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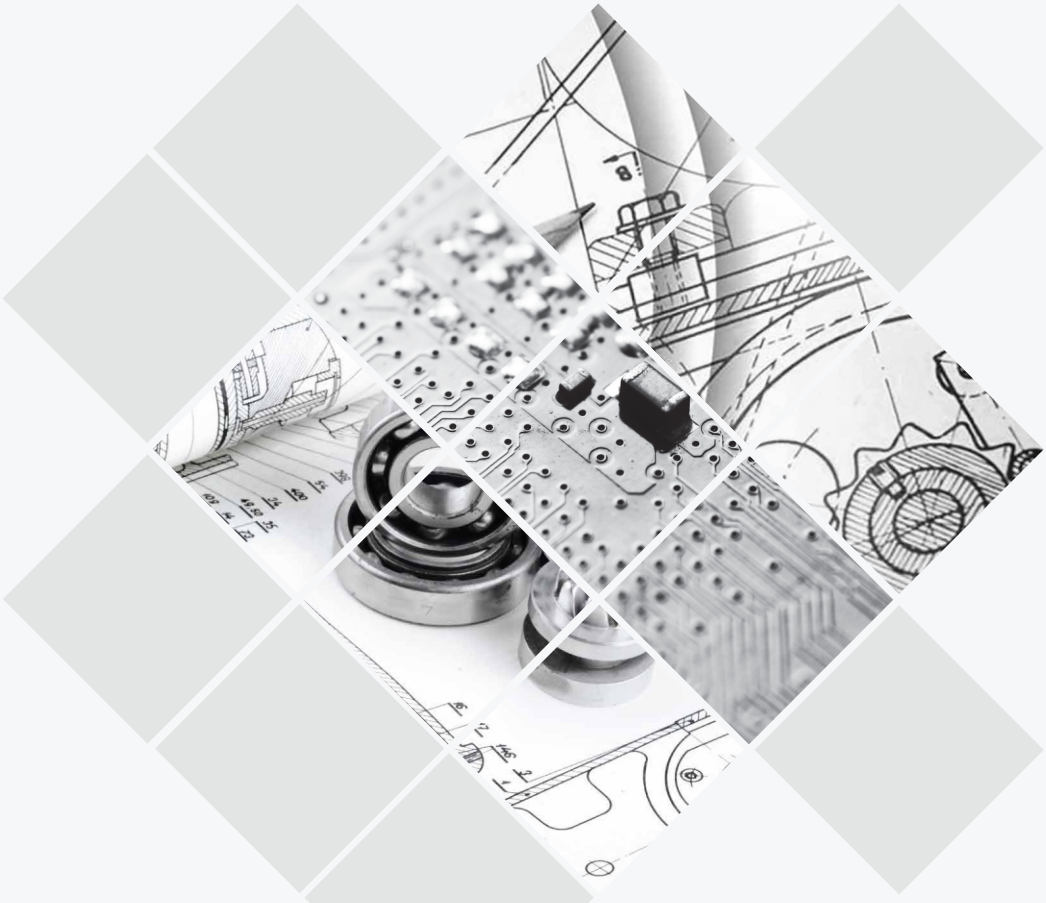
UPnP in digital home networking



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UPnP in Digital Home Networking

Abstract

This paper provides an overview of Universal Plug and Play (UPnP) and how it works to build a digital home network. UPnP network technology allows personal computer and consumer electronics devices to advertise and offer their services to network clients. UPnP can be viewed as the technological foundation of the digital home, enabling innovative usage models, higher levels of automation, and easier integration of devices from different manufacturers. UPnP technology is all about making home networking simple and affordable for users . UPnP architecture offers pervasive peer-to-peer network connectivity of PCs of all form factors, intelligent appliances, and wireless devices. UPnP architecture leverages TCP/IP and the Web to enable seamless proximity networking in addition to control and data transfer among networked devices in the home, office, and everywhere in between. UPnP technology can be supported on essentially any operating system and works with essentially any type of physical networking media - wired or wireless - providing maximum user and developer choice and great economics.

What is UPnP?

UPnP technology is a distributed, open networking architecture that employs TCP/IP and other Internet technologies to enable seamless proximity networking, in addition to control and data transfer among networked devices in the home, office, and public spaces. UPnP technology enables developers to create such products — products that free their customers from thinking about network configurations, setup, maintenance, software or Internet protocols. Universal Plug and Play (UPnP) extends this simplicity to include the entire network, enabling discovery and control of devices, including networked devices and services, such as network-attached printers, Internet gateways, and consumer electronics equipment. UPnP is more than just a simple extension of the Plug and Play peripheral model. It is designed to support zero-configuration, "invisible" networking, and automatic discovery for a breadth of device categories from a wide range of vendors. With UPnP, a device can dynamically join a network, obtain an IP address, convey its capabilities, and learn about the presence and capabilities of other devices—all automatically; truly enabling zero configuration networks. Devices can subsequently communicate with each other directly; thereby further enabling peer to peer networking.

UPnP uses standard TCP/IP and Internet protocols, enabling it to seamlessly fit into existing networks. Using these standardized protocols allows UPnP to benefit from a wealth of experience and knowledge, and makes interoperability an inherent feature. Because UPnP is a distributed, open network architecture, defined by the protocols used, it is independent of any particular operating system, programming language, or physical medium (just like the Internet). The “Digital Home Platform” UPnP is gaining momentum as the preferred device discovery and control protocol for IP networks in the home and small office. There are many UPnP SDKs (software development kits) and development tools available. Over time, as more and more UPnP devices appear based on these SDKs, a new digital home platform will emerge with UPnP technology as the foundation. The digital home platform will span wired and wireless networks, entertainment devices, telephone equipment, home control, and so on. It will link the various networks in the home—entertainment, home control and automation, communications, and the data network—into a single logical network of programmable devices. The resulting logical network will contain a multitude of UPnP devices that will be able to interact with each other. Speakers, for example, could be networked and used for a variety of purposes, not just for playing audio. Control points on the network, such as the PC in the den, or the television and remote in the entertainment area, will have programmatic access to all of the devices on this network and will be able to run programs that aggregate the devices into

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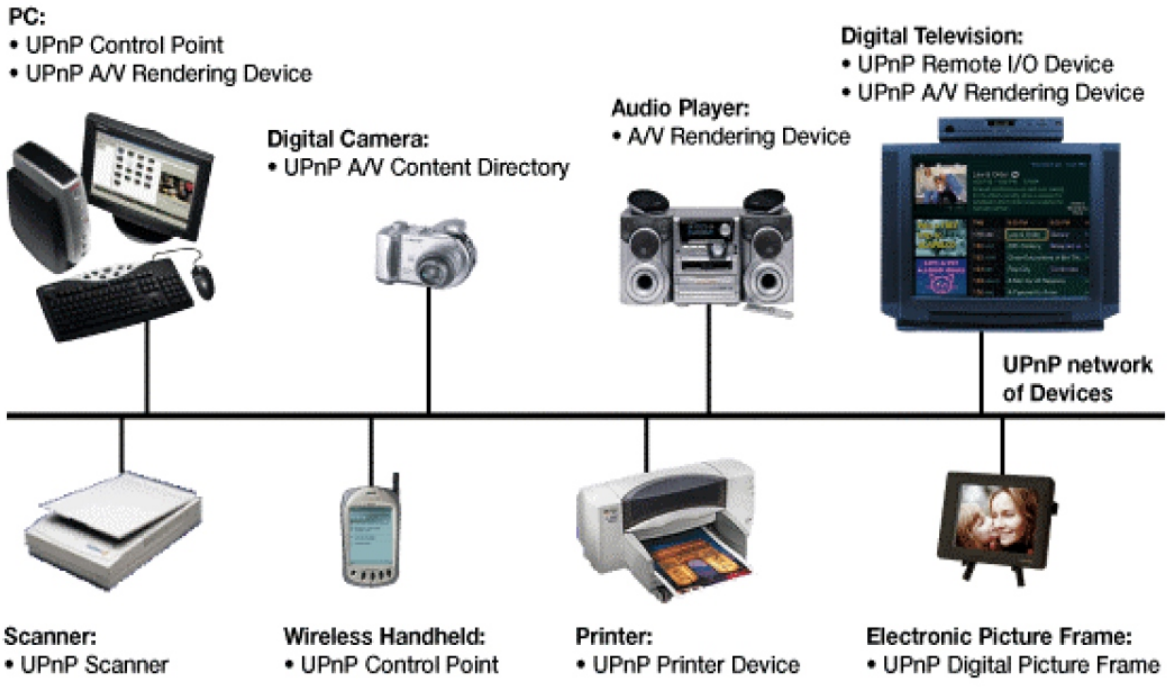
innovative applications. The UPnP foundation of the digital home will enable a transition to new home networking usage models. This transition will have great benefits for people in the home, as the focus will shift from a specific user interaction model— “the computer in the den"—to devices supporting user activities in the home in their natural settings. Eventually, entertainment devices will be networked and have UPnP device apabilities built-in and won't need a proxy UPnP device. Devices will work
together to provide new usage models that support the various activities in the home, providing new kinds of user interaction paradigms and new levels of automation. The figure shows a sample home network with some of today's UPnP devices.



The UPnP Device Architecture

The key components of the UPnP architecture are as follows:

Devices

A UPnP device can contain a number of services and nested devices. For identification purposes, the device must host an XML device description document that lists specific properties about the device, the services associated with the device, and the nested devices. The device description document must also include a Uniform Resource Locator (URL) for the service description. The service description is an XML document that lists the actions and state variables that apply to a specific service offered by the device.

Services

Services or functionalities are provided by a UPnP device for other devices to use. A UPnP service consists of state variables that provide information about the service, and actions that can be invoked to take advantage of what the service provides.

Control Points

A UPnP control point is a controller (which may be embedded in a UpnP device but typically a PC) capable of discovering and controlling other devices. A control point is able to retrieve descriptions of devices and the services they offer, invoke the advertised actions to use the service and subscribe to a service to receive event messages.

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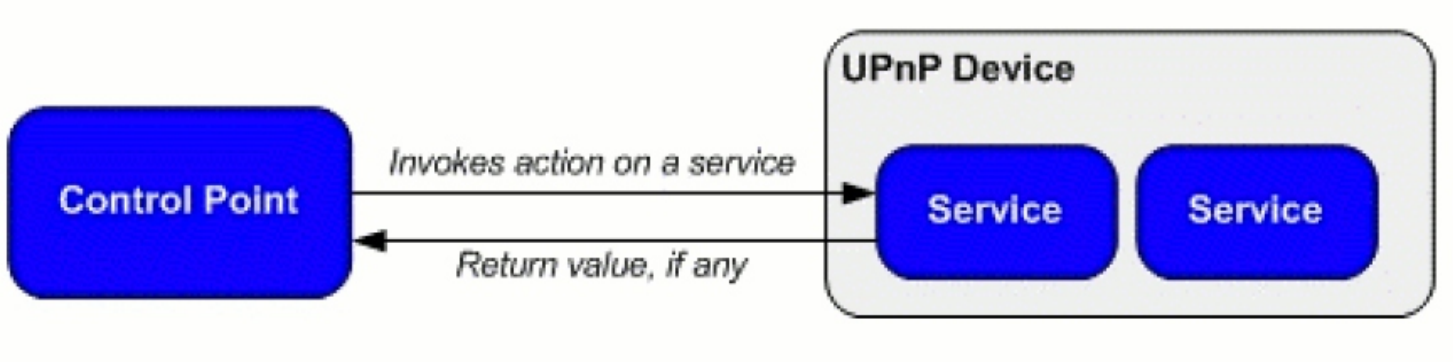


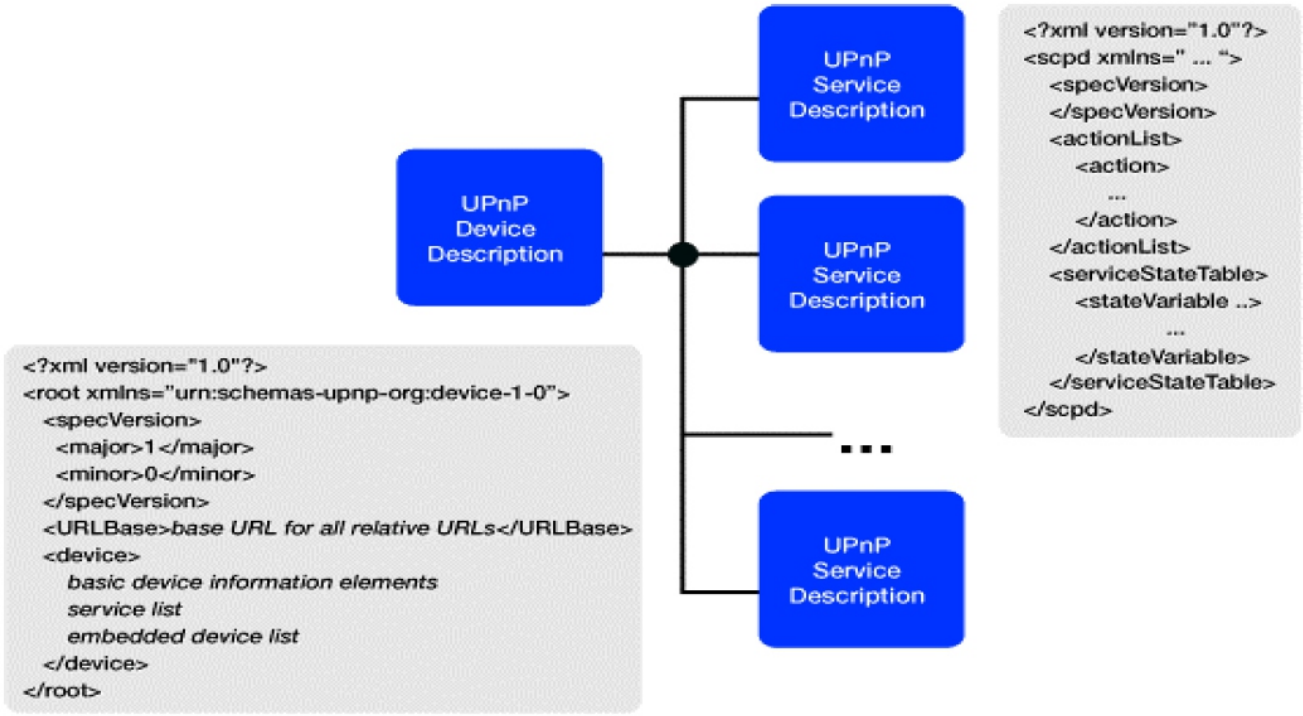
UPnP Networking Mechanisms

There are seven steps in the UPnP mechanism.

Step 0: Addressing The device and control point search for a DHCP server to get an IP address.
If no DHCP server is available, automatic IP addressing (Auto IP) should be used to obtain an IP address.

Step 1 : Description

Description allows devices to list the functionality they provide. Descriptions of devices and their services are contained in XML-based description documents. The device description document contains device information such as manufacturer, make, model, and serial number; a list of services provided by the device; and a list of embedded devices. A service description
document contains detailed information about a device's service, the actions that service provides, and the service's parameters and return value. Control points in the device discovery process use description documents in order to learn more about a device. The figure illustrates the device and service description hierarchy.



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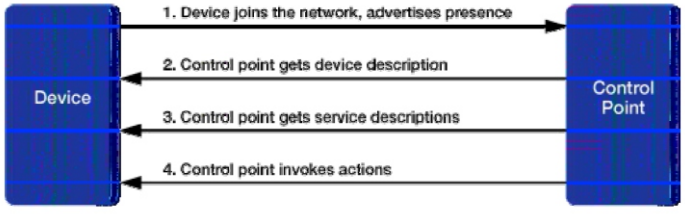
Step 2: Discovery

The device advertises its services to the control point on the network when it is added to the network. The discovery process enables control points to find devices and services of interest and retrieve information about them. UPnP devices use the Simple Service Discovery Protocol (SSDP) for Discovery. SSDP extends the HTTP (Hypertext Transfer Protocol) header to provide a simple multicast-based discovery protocol.
Once a device has acquired an IP address, that device periodically advertises itself and its services on the network. A device includes a URL of its device description XML document in its advertisement and discovery responses. That URL provides control points with the information those control points need to retrieve the device and service descriptions

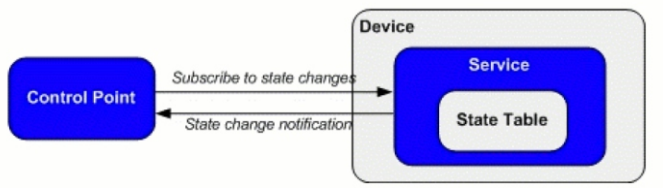


Step 3: Control

The control point can invoke actions to manipulate the services on a device by sending suitable control messages to the device using the Simple Object Access Protocol (SOAP).

Step 5: Eventing

The control point can subscribe to a device's service for event messages. Event messages are published when changes in device status occur. The messages contain the name of one or more state variables and the current value of those variables. Event messages are expressed in XML syntax and formatted using the General Event Notification Architecture (GENA). The figure shows how a control point communicates with a service to subscribe to and receive notifications of state variable changes.

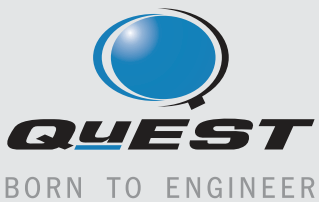


Step 6: Presentation

The control point can display a user interface provided by the device. By retrieving a page from the device URL into a browser, you can view the device's status and/or control the device.

Conclusion

UPnP is the foundation of other home networking standards such as the Digital Living Network Alliance (formerly the Digital Home Working Group) and Intel's Networked Media Products Requirements (NMPR) specifications. These specifications add to the UPnP foundation, going beyond the basic UPnP device architecture specification to include media formats and other issues such as Digital Rights Management (DRM) to ensure a higher degree of device interoperability UPnP implementation is not rocket science, and there are excellent tools to make the design of UpnP enabled devices even easier. User interface design can be as simple as an HTML page. No additional hardware is required. Once vendors and users see the power of UPnP, every network-enabled device will also be UPnP enabled.



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