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# Home Networking Middleware

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## Summary

This white paper presents an overview of how home networking middleware supports the seamless convergence of broadcast and home network applications. The fusion between both of these technologies facilitates the deployment of a range of new entertainment services within the home. The OSGi specification provides a common foundation for ISPs, network operators, and equipment manufacturers to deliver a wide range of e-services via gateway servers running in the home or remote office.

This white paper describes OSGi within the context of a home networking environment. It is a distributed, open networking architecture providing pervasive and peer-to-peer network connectivity to PCs, intelligent appliances, and wireless appliances. UPnP leverages Internet and Web components (like IP, TCP, UDP, HTTP, and XML) and enables seamless proximity networking in addition to control and data transfer among networked appliances in the home, office, and everywhere else.


## Introduction

Broken down to its simplest form, home networking middleware is a layer of software that lies on top of an information appliance operating system. It provides “hooks” or APIs to which home networking applications can be attached. Analysts are forecasting that the market for home networking middleware will be worth several billion dollars in a couple of years time. To capitalize on this opportunity, a number of consortiums have been established to deliver products into this new and evolving marketplace. Current initiatives include OSGi, UpnP, Jini, HAVi, VESA, Interactive TV software providers, DVB, and OpenCable.

## Introduction to Home Networking Middleware

Consumer electronic appliances such as set-top boxes, PVRs, and DVD players are sophisticated and expensive digital processing systems. By connecting these information appliances to home networks, it is possible to share processing and storage resources between members of the family. Central to the fabric of all home networks is a software system called “middleware”. This software system allows connected information appliances to exchange both control information and streaming multimedia content. Middleware is a relatively new term in the home networking business. If we compare it to an IT environment, it equates to the presentation layer of the OSI (Open Systems Interconnect) seven layer model.

> **Note:** OSI is a networking framework that defines a set of protocols for implementing communications between two information appliances.

Middleware is used to isolate application programs from the details of the underlying hardware and network components. In the world of home networking, we encounter many types of hardware information appliances from different manufacturers. To provide interoperability between these diverse systems, a number of home networking middleware applications have evolved. The key middleware products are OSGi, UPnP, Jini, VESA, HAVi, OpenCable, and DVB.

## OSGi

The Open Services Gateway Initiative (OSGi) was started in March 1999 to standardize efforts in connecting a wide array of information appliances to the residential gateway. It is a group of over 60 companies led by giants such as Ericsson, Cisco, Nokia, Siemens, Sun Microsystems, Motorola, IBM, Nortel, Philips, Oracle, Alcatel, Lucent, Toshiba, Texas Instruments, and more. The OSGi middleware specifications deliver an open, common architecture for service providers, system developers, software vendors, information appliance vendors, and

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equipment manufacturers to easily develop, deploy, and manage multiple services in a coordinated fashion.

## OSGi Architectural Framework

The OSGi architecture is based on requirements from several new markets. The major identified components of the complete end-to-end OSGi framework model include:

- **Services gateway:** The central component of the OSGi end-to-end framework is the services gateway. The services gateway enables, consolidates, and manages multimedia communications to and from the home and office networks. The services gateway can also function as an application server for a range of high-value services such as energy management and control, safety and security services, health care monitoring services, information appliance control and maintenance, electronic commerce services, and more.

  **Note:** Service gateways used to connect home networks to the public Internet are commonly called residential gateways.
- **Service provider:** Within a home networking environment, the service provider provides a range of services to consumers. From a technical perspective, the delivery of such services is enabled through the download of a software application into the residential gateway.
- **Service aggregator:** As this computing paradigm evolves, OSGi is expecting to see the creation of new types of service providers who will offer a set of services (for example, automatic reading of electricity, gas, and water meters) bundled together.
- **Gateway operator:** The main responsibility of this OSGi entity is to manage and maintain the residential gateway and its services. Functions of a typical gateway operator range from starting, stopping, updating, and removing services to managing the status of the residential gateway.
- **Wide area network and Carrier/ISP:** The wide area network provides the necessary communications between the service gateway, the gateway operator, the service aggregator, and the service provider. This communication platform is provided and managed by a telecommunications carrier or, when the wide area network is the Internet, by an Internet Service Provider (ISP).
- **Information appliances and networks:** The last major piece of the OSGi framework is the local home network and information appliances attached to the services gateway.

The relationship between the major components are illustrated in Figure 1.

