Universal Plug and Play Device Architecture

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Introduction

What is Universal Plug and Play?

Universal Plug and Play is an architecture for pervasive peer-to-peer network connectivity of intelligent appliances, wireless devices, and PCs of all form factors. It is designed to bring easy-to-use, flexible, standards-based connectivity to ad-hoc or unmanaged networks whether in the home, in a small business, public spaces, or attached to the Internet. Universal Plug and Play is a distributed, open networking architecture that leverages TCP/IP and the Web technologies to enable seamless proximity networking in addition to control and data transfer among networked devices in the home, office, and public spaces.

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. This means a device can dynamically join a network, obtain an IP address, convey its capabilities, and learn about the presence and capabilities of other devices. DHCP and DNS servers are optional and are used only if available on the network. Finally, a device can leave a network smoothly and automatically without leaving any unwanted state behind.

UPnP leverages Internet components, including IP, TCP, UDP, HTTP, and XML. Like the Internet, contracts are based on wire protocols that are declarative, expressed in XML, and communicated via HTTP. IP internetworking is a strong choice for UPnP because of its proven ability to span different physical media, to enable real world multiple-vendor interoperation, and to achieve synergy with the Internet and many home and office intranets. UPnP has been explicitly designed to accommodate these environments. Further, via bridging, UPnP accommodates media running non-IP protocols when cost, technology, or legacy prevents the media or devices attached to it from running IP.

What is "universal" about UPnP? No device drivers; common protocols are used instead. UPnP networking is media independent. UPnP devices can be implemented using any programming language, and on any operating system. UPnP does not specify or constrain the design of an API for applications running on control points; OS vendors may create APIs that suit their customer's needs. UPnP enables vendor control over device UI and interaction using the browser as well as conventional application programmatic control.

UPnP Forum

The UPnP Forum is an industry initiative designed to enable easy and robust connectivity among stand-alone devices and PCs from many different vendors. The UPnP Forum seeks to develop standards for describing device protocols and XML-based device schemas for the purpose of enabling device-to-device interoperability in a scalable networked environment. The UPnP Forum oversees a logo program for compliant devices.

The UPnP Forum has set up working committees in specific areas of domain expertise. These working committees are charged with

creating proposed device standards, building sample implementations, and building appropriate test suites. This document indicates specific technical decisions that are the purview of UPnP Forum working committees.

UPnP vendors can build compliant devices with confidence of interoperability and benefits of shared intellectual property and the logo program. Separate from the logo program, vendors may also build devices that adhere to the UPnP Device Architecture defined herein without a formal standards procedure. If vendors build non-standard devices, they determine technical decisions that would otherwise be determined by a UPnP Forum working committee.

In this document

The Universal Plug and Play Device Architecture (formerly known as the DCP Framework) contained herein defines the protocols for communication between controllers, or *control points*, and devices. For discovery, description, control, eventing, and presentation, UPnP uses the following protocol stack.

<table>
<tr><td colspan="6">UPnP vendor [purple]</td></tr>
<tr><td colspan="6">UPnP Forum [red]</td></tr>
<tr><td colspan="6">UPnP Device Architecture [green]</td></tr>
<tr><td colspan="2">HTTPMU (multicast) [black]</td><td>GENA [navy]</td><td>SSDP [blue]</td><td>HTTPU (unicast) [black]</td><td>SSDP [blue]</td></tr>
<tr><td colspan="4" rowspan="2"></td><td>SOAP [blue]
HTTP [black]</td><td>HTTP [black]</td><td>GENA [navy]</td></tr>
<tr><td colspan="4">UDP [black]</td><td colspan="2">TCP [black]</td></tr>
<tr><td colspan="6">IP [black]</td></tr>
</table>

At the highest layer, messages logically contain only UPnP vendor-specific information about their devices. Moving down the stack, vendor content is supplemented by information defined by UPnP Forum working committees. Messages from the layers above are hosted in UPnP-specific protocols, defined in this document. In turn, the above messages are formatted using the Simple Service Discovery Protocol (SSDP), General Event Notification Architecture (GENA), and Simple Object Access Protocol (SOAP). The above messages are delivered via HTTP, either a multicast or unicast variety running over UDP, or the standard HTTP running over TCP. Ultimately, all messages above are delivered over IP. The remaining sections of this document describe the content and format for each of these protocol layers in detail. For reference, colors in [square brackets] above indicate which protocol defines specific message components throughout this document.

