities of their operation. It is expected that HAVi will become the de facto standard for high quality A/V networks

HAVi will provide for a home network, which is optimised for audio and video devices .

The main reason for having a dedicated HAVi network for the audio and video devices is that for the exchange of high quality digital video and high fidelity audio signals, a much higher bandwidth is necessary than can be provided by other home networks that are optimized e.g. to control home devices such as lighting, heating, air-conditioning, cooking appliances, etc. The possibility to integrate other home networks such as existing analog links, telephone lines or new wireless technologies into the HAVi network, was built into the HAVi architecture from the beginning and bridges to these networks are likely to be developed in the future.

HAVi is an initiative from eight major Consumer Electronics companies. The eight CE companies are Grundig AG, Hitachi, Ltd., Matsushita Electrical Industrial Co., Ltd. (Panasonic), Royal Philips Electronics, Sharp Corp., Sony Corp., Thomson Multimedia and Toshiba Corp.

## HAVi Principles of Operation

HAVi provides an environment for audio and video devices to interoperate with each other, irrespective of the actual brands or their HAVi implementation. The HAVi architecture is open, scaleable in implementation complexity, platform-independent and language neutral, i.e. HAVi can be implemented in any programming language and on any CPU or real-time operating system. It provides CE manufacturers the freedom to develop interoperable devices while additionally, application developers can write Java applications for these devices using the open Interoperability API that HAVi provides.

Current CE devices, such as Digital STBs and DV camcorders, contain sophisticated digital processing and storage systems. Future devices will contain even more sophisticated resources. By connecting these devices into the HAVi network it is possible to share their resources and use these to build up more sophisticated applications, such as having two VCRs connected to two tuners with either VCR able to record the signal from either tuner.

Under the HAVi system there is no single master controlling device: any device in the HAVi network that has been designed to do so can control other devices. Both the controlling devices and the controlled devices can be located anywhere within the HAVi network. HAVi also allows a device to be a controlling device and a controlled device at the same time.

The benefit of a network of interoperable devices is that the whole is greater than the sum of all the components. For example, the time and program channels of a video recorder could be set by the information received by the television tuner. The user can now program a recording on a VCR following a menu generated by the TV on the TV screen. Even one step further, HAVi allows the TV to generate a complete menu structure to interact with any HAVi device or a combination of devices in the network, using ONLY the TV's remote control, and present the system in a consistent way to the user. This will significantly improve the user-friendliness of the system. In the same example, if the VCR is also a controlling device, it could detect at recording time that the original tuner is not available e.g. because it is already in use by someone else. It could try to resolve this situation by trying to find another

tuner in the system or to negotiate with the other user to release the original tuner to the VCR.

In order to be able to handle both commands and multiple digital audio and video streams, HAVi uses the digital IEEE-1394 network, a standard which enjoys broad support from both the CE and IT industries. IEEE-1394 currently provides a bandwidth of up to 400 Mb/s and is capable of isochronous communication which makes it suitable to simultaneously handle multiple real-time digital AV streams. Longer transmission distances under the IEEE 1394 standard are near to completion and will allow the IEEE-1394 network to span multiple rooms in a home.

## HAVi in operation

HAVi is a distributed software architecture, the software elements of which implement basic services such as network management, device abstraction, inter-device communication and device user interface management. Collectively, these software elements together expose the HAVi Interoperability API, a set of services for building portable distributed applications on the network. Software elements on different HAVi devices communicate with each other via HAVi defined protocols to offer the desired service and the Interoperability API. The software elements on a HAVi device are implemented on top of a device- and vendor specific platform, such as a real-time operating system. Applications (which are software elements themselves) can then access these APIs transparently across the network.
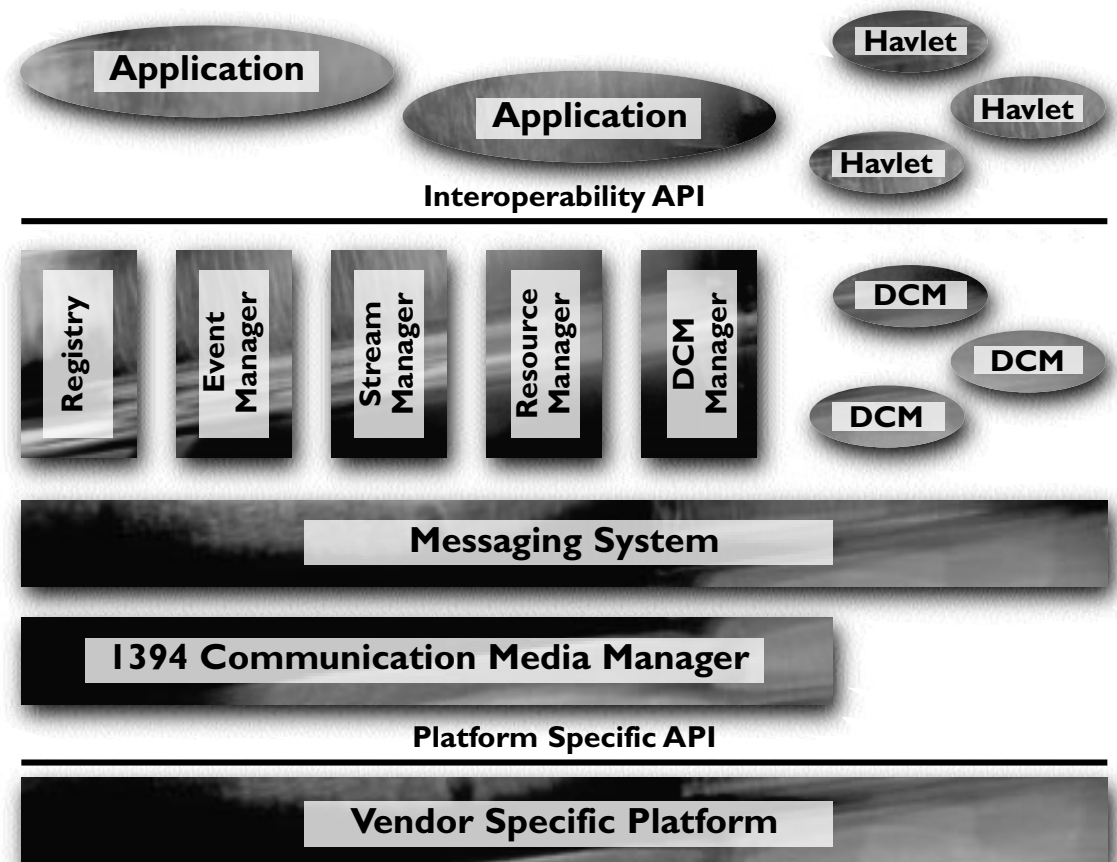
The diagram depicts the HAVi software elements on a HAVi device and highlights how they form a middle layer between platform specific APIs and platform independent applications.

The software elements comprising the HAVi architecture are:

- 1394 Communication Media Manager, which allows other elements to perform asynchronous and isochronous communication over the IEEE-1394 network.
- Messaging System, which is responsible for passing messages between the HAVi software elements.
- Registry, which serves as a directory service, allowing any software element to locate other software elements on the network and detect its capabilities and properties.
- Event Manager, which serves as an event delivery service. Events are changes in state of the HAVi software elements or the HAVi network configuration.
- Stream Manager, which is responsible for managing real-time transfer of AV streams between functional components.
- Resource Manager, which facilitates sharing of resources and scheduling of actions.
- DCM (Device Control Module), a software element that represents a single device on the HAVi network and exposes the HAVi defined APIs for that device. DCMs are dynamic in nature: if a device is inserted or removed from the network, a DCM for that device needs to be installed or removed respectively in the network. DCMs are central to the HAVi concept and the source of flexibility in accommodating new devices and features into the HAVi network.
- FCM (Functional Component Module). Contained within a DCM are the Functional Component Modules (FCMs) for each controllable function within the device. Which FCMs are present in a DCM depends of course on the device in question and is decided by the manufacturer. Currently HAVi defines FCMs and corresponding APIs for functions like a tuner, VCR, disc based storage, AV display, camera, modem. In the future it can be expected that new FCMs will be defined for HAVi.
- DCM Manager, which is responsible for installing and removing DCMs.
- Applications. Applications need to make themselves known in the HAVi network as a software element to enable communication with other software elements such as the Registry or DCMs but also other applications.

In addition to the Software Elements described above, HAVi contains some special software elements that serve to create User Interfaces on remote display devices. Having this facility is one of the key features of HAVi and allows a user to access vendor-specific device features, for example, or to interact with new DCMs which are added later on to the HAVi specification and installed in an existing system in which the applications do not know what the new DCM is capable of doing.

- DDI (Data Driven Interaction). This is not a software element but only a protocol that is executed between Applications or DCMs whose User Interface needs to be displayed on one side and a display device on the other.
- Havlet. Havlets are Java applications that can be extracted from a DCM or an Application on request of a display device. They are executed on a Java enabled display device and can draw a User Interface on behalf of that DCM or Application by means of a Java Graphical User Interface API (GUI).

All HAVi software elements communicate using a message passing mechanism. Although the actual implementation of the message passing mechanism can differ from device to device and between brands, the format of HAVi messages and the protocol used for their delivery, are fully specified by HAVi to ensure interoperability.

## Inter-relationships between HAVi and other 'Networking' standards

The inter-relationships between HAVi and other networking standards is examined from the audio/video point of view and, in particular, their applicability to handling digital AV signals as HAVi networks are aimed to do. HAVi

regards inter-relationship as an important aspect and aims to build bridges with other networking standards when it offers the consumer additional benefits.

The *Internet* and its protocols and services are likely to be the source of an ever increasing amount of AV content and services that users want to access via CE devices at home. HAVi defines an FCM with APIs that allow HAVi applications to take part in widely used Internet protocols such as HTTP, FTP, POP3, etc. It is the manufacturer's choice whether or not to implement this FCM in a DCM for a particular HAVi device but. a Web-TV, for example, is likely to do so.

*HAVi and Jini Network Architectures*
In January 1999 it was announced that a bridge would be built between the HAVi architecture and Sun Microsystems' Jini technology. The aim is to provide a solution bridging HAVi compliant audio-video devices in the home e.g. to services provided outside the home over the Internet by Jini technology.

Co-operation between Philips, Sony and Sun Microsystems focuses on the creation of a bridge allowing HAVi compliant products and Jini technology compliant products to communicate and interact. This will allow users to operate HAVi devices in their homes from remote or mobile locations and also allow HAVi devices in the home to access a wide variety of Jini-based digital network services. HAVi and Jini complement each other in providing an open interoperability between audio-video devices and services.

*Home API* is a Windows set of programming interfaces on a PC enabling PC applications to discover and control home devices such as TVs, VCRs, lights, security systems, thermostats, ovens, etc. To implement these APIs over a real network requires a protocol stack such as HAVi over IEEE-1394. These protocols and networks are not specified by Home API itself. Home API is used for general home control devices including AV devices. HAVi and IEEE-1394 may therefore well be used as one of the protocol stacks on a PC for Home API. At the same time other Home API devices, possibly on other networks, can be represented as DCMs running on the PC on top of the *Home API* interfaces. Such a HAVi – Home API bridge would allow Home API applications to control a HAVi VCR, for example, while HAVi applications could control a thermostat.

*Universal Plug and Play* is Microsoft's initiative for using Internet based protocols in the home network for service discovery and automatic network and device configuration. Bridges will be built between HAVi and Universal Plug and Play offering similar features to the HAVi – Home API bridge.

*Bluetooth* is a technology specification for small form factor, low-cost, short and medium-range 1 Mb/s radio links between mobile PCs, mobile phones and other portable devices. Bluetooth enjoys, just like HAVi, strong industry support.

*Home RF* is an open industry specification for wireless digital communication between PCs and consumer electronic devices anywhere in and around the home. It currently has a bandwidth of maximum 2 Mb/s.

A Bluetooth or Home RF device used as an AV display can be controlled as an LAV device provided there is an IAV or FAV in the HAVi network that has a Bluetooth or Home RF interface and that can install a DCM for it. Although today only limited quality digital video can be transmitted over these links it can be expected that such IAVs or FAVs will be developed.

The eight HAVi companies are actively promoting the HAVi specification to the DVB, ARIB, DAVIC and other Home networking organizations as a widely supported industry standard for in-home networks.

## The Benefits of HAVi

HAVi, being promoted by the CE companies responsible for the major market share in the world, will make its impact on the CE audio-video market in a relatively short time. It is expected that in order for their products to be able to be connected into a HAVi network, other CE device manufacturers will obtain a licence to manufacture HAVi compliant devices. This will increase the choice for the consumer. There is already a large installed base of CE devices incorporating the IEEE-1394 interface which can be integrated into a HAVi network as an LAV device.

HAVi is an open standard, providing compatibility and interoperability between multi-brand AV devices. This provides consumers with a wide choice when designing their personalised audio-video systems, without sacrificing functionality. In fact, utilisation of the HAVi architecture increases the functionality of the network and of individual devices.

The digital evolution of video systems in particular is just taking off, enabling CE manufacturers to take the initiative and implement the HAVi software elements and interfaces in new products. Legacy devices can also form part of the network. Because no one device is the master HAVi-controller of the network and the capability to handle new devices as well as non-standard device features was designed into HAVi from the beginning, the network can evolve as new products are introduced giving the user automatic access to this new functionality.

As Java is becoming the major language for the development of interactive networked applications on the Internet as well as in digital broadcasting, its support in HAVi will greatly benefit the user in getting access to interesting applications that will exploit the benefits of his HAVi network at home.

## HAVi in practice

In a HAVi architecture all devices share the resources available within the network. The user does not have to know from where the functionality is provided, only that it is available. To access or make use of a particular function, the user only has to access the user interface of the function, which may be presented remotely from the actual device supplying the function. A common presentation medium will be the TV screen, with the function presented as a simple menu and stepped through using ONLY the TV's remote control.

A simple example to illustrate the ease of use is the setting of a VCR to make a recording. Today, the VCR has to have a number of settings made before a recording can be started. It has to be set to the desired channel and the recording has to be started or a time set for a later start time and the length of recording. But what if the VCR is
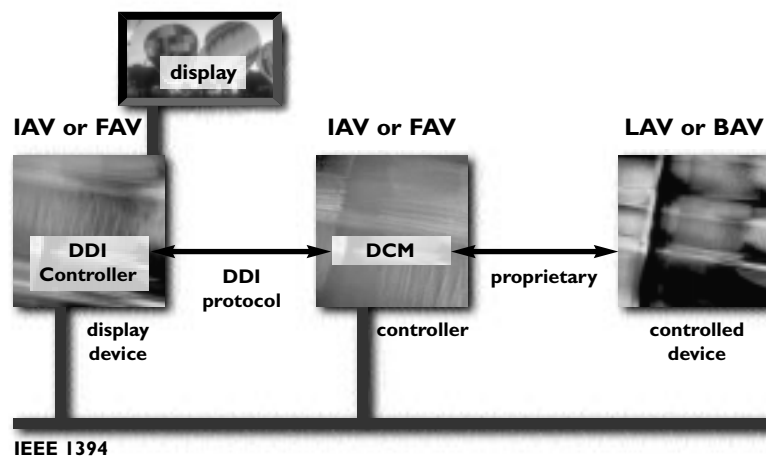


**IAV or FAV as display device**

in a different room and the user wants to make a recording immediately of something being shown on TV? With HAVi, this is no problem. All it takes is an entry of the 'record' command using the remote control on the TV in the room where the user is located and all the necessary actions are taken by the HAVi system.

In this example, the TV automatically programs the VCR using data obtained from the Electronic Program Guide received by the TV. The VCR automatically sets and updates its own time based on the clock of the TV, which is set by a satellite receiver or other broadcast source. If the VCR is disconnected, the network will notice this and inform the user that programmed recordings are no longer possible. It can also search the network to find another connected and available VCR and use that one instead, thereby transparently delivering the functionality originally requested by the user, even though changes took place in the network configuration.

## HAVi Status

*The HAVi 1.0 specification*
The HAVi v1.0 beta specification was published in December 1998 and was made available on the net at www.havi.org for evaluation purposes. The specifications have now been verified and approved. This verification took place by prototype implementations and extensive interoperability testing by the eight companies that started the HAVi initiative.

The joint patent license program will start in the beginning of 2000 and covers both the use of the HAVi logo and HAVi patents, with Philips acting as the licensing contact.
The HAVi Organization, with the aim of promoting HAVi and supporting contacts between HAVi supporters, started in November 1999 and is open to companies and non-profit organizations. Details are available on request from the address mentioned on the front page of this document or at www.HAVi.org.
Commercial products complying to the HAVi architecture will be available in the second half of 2000.