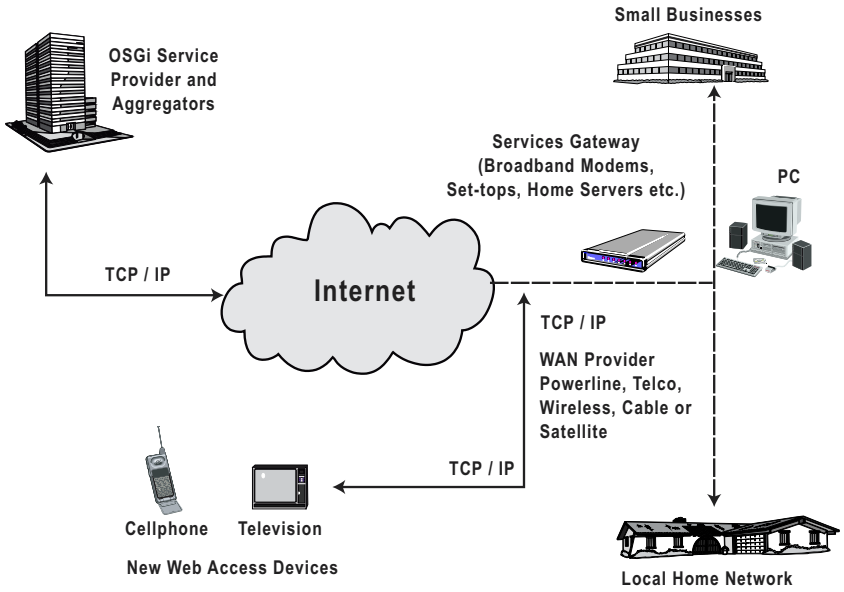


*Figure 1:* **OSGi Architectural Framework**

## Middleware Anatomy (OSGi)

The major technical effort in the first release of the OSGi specification is on the Application Programming Interfaces (APIs) implemented on the gateway. OSGi is an open standard that enables multiple software services to be installed and operate on a services gateway such as a set-top box, cable modem, DSL modem, PC, or dedicated residential gateway. It is focussed on the residential gateway with the software environment based on Sun's Java virtual machine.

The decision by OSGi to use Java as their core technology gives service providers, network operators, and appliance manufacturers a vendor neutral application and information appliance layer APIs and functions. One of the main benefits of Java is that it is an open technology that can run on multiple platforms including residential gateways, consumer electronics equipment, household appliances, communications appliances, computers, and more. Technically, the services gateway is an embedded server that is attached to the broadband access network to connect external service providers to information appliances that are connected to an in-home network.

In addition to supporting a Java Virtual Machine, OSGi-based gateways also include an information appliance access manager and a method of logging activity details. To gain a better understanding of the gateway middleware anatomy, let's take a closer look at the Java embedded server product from Sun Microsystems that complies with the OSGi specification.

## Java Embedded Server (JES)

Targeted at the exploding home networking market, JES is a small footprint software framework that runs in a residential gateway, providing service providers with the ability to deliver managed services to the networked home on-demand. From a technical perspective, JES consists of two primary components: a service space framework and a number of modular in home application services that are executed within this framework.

Originally developed by Sun Microsystems, this service framework allows programmers to write Java-based in-home applications as independent components that can be managed independently of one another and can be dynamically added, removed, executed or updated from within a running application. Home applications that run in the Java Embedded Server are called *application services*. The Java Embedded Server comes with a set of pre-built services that address a variety of common requirements for networked homes.

## Benefits of OSGi

The main benefit of having such an organization developing APIs for residential gateways include:

- **Platform neutrality:** They produce middleware, which is platform independent. In other words, the OSGi software can be implemented on different types of residential gateways.
- **Security:** The OSGi specification offers several levels of system security allowing digital signing of downloaded e-services and object access control.
- **Multiple service capabilities:** Also the middleware provides the ability to host multiple services. By providing a single gateway platform, the gateway can become a service integration and management point in the residence, while a set of Java-based APIs provide value added services.
- **Support for an array of home networking technologies:** The OSGi specification provides the ability to support multiple local network technologies such as wired and wireless, data, and audio-video transport standards that are emerging.

# UPnP

The Universal Plug and Play (UPnP) forum is an industry initiative designed to enable easy and robust connectivity among standalone information appliances and PCs from different manufacturers.

UPnP uses open Internet communication standards to transparently connect consumer electronic information appliances to standard PCs. UPnP makes it possible to initiate and

control the transfer of files and A/V streams from any information appliance on the in-home network. UPnP is an extension to the plug and play initiative that was introduced by Intel, Compaq, and Microsoft back in 1992. It defines a set of common interfaces that allows you to plug an information appliance directly into the in-home network. In other words, you can begin using a new information appliance without worrying about configuration settings and installing new drivers. A high-level overview of the software architecture of UPnP is illustrated in Figure 2.