The foundation for UPnP networking is IP 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, i.e., the network is managed, the device must use the IP addressed assigned to it. If no DHCP server is available, i.e., the network is unmanaged, the device must use Auto IP to get an address. In brief, Auto IP defines how a device intelligently chooses an IP address from a set of reserved addresses and is able to move easily between managed and unmanaged networks. If during the DHCP transaction, the device obtains a domain name, e.g., through a DNS server or via DNS forwarding, the device should use that name in subsequent network operations; otherwise, the device should use its IP address.

Given an IP address, Step 1 in UPnP networking is discovery. When a device is added to the network, the UPnP discovery protocol allows that device to advertise its services to control points on the network. Similarly, when a control point is added to the network, the UPnP discovery protocol allows that control point to search for devices of interest on the network. The fundamental exchange in both cases is a discovery message containing a few, essential specifics about the device or one of its services, e.g., its type, identifier, and a pointer to more detailed information. The UPnP discovery protocol is based on the Simple Service Discovery Protocol (SSDP). The section on Discovery below explains how devices advertise, how control points search, and details of the format of discovery messages.

Step 2 in UPnP networking is 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, as well as functional units, or *services*. The UPnP description for a device is expressed in XML and includes vendor-specific, manufacturer information like the model name and number, serial number, manufacturer name, URLs to vendor-specific Web sites, etc. The description also includes a list of any embedded devices or services, as well as URLs for control, eventing, and presentation. For each service, the description includes a list of the commands, or *actions*, the service responds to, and 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. The section on Description below explains how devices are described and how those descriptions are retrieved by control points.

Step 3 in UPnP networking is control. After a control point has retrieved a description of the device, the control point can send actions 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 the Simple Object Access Protocol (SOAP). Like function calls, in response to the control message, the service returns any action-specific values. The effects of the action, if any, are modeled by changes in the variables that describe the run-time state of the service. The section on Control below explains the description of actions, state variables, and the format of control messages.

Step 4 in UPnP networking is eventing. A 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 the General Event Notification Architecture (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 scenarios with multiple control points, eventing is designed to keep all control points equally informed about the effects of any action. Therefore, all subscribers are sent all event messages, subscribers receive event messages for all evented variables that have changed, and event messages are sent no matter why the state variable changed (either in response to a requested action or because the state the service is modeling changed). The section on Eventing below explains subscription and the format of event messages.

Step 5 in UPnP networking is presentation. If a device has a URL for presentation, then the control point can retrieve a page from this URL, load the page into a browser, and depending on the capabilities of the page, allow a user to control the device and/or view device status. The degree to which each of these can be accomplished depends on the specific capabilities of the presentation page and device. The section on Presentation below explains the protocol for retrieving a presentation page.

Audience

The audience for this document includes UPnP device vendors, members of UPnP Forum working committees, and anyone else who has a need to understanding the technical details of UPnP protocols.

This document assumes the reader is familiar with the HTTP, TCP, UDP, IP family of protocols; this document makes no attempt to explain them. This document also assumes most readers will be new to XML, and while it is not an XML tutorial, XML-related issues are addressed in detail given the centrality of XML to UPnP. This document makes no assumptions about the reader's understanding of various programming or scripting languages.

Required vs. recommended

In this document, features are described as Required, Recommended, or Optional as follows:

Required (or Must).
: These basic features must be implemented to comply with UPnP.

Recommended (or Should).
: These features add functionality supported by UPnP and should be implemented. Recommended features take advantage of the capabilities UPnP, usually without imposing major cost increases. Notice that for compliance testing, if a recommended feature is implemented, it must meet the specified requirements to be in compliance with these guidelines. Some recommended features could become requirements in the future.

Optional (or May).
: These features are neither required nor recommended by UPnP, but if the feature is implemented, it must meet the specified requirements to be in compliance with these guidelines. These features are not likely to become requirements in the future.

Acronyms

Acronym	Meaning	Acronym	Meaning
ARP	Address Resolution Protocol	SSDP	Simple Service Discovery Protocol
DHCP	Dynamic Host Configuration Protocol	UPC	Universal Product Code
DNS	Domain Name System	UPnP	Universal Plug and Play
FXPP	Flexible XML Processing Profile	URI	Uniform Resource Identifier
GENA	General Event Notification Architecture	URL	Uniform Resource Locator
HTML	HyperText Markup Language	URN	Uniform Resource Name
HTTPMU	HTTP Multicast over UDP	UUID	Universally Unique Identifier

HTTPU	HTTP (unicast) over UDP	XML	Extensible Markup Language
ICANN	Internet Corporation for Assigned Names and Numbers		
SOAP	Simple Object Access Protocol		

References and resources

RFC 2616
HTTP: Hypertext Transfer Protocol 1.1. IETF request for comments. <http://search.ietf.org/rfc/rfc2616.txt?number=2616>.
RFC 2279
UTF-8, a transformation format of ISO 10646 (character encoding). IETF request for comments. <http://search.ietf.org/rfc/rfc2279.txt?number=2279>.
XML
Extensible Markup Language. W3C recommendation. <http://www.w3.org/XML/>.

Each section in this document contains additional information about resources for specific topics.

Acknowledgments

The UPnP team at Microsoft gratefully acknowledges the help we received from the many technical reviewers representing the UPnP Forum Steering Committee and the UPnP vendor community. These reviewers contributed technical information, insights, and wisdom in developing this document.

We are also grateful to the software engineers, testers, and program managers at Microsoft who contributed feedback and technical content to ensure that the information in this document is accurate and timely.

0. Addressing

Addressing is Step 0 of UPnP networking. Through addressing, devices get a network address. Addressing enables discovery (Step 1) where control points find interesting device(s), description (Step 2) where where control points learn about device capabilities, control (Step 3) where a control point sends commands to device(s), eventing (Step 4) where control points listen to state changes in device(s), and presentation (Step 5) where control points display a user interface for device(s).

The foundation for UPnP networking is IP 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, i.e., the network is managed, the device must use the IP addressed assigned to it. If no DHCP server is available, i.e., the network is unmanaged; the device must use automatic IP addressing (Auto-IP) to obtain an address.

Auto-IP defines how a device: (a) determines if DHCP is unavailable, and (b) intelligently chooses an IP address from a set of link-local IP addresses. This method of address assignment enables a device to easily move between managed and unmanaged networks.

The operations described in this section are further clarified in the reference documents listed below. Where conflicts between this document and the reference documents exist, the reference document always takes precedence.

0.1 Addressing: Determining whether to use Auto-IP

A device that supports AUTO-IP and is configured for dynamic address assignment begins by requesting an IP address via DHCP by sending out a DHCPDISCOVER message. The amount of time this DHCP Client should listen for DHCPOFFERS is implementation dependent. If a DHCPOFFER is received during this time, the device must continue the process of dynamic address assignment. If no valid DHCPOFFERS are received, the device may then auto-configure an IP address.

0.2 Addressing: Choosing an address

To auto-configure an IP address using Auto-IP, the device uses an implementation dependent algorithm for choosing an address in the 169.254/16 range. The first and last 256 addresses in this range are reserved and must not be used.

The selected address must then be tested to determine if the address is already in use. If the address is in use by another device, another address must be chosen and tested, up to an implementation dependent number of retries. The address selection should be randomized to avoid collision when multiple devices are attempting to allocate addresses.

0.3 Addressing: Testing the address

To test the chosen address, the device must use an Address Resolution Protocol (ARP) probe. An ARP probe is an ARP request with the device hardware address used as the sender's hardware address and the sender's IP address set to 0s. The device will then listen for responses to the ARP probe, or other ARP probes for the same IP address. If either of these ARP packets is seen, the device must consider the address in use and try a new address.

0.4 Addressing: Periodic checking for dynamic address availability

A device that has auto-configured an IP address must periodically check for the existence of a DHCP server. This is accomplished by sending DHCPDISCOVER messages. How often this check is made is implementation dependent, but checking every 5 minutes would maintain a balance between network bