

Establishing Home Interoperability with UPnP

Soumya Samant September 2007



Table of Contents

1	What is UpnP?	- 3
2	What does UPnP do in a device?	- 3
3	UPnP and DLNA	- 3
4	Key Features	- 4
5	Network Protocol Stack	- 4
6	Steps involved in UPnP networking	5
7	UPnP Audio/Video	7
8	Trianz Middleware Solution	- 8
9	Snapshot	9
10	Implementation Scenarios	· 10
11	UPnP and SCP	11
12	Summary	11
13	For more information	12

1 What is UPnP?

Universal Plug and Play protocol extends the simplicity of the Plug and Play peripheral model 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. It is designed to support zero-configuration "invisible" networking, so 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. UPnP uses standard TCP/IP and internet protocols enabling it to seamlessly fit into existing networks. A distributed, open network architecture, it is independent of any particular OS, programming ;language, or physical medium. UPnP does not specify the APIs the applications will use, allowing operating system vendors to create APIs that will meet their customer needs.

What does UPnP do in a device?

UPnP enabled devices seamlessly and transparently locate each other. UPnP technology defines a standard way of controlling devices using extensible markup language (XML), and simple object access protocol (SOAP), which is the standard for Web messaging. DHCP (Dynamic Host Configuration Protocol) and DNS (Domain Name System) servers are optional and are used only if available on the network. A device can smoothly and automatically leave or be removed from a network without leaving behind any unwanted state information.

3 UPnP in a broader sense: collaborating for Digital Interoperability

In order to share information and collaborate to enhance the whole home network, UPnP Implementers Corporation (UIC) has a joint alliance with a group called Digital Living Network Alliance. DLNA has incorporated UPnP architecture and Audio-Video (AV) DCPs into its certification process. Now all devices must pass the UPnP AV device certification process.

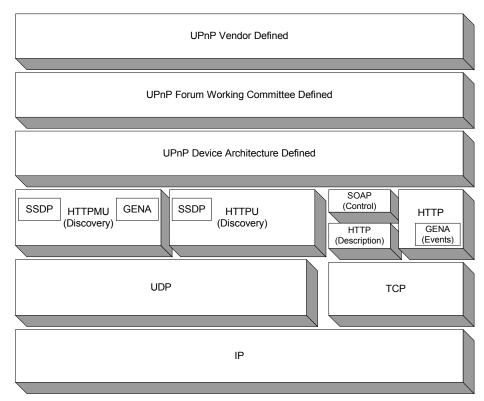
DLNA creates a framework for how UPnP technology works with the network protocol stack. DLNA's interoperability Guidelines Functional Components and Technology ingredients include:

- Connectivity using Ethernet, 802.11 and Bluetooth
- Networking using IPv4 Suite
- Device discovery and control using UPnP device architecture v1.0
- Media management and control using UPnP AV v1 and UPnP printer:1
- Media formats applying required and optional format profiles, and
- Media transport using HTTP and RTP.

4 Key Features of UPnP

- Media and device independence: UPnP technology can run on any medium that supports IP networking, including phone line, power line, Ethernet, RF, Wireless, and 1394.
- Platform independence: Vendors can use any operating system and any programming language to build UPnP products.
- Internet-based technologies: UPnP technology is built upon IP, TCP, UDP, HTTP, and XML among others.
- UI control: UPnP architecture enables vendor control over device user interface and user interaction using a web browser.
- Programmatic control: UPnP architecture also enables conventional application programmatic control.
- Common base protocols: Vendors agree on base protocol sets on a per-device basis.
- Extendable: Each UPnP product can have a value-added services layered on top of the basic device architecture provided by individual manufacturers.

5 UPnP Protocol stack



6 Steps involved in UPnP networking:

Addressing

The foundation for UPnP networking is the TCP/IP protocol suite and the key to this suite is addressing. Each device must have a Dynamic Host Configuration Protocol (DHCP) client and search for a DHCP server when the device is first connected to the network. If a DHCP server is available, the device must use the IP address assigned to it. If no DHCP server is available, the device must use Auto IP to get an address.

Discovery

When a device is added to the network, SSDP allows that device to advertise its services to control points on the network. When a control point is added to the network, SSDP allows that control point to search for devices of interest on the network.

Discovery-Advertisement

When a new device is added to the network, it multicasts discovery messages advertising its embedded devices and services. Any interested control point can listen to the standard multicast address for notifications that new services are available.

Discovery-Search

When a new control point is added to the network, it multicasts a SSDP discovery message, searching for interesting devices and services. All devices must listen to the standard multicast address for these messages and must respond if any of their embedded devices or services matches the search criteria in the discovery message.

Description

After a control point has discovered a device, the control point still knows very little about the device. For the control point to learn more about the device and its capabilities, or to interact with the device, the control point must retrieve the device's description from the URL provided by the device in the discovery message.

Devices may contain other, logical devices and services. The UPnP description for a device is expressed in XML and includes vendor-specific, manufacturer information including the model name and number, serial number, manufacturer name, URLs to vendor-specific Web sites, and so forth. The description also includes a list of any embedded devices or services, as well as URLs for control, eventing, and presentation.

Control

To learn more about the service, a control point must retrieve a detailed UPnP description for each service. The description for a service is also expressed in XML and includes a list of the commands or actions the service responds to, and the parameters or arguments for each action. The description for a service also includes a list of variables; these variables model the state of the service at run time, and are described in terms of their data type, range, and event characteristics.

To control a device, a control point sends an action request to a device's service. To do this, a control point sends a suitable control message to the control URL for the service (provided in the device description). Control messages are also expressed in XML using SOAP.

In response to the control message, the service returns action-specific values or fault codes.

Eventing

UPnP description for a service includes a list of actions the service responds to and a list of variables that model the state of the service at run time. The service publishes updates when these variables change, and a control point may subscribe to receive this information.

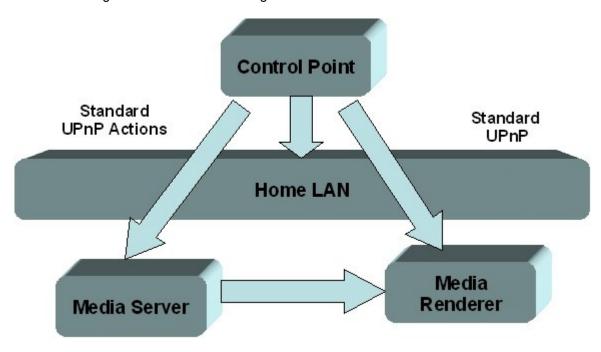
The service publishes updates by sending event messages. Event messages contain the names of one of more state variables and the current value of those variables. These messages are also expressed in XML and formatted using GENA.

A special initial event message is sent when a control point first subscribes; this event message contains the names and values for all evented variables and allows the subscriber to initialize its model of the state of the service.

To support multiple control points, all subscribers are sent all event messages. Subscribers receive event messages for all evented variables, and event messages are sent no matter why the state variable changed (in response to an action request or due to a state change).

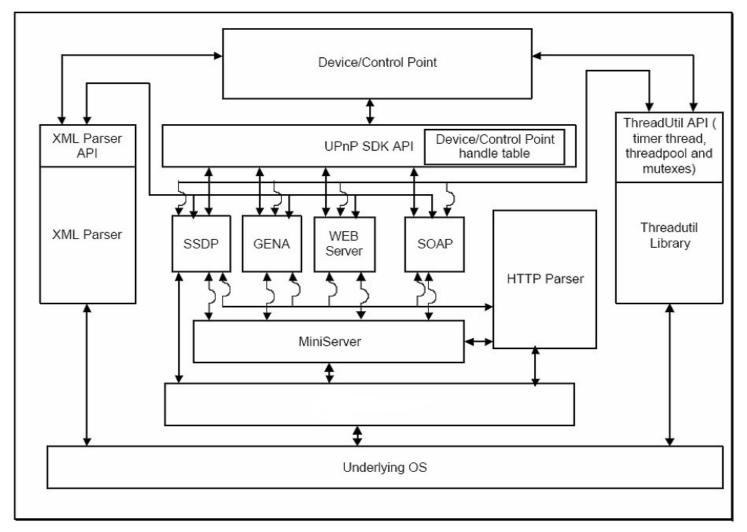
7 UPnP Audio/Video

UPnP supports a powerful architecture for management and playback of media. The application we have built showcases the unique capabilities of this architecture utilizing the three way communication model of Renderer, Media Server, and Controller and the streaming of audio and video among them.



UPnP A/V architecture

8 Trianz Middleware Solution

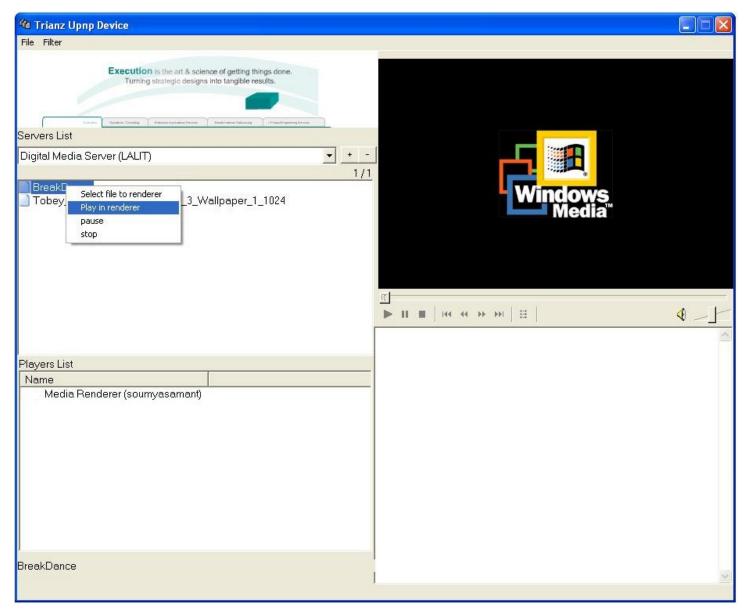


The stack diagram above elucidates the protocols and technologies that Trianz has worked on to develop a UPnP device and Control Point.

The following modules/Technologies/Protocols have been successfully implemented

- XML Parsers
- HTTP Parsers
- Miniserver: used to handle incoming requests and giving control to other modules
- Socket Programming

- Simple Service Discovery Protocol (SSDP)
- Simple Object Access Protocol (SOAP)
- General Event Notification Architecture (GENA)



9 A Snapshot of the application (Front End for Control Point and Media Server)

10 Some UPnP implementation Scenarios:

Digital Media Printer

Simply plug the printer into any available network port, be it phone line, power line, or Ethernet, and have the printer immediately available to all devices and users of the network. No need for Network configuration and installation of drivers!

Home Theatre Mode

When it's time to watch your favorite movie, a single script can automate the entire experience:

- The TV is turned on to the proper channel.
- The DVD player is turned on.
- The stereo is turned on to the Video mode, and the volume is turned up to theater levels.
- The lights in the house turn off, except for the living room where they dim slightly.
- The DVD is played.

The Master Switch

You come home from a hard day's work and walk in your front door. You flip a wall switch, which, to most of us, just turns on the light in the foyer. With UPnP, this switch is much more than that. This switch is simply a UPnP service whose state is defined by a variable called "Position." When you flip the switch, "Position" changes to "On" and a script running on your Windows-based PC goes into action.

The script gets the notification that the position of the master switch has changed to "on". It then does the following:

- The heat turns on to your preset temperature.
- The answering machine starts playing new messages.
- Your stereo system turns on and is set to your favorite classical station, and the volume is set for ambient level.
- The window blinds raise, but only if it's after sunset (sunrise/sunset data is easily obtainable from the Internet).
- Optionally, the TV is turned on and set to the news station, with the sound off and the closed captioning turned on.
- The light in the foyer also turns on.

11 Extension of UPnP: SCP

Dues to some limitations like the cost involved in supporting the technology and some seemingly stringent requirements like the device must have a full featured TCP/IP network stack and HTTP 1.0 compliant web server, an alternative to UPnP has been developed. Simple Control Protocol (SCP) is intentionally designed to run over low bandwidth communication networks such as home power line networks. It brings the UPnP device architecture to very small low-cost devices that wouldn't normally be able to afford a full UPnP stack.

12 Summary

A combination of high speed computing power and connectivity in everyday devices is the buzzword in industry today. Due to the advent of inexpensive and ubiquitous networking media technologies, the task has been simplified to an extent. Though the fact still remains that we have to utilize these technological advancements in a way that it doesn't leave people overwhelmed, the applications must surely be as user friendly as they can be.

At Trianz we have tried to achieve exactly this purpose. Taking into account existing standards prescribed by UPnP forum, we have developed an application that is simple enough to be implemented in the smallest of appliances, powerful enough to scale to the global internet, and is based on the proven approach of internet protocols.

13 For more information

References

Universal Plug and Play device Architecture

http://www.upnp.org/Device_Architecture_v0.92_.htm

GENA

General Event Notification Architecture. IETF Draft.

SSDP

Simple Service Discovery Protocol. IETF Draft.

SOAP

Simple Object Access Protocol.

Defines a protocol in XML, over HTTP, for remote procedure calls.

IETF draft and W3C Technical Report.

About the Author

Soumya Samant, a software engineer at Trianz, has more than two years of experience in Embedded System development. His expertise is in developing device drivers on Win CE RTOS and middleware development like UPnP and DLNA. He has successfully implemented UPnP on Windows. He has implemented Digital Living Network Alliance using UPnP AV architecture and developed the control point application. Currently, he is working on Win CE device driver development based on ARM platform. He can be contacted at Soumya.samant@trianz.com.

About Trianz

Trianz is a management consulting, technology, engineering, and outsourcing services firm that helps senior leaders execute business and technology initiatives. A unique mix of business consulting and technology capabilities has helped Trianz rapidly grow since its inception in 2000. Trianz provides services to a diversified global client base. Clients are result-focused leaders employed in businesses ranging from Fortune 1000 corporations to emerging rapid-growth companies. Service offerings focus on the following areas:

Operations Consulting Services

Enterprise Applications Services

Software Product Engineering Services

Transformational Outsourcing Services

Disclaimer for white papers

©2006 Trianz. All rights reserved

Copyright in whole and in part of this document belongs to Trianz, Inc. This work has been provided for informational purposes only, and may be copied for personal use only. This work may not be used, sold, transferred, adapted, abridged, copied, or reproduced in whole or in part, in any media, by enterprises, without the prior written permission of Trianz, AND an acknowledgement of "Trianz" as the source of the content. All trademarks and copyrights mentioned in this white paper are the property of their respective owners. Neither the author nor Trianz bears any responsibility for damage resulting from the use of the information contained herein.

For more information about Trianz and its capabilities, visit 'www.trianz.com'