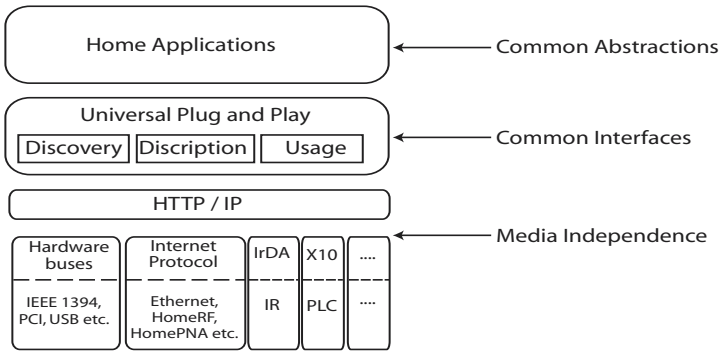


*Figure 2:* **UPnP High-Level Architecture**

UPnP was developed within the context of existing industry standards. For instance, UPnP provides developers with a common set of interfaces for accessing services on a home network. Another advantage of UPnP middleware is its independence of the physical network media in the home. It is compatible with existing networks, such as standard 10BaseT Ethernet and new networking technologies that don't require costly installation of new wiring systems in existing homes—HomePNA and HomeRF.

Rather than concentrating on one particular information appliance type, UPnP interconnects all types of information appliances in the home, including: PCs, PC peripherals, new smart home appliances, residential gateways, home control systems, and Web connectable appliances. The result of this pragmatic and relatively simple approach from Microsoft is that implementing UPnP in the home network requires very little work and human intervention. UPnP is equally adaptable to both dynamic home environments and fixed, configured corporate networks.

## Middleware Anatomy

The foundation blocks for the UPnP standard leverages a number of industry standards including:

- TCP/IP (Transmission Control Protocol/Internet Protocol)
- DNS (Domain Name System)
- HTTP (HyperText Transfer Protocol)
- HTML (Hypertext Markup Language)
- UDP (User Datagram Protocol)
- LDAP (Lightweight Directory Access Protocol)
- XML (eXtensible Markup Language)
- XSL (Extensible Stylesheet Language)
- ARP (Address Resolution Protocol)

A typical UPnP middleware environment comprises of the following logical components:

- **User control point:** A set of software modules that facilitates communication between itself and a number of controlled information appliances on a home network. Examples of information appliances that could function as a user control point include a standard PC, a digital set-top box, and high-speed broadband modems.
- **Controlled information appliance:** A set of software modules that facilitates communication with a user control point. The primary difference between a user control

point and a controlled information appliance is that the user control point is always the initiator of the communications session. Examples of information appliances that could function as a controlled information appliance include VCRs, DVD players, security systems, and automated light controllers.

- **Bridge:** A set of software modules that allows legacy information appliances to communicate with native UPnP information appliances.
- **Legacy information appliance:** Any non-UPnP compliant information appliance.
- **Bridged information appliance:** An information appliance that cannot participate in UPnP at the native protocol level, either because the information appliance does not have sufficient hardware resources or because the underlying media is unsuitable to run TCP and HTTP protocols. Examples of information appliances that could be bridged information appliances are powerline controlled A/V equipment, light switches, thermostats, wristwatches, and inexpensive toys.

## Plugging a New Appliance into a UPnP-Based Home Network

When a new appliance is connected to a UPnP based home network, a process called discovery is initiated. The first part of the discovery process takes place when an appliance connects into the home network. It sends out a small packet of data to other appliances on the network. The packet essentially says “I am here, I am a DVD player”, for example, “and you can reach me at this address”. The discovery process returns only the basic information needed to connect the appliance into the network. More detailed information about the home networking environment is provided to the appliance in the form of a schema. A schema is a structured data definition that defines a set of values about various services operational on the network.

## Benefits of UPnP

A UPnP compliant appliance can offer number of important advantages, including:

- **Open standards:** Relatively simple and open protocols, such as those that have been defined by the Internet Engineering Task Force (IETF), have a proven track record on the Internet. TCP/IP for instance, allows numerous different types of computing platforms to communicate reliably with each other. Because UPnP is based on standard Internet protocols, it can work with a broad range of information appliances, from large PCs to small consumer electronics information appliances.
- S**calability:** UPnP normally functions in small network environments, however, it is possible to scale upwards to larger networks.
- **Plug and Play:** Most home users want to just plug it in and have it work immediately with no hassles. UPnP is based on straight forward, innovative mechanisms for discovery and connectivity that provide a basis for enabling information appliance services.
- **Low footprint:** Unlike traditional PC-based solutions, consumer electronic appliances have radically less systems resources at hand. Typically, they are based on a low-cost microcontroller and 200-1000 KBytes of RAM and flash memory. Implementing Universal Plug and Play requires very little development work and requires only a very small amount of system resources and footprint.
- **Multi-vendor and mixed media environment:** Analysts are predicting that mixed-media, multi-vendor in-home networks will be a common scenario in the future. Consequentl,y UPnP has been explicitly designed to accommodate these environments. A typical home

networking environment is shown in Figure 3.

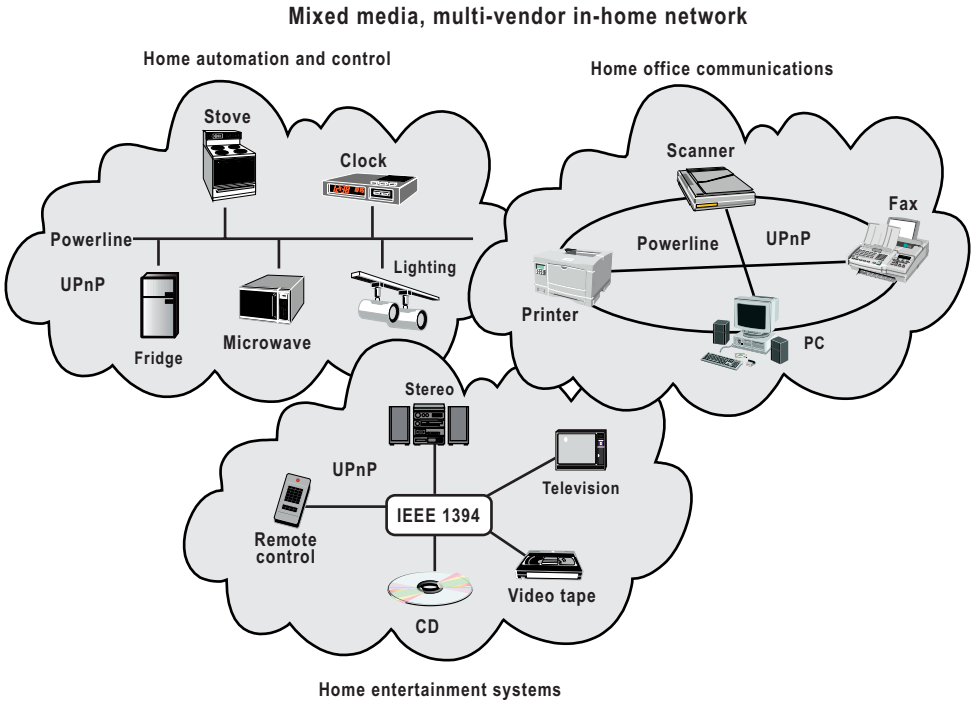


*Figure 3:* **Mixed Media, Multi-Vendor Home Network**

- **Smooth integration with legacy systems and non-IP information appliances:** Although IP inter-networking is a strong choice for Universal Plug and Play, it also accommodates home networks that run non-IP protocols such as IEEE 1394-based entertainment networks. The home network, for example, could use a Windows PC to host several different types of legacy information appliances and use the UPnP mechanism to make these information appliances discoverable to other peers on the network.
- **Non-PC-centric architecture:** The configuration of a UPnP based network can be based on a peer-to-peer network architecture, which means that the home network can function without a PC. This doesn't, however, mean that the PC has no role in a UPnP based network. The PCs general-purpose nature and substantial resources will make it a valuable part of any network where it is present.

## Jini Connection Technologies

Now that we have looked at Universal Plug and Play home networking technology, its time to review Sun Microsystems home networking middleware technologies—Jini. Jini is Sun Microsystems home networking software solution. It is a layer of Java software that allows information appliances to plug directly into a home network without the hassle of installing drivers and configuring operating systems. In some ways the history of Jini is the history of Java — Jini is really the fulfillment of the original Java vision of groups of consumer-orientated electronic information appliances interchanging information. This vision requires mechanisms that we don't typically associate with desktop computers including:

- The software infrastructure for these consumer and in-home appliances must be incredibly robust. Freezers and microwaves simply cannot fail with a message asking "Abort, Retry, or Ignore?".
- The information appliances connected to a home network have to support true, effortless "plug and play". In other words, "You" plug them in and they just work.
- Upgrades of software are also an important issue for home networking users if an IT professional needs to be called to upgrade all appliances on a home network, chances are

the appliances simply won't get upgraded.

The vision of legions of information appliances and software services working together simply and reliably, had been espoused by a number of researchers and computer industry leaders before. Mark Weiser of the Xerox Palo Alto Research Centre called this vision "ubiquitous computing." With this vision in mind, a group of software engineers at Sun Microsystems set out to provide a suite of technologies that realized Mark's vision—this project became known as Jini.

The name Jini was chosen by the creators of the system because it is energetic and easy-to-remember word that begins with "J" and has the same number of letters as "Java". The Jini project was being designed at Sun, hidden from public eyes, until 1999 when the technology was officially made available to the public with a host of licensees already on board. These partners today are building Jini enabled services and information appliances, including hard drives, digital cameras, handheld computers and much more. For its part, Sun is rapidly aligning behind Jini, in much the same way it aligned around Java back in 1995.

## Middleware Anatomy

Jini software can run on anything with a digital heartbeat—cellular phones, digital cameras, PDAs, alarms, televisions, and even smart cards.

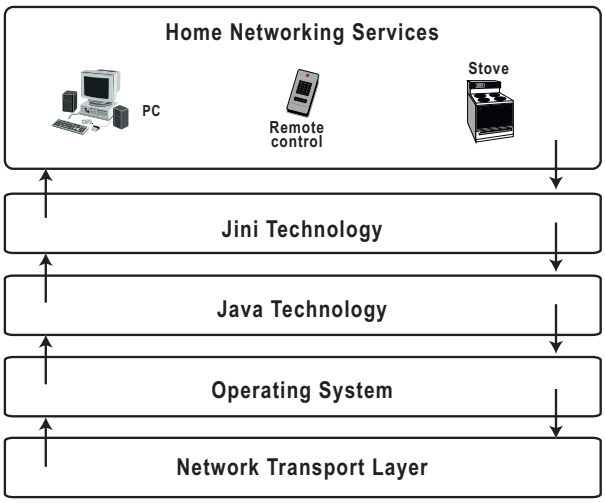


*Figure 4:* **Jini Software Architecture**

As illustrated in Figure 4, the Jini software is an infrastructure that runs on top of a Java platform to create a federation of virtual machines. Each virtual machine sits on top of an operating system that sits on top of the network. It is based on a simple model that information appliances with microchips should connect and work together in *communities*. A Jini community is a group of services on a home network that are available, both to each other and to the consuming applications. Each community on a home network has a unique name. The formation of these communities requires:

- No information appliance drivers
- No operating systems
- No new cabling systems
- And no human intervention

Each information appliance on the home network provides *services* that other information appliances in the community may use. These appliances provide their own interfaces, which ensures reliability and compatibility. Sun Microsystems is currently working with a number of manufacturers to integrate the Jini home networking technology into the next generation of

digital appliances. Jini technology uses a lookup service with which information appliances and services register.

## Plugging a New Appliance into a Jini-Based Home Network

Similar to UPnP when an appliance plugs in to the home network, it goes through an add-in protocol called discovery and join-in. The information appliance first locates the lookup service (discovery) and then uploads an object that implements all of its services' interfaces (join). For an information appliance to use a particular home networking service, it uses the lookup service to identify the resource. The service's object is copied from the lookup service to the requesting information appliance where it will be used. The lookup service acts as an intermediary to connect an appliance looking for a service with that service. Once the connection is made, the lookup service is not involved in any of the resulting interactions between that information appliance and that service.

In a Jini enabled home network there is no central repository of drivers, or anything else for that matter. The Java programming language is the key to making Jini technology work. Information appliances in a network employing Jini technology are tied together using Java Remote Method Invocation (RMI).

> **Note:** RMI is best described as a set of protocols being developed by Sun's JavaSoft division that enables Java objects to communicate remotely with other Java objects.

Jini technology not only defines a set of protocols for discovery, join, and lookup, but also a leasing and transaction mechanism to provide resilience in a dynamic networked environment.

## Jini Benefits

A HAVi compliant appliance can offer number of important advantages, including:

- **Reduced cost of ownership:** Self-managing appliances reduce further the need for expert help from IT professionals, and this lowers the total cost of ownership for Jini connection technology-based systems.
- **Ease of development:** Because Jini technology is based on the Java platform, any existing development tool that can be used for Java software development can be used for Jini software development. In addition, utility classes and implementations are being developed that will be freely available, which will ease the development of services and clients using Jini technology.
- **Small footprint:** The code required to implement Jini technology is so small that all types of home appliances can use it, from lamps and coffee makers to dishwashers and water heaters.
- **Appliance agnosticism:** Jini is agnostic with regard to appliances. What does this mean for users of home networks? Essentially it means that Jini is designed to support a wide variety of entities that can participate in a community. These "entities" may be appliances or software or some combination of both. If a hardware appliance is connected to a home network, Jini is flexible about how much computational power it needs to have. Jini can work with a full-blown multimedia computer capable of running multiple Java Virtual Machines and connecting with each other at gigabit speeds. It can also work with such appliances as PDAs and cell phones that may have only limited Java capabilities. In fact, Jini is actually designed to accommodate appliances that are so simple they may have small amounts or no computational intelligence—a light switch for instance.
- **Simplicity:** Jini technology is all about simplifying interactions with a home network. Sun has portrayed Jini as a simple way for appliances to find and use each other over a network. No configuration hassles or appliance drivers is one of Jini's principles. Jini technology will allow you to use the network as easily as using a phone.
- **Reliability:** Communities of Jini services are largely self-healing. This is a key property built into Jini from the ground up; Jini doesn't make the assumption that in-home networks are perfect, or that software never fails. Given time, the system will repair damage to itself.

## HAVi

HAVi (Home Audio/Video Interoperability) is a project that was started by Sony and Philips in 1996. Since then six other companies have joined—Thomson, Hitachi, Toshiba, Matsushita, Sharp, and Grundig. HAVi adopted the IEEE 1394 bus standard as the underlying network technology for the HAVi protocols as well as for the transport of the real-time audio/video (A/V) streams. IEEE 1394 is the interface of choice for digital audio and video. 1394 benefits include high speed, flexible connectivity, and the ability to link as many as 63 appliances together. No other interconnection technologies such as wireless, HomePlug, HomePNA, and USB are capable of distributing high-speed video applications. The HAVi middleware architecture is an open, lightweight, and platform independent specification that allows developers to write home networking applications. It specifically focuses on the transfer of digital audio/video content between in-home digital appliances as well as the processing (rendering, recording, and play back) of this content by HAVi enabled appliances. It does not, however, address home networking functions such as controlling your lights or monitoring the climate within the house.

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 AV content.

Today in the world of analog consumer electronic appliances, there exists a number of proprietary solutions for interoperability between appliances from one brand or vendor. In the upcoming world of digital technologies, HAVi extends this networking model by allowing communication between consumer electronic appliances from multiple brands in the home.

### Middleware Anatomy (HAVi)

The HAVi middleware architecture specifies a set of APIs 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 *isonchronous* communications.

> **Note:** The term isochronous (iso meaning equal or identical and chronous meaning time) refers to the ability of 1394 to guarantee delivery of data packets at fixed intervals.

HAVi comprises of software elements that facilitate the interoperability between different brands of entertainment appliances within your home. 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.

Table 1 summarizes the functions of the various architectural software elements that are present in a HAVi based appliance.

*Table 1:* **Explanation of HAVi Software Elements**

| Software Element | Description |
|---|---|
| Communications Media Manager (CMM) | This software element allows appliances to communicate over a home network based on 1394 bus technologies. |
| Messaging System | The main responsibility of this software element includes the passing of messages between different appliances connected to the home network. |
| Event Manager | As the name implies, the event manager manages events and reports the details to “interested” software elements.<br>An event is best described as a change in the operational state of the home network. |

*Table 1:* **Explanation of HAVi Software Elements *(Continued)***

| Software Element | Description |
|---|---|
| Registry | The registry software acts as a directory service. It allows any software object to locate another software object on the home network. |
| Stream Manager | This element is responsible for managing real-time transfer of multimedia content between components on your home network |
| DCMs and FCMs | The Device Control Module (DCM) provides home networking applications with an interface to the physical appliance whereas the Functional Component Module (FCM) represents the functionality of an appliance. HAVi has defined the following FCMs: tuner, VCR, clock, camera, AV disc, amplifier, display, AV display, modem, web proxy, and converter. |
| Resource Manager | As the name implies this element manages the sharing and allocation of resources on the home network. |
| Havlet | In addition to the above software elements specified by the HAVi architecture, devices on the in-home network may also contain a number of havlets that are specific to a home networking environment. A havlet is typically a proprietary application that offers a user interface for controlling appliances. |

## Network Configuration and Appliance Classification

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.

> **Note:** The peer-to-peer network architecture eliminates the need to have a PC connected to the home network.

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 in your home, with one per floor or per room. Over time these clusters will be connected with technologies such as *1394 long* or wireless 1394.

> **Note:** As the name indicates 1394 long supports distances of up to 100 metres.

HAVi consumer electronic appliances can be categorized according to the degree to which they support the 1394 standard:

1. Non-1394 based appliances
2. Appliances that use 1394 but do not support the HAVi architecture
3. Appliances that use 1394 and support HAVi

Currently, most of the appliances that are in the home fall into the first category.

## Benefits of HAVi

A HAVi compliant appliance can offer a number of important advantages, including:

- **Automatic detection:** It can automatically detect other information appliances on your home network.
- **Automatic registration:** Each added appliance to the HAVi network is automatically registered so that other appliances know its capabilities. This level of functionality helps

other appliances utilize the useful resources of this appliance without a need to own the same resources themselves.

- **Automatic software upgrades:** Some HAVi compliant appliances are capable of installing new software on all appliances connected to the same home network. For instance, a HAVi Panasonic VCR can install the necessary application on a Sony TV in order to make two appliances interoperable. This reduces the need for network administration.
- **Manageability:** HAVi software takes advantage of the powerful resources of silicon chips built into modern audio and video appliances to give you the management function of a dedicated audio-video networking system.
- **Brand independence:** Entertainment products from different manufactures will communicate with each other when connected into a HAVi network. For example, a Panasonic VCR can work and share its resources with a Sony amplifier and be controlled by a Mitsubishi TV remote control as long as all of these devices are HAVi compliance.
- **Plug and Play capabilities:** Hot Plug and Play is another exciting feature that HAVi compliant appliances are equipped with. In other words, an appliance configures itself and integrates itself into the home network without user intervention.
- **Legacy appliances:** The HAVi architecture supports legacy appliances. This plays an important role since the transition to networked devices is going to be gradual and not very rapid. Manufacturers are not suddenly producing only networked appliances and consumers are not suddenly replacing their existing appliances.

## VESA

The Video Electronics Standards Association (VESA), started in 1995, develops interoperability standards for information appliances that connect to the Internet. In 1999, they released a draft home networking specification, making it possible for consumers to access information appliances, such as VCRs and security systems, easily and remotely.

The standard uses a long distance version of IEEE 1394 as the digital backbone and Internet Protocols (IP) for internetworking. External access networks such as telephone, cable TV, broadcast TV, and direct-broadcast satellite, interface with the VESA Home Network (VHN) via access devices such as residential gateways, xDSL modems, or cable modems.

### VESA Technical Overview

The VHN network architecture is shown in Figure 5.

The backbone network spans the whole house so those devices located on component networks anywhere in the house can communicate with each other. The backbone provides sufficient bandwidth and quality of service for the applications and devices that communicate over it.

The component networks enable devices connected to them to communicate with each other, perhaps over a relatively short distance, such as within a room. The choice of a component network is dictated by the communication needs and cost of the device. Examples of important component networks are IEEE 1394, Fast Ethernet, powerline CEBus, phoneline, and RF wireless LAN. An access-backbone interface connects an external access network to the home network. An access-component Interface provides a similar function for an access network to connect to a component network. A POTS modem, an ISDN adapter, a cable modem,

residential gateway, and a set-top box are all examples of devices containing access-component interfaces.

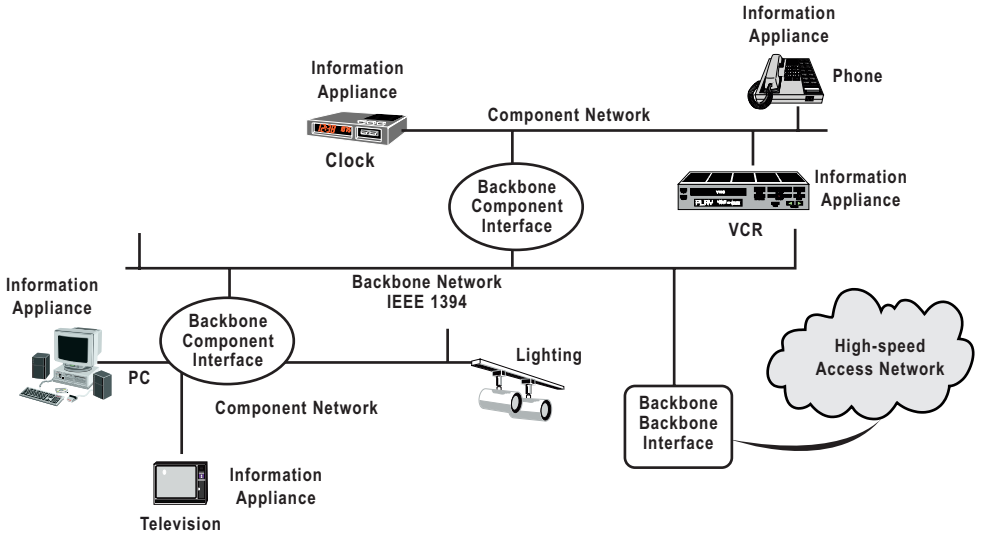


*Figure 5:* **VESA Home Network Architecture**

An information appliance is a digital device connected to a network whose purpose is to provide some utility (other than network service) to the end user. Examples of end devices are printers, TVs, audio speakers, security sensors, and HVAC controllers. A backbone-component interface connects a component network to the backbone network. Backbone-component interfaces may function as repeaters, bridges, or routers, and may be standalone, or embedded in an information appliance or PC.

## Interactive TV Middleware

With digital television becoming widespread, a number of cable and satellite communication companies are on the edge of promoting the adoption of home networking to their subscriber base. The move by cable TV companies towards the deployment of home networking services is expected to increase the demand for interactive TV middleware providers to start adding home networking functionality to their software. There are several interactive TV middleware systems that have been developed specifically for set-top boxes including:

### PowerTV

PowerTV provides an advanced set-top box operating system that includes an Internet-leveraged middleware platform with support for HTML, JavaScript, and PersonalJava. The company also provides a suite of Internet- based digital cable services such as e-mail, Web casting, and Web browsing. PowerTV is currently expanding the functionality of their middleware system by adding support for the USB standard.

The integration of USB will facilitate data exchange between set-top boxes and various types of home networking appliances. Equally as important, it will enable cable operators to generate additional revenue through highly personalized services tied to specific consumer devices, such as digital image uploads to a photo processing service, hard copy printing of e-mails, and web pages or audio clip downloads to MP3 players.

### OpenTV

OpenTV builds a complete software and infrastructure platform that enables digital interactive television and brings on-demand content to other digital communications devices in the home. OpenTV solutions include operating middleware, content applications, and a number of different content creation tools. OpenTV middleware has been shipped with or installed in more than 11 million digital set-top boxes worldwide.

### Liberate Technologies

Liberate Technologies is a provider of software platforms for delivering Internet-enhanced content and applications to information appliances, such as television set-top boxes and game consoles. Liberate's move into the home networking middleware market has been bolstered by a series of recent partnerships with consumer electronics companies.

### Microsoft TV

Microsoft TV is a suite of development software that provides the television industry with an end-to-end solution for bringing a host of new enhanced TV services to consumers the world over. Microsoft TV supports a range of TV devices—from current and next generation set-top boxes and digital video recorders, to integrated TVs and combination devices. Microsoft TV has been designed to support worldwide digital TV broadcast standards. It also supports commonly used Internet standards such as HTML, JavaScript, and Dynamic HTML, as well as all interactive content authored according to the Advanced Television Enhancement standard. Support for all of the standards outlined above allows Microsoft to seamless integrate their interactive TV software platform with the UPnP home networking middleware standard.

## DVB In-Home Digital Network

The DVB In-home Digital Network (IHDN) can be subdivided into a Home Access Network (HAN) for the connection to external networks and a Home Local Network (HLN) for interconnections of user equipment to clusters and between rooms. The architecture of a typical IHDN environment is shown in Figure 6.

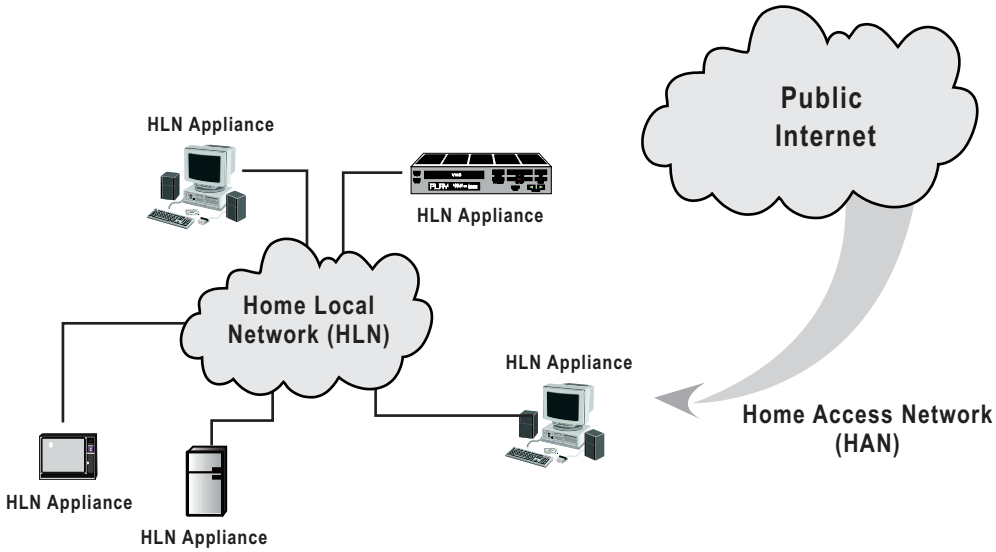


*Figure 6:* **DVB-IHDN Networking Model**

As part of the model shown in the diagram, DVB has defined a suite of software and middleware components for the HLN networking model.

This includes the specification of the APIs that an application on an HLN appliance can access in-home services provided by this appliance or any other HLN appliance, as well as a Java language binding for these APIs. The media gateway connected to the home access network fully supports the HAVi middleware software standard. This HLN specification also allows for multiple in-home applications to execute simultaneously on multiple HLN appliances.

## CableLabs In-Home Networking Project

Similar to DVB, CableLabs has also embarked on an exciting project to extend cable TV based services to network appliances within the home. At the time of writing this guide, CableLabs had established a dedicated team to work with technology vendors to develop a range of home networking interface standards.

## Conclusion

Jini is based on the concept that the appliance first locates the lookup service, which is termed as the discovery phase. It then uploads an object that implements all its services termed as ”join in”. Jini just like UPnP does not care about the OS or network. It is a technology brought about to allow OEMs to develop their products based on Jini without worrying about the network. The importance of the HAVi middleware software system cannot be exaggerated.

HAVi is a software standard that allows all types of digital consumer electronics and home appliances to communicate with each other. Most analysts agree that the combination of IEEE 1394 and HAVi is the best solution for distributing rich multimedia entertainment content around a home. The VESA Home Network specification allows consumers to connect together their disparate networks in the home, such as Ethernet, HomeRF, and other “no-new-wires” networks. The APIs used by the DVB networking standard allow in-home appliances to access a range of different Internet and home centric based applications.

## Revision History

The following table shows the revision history for this document.

| Date | Version | Revision |
|---|---|---|
| 03/21/01 | 1.0 | Initial Xilinx release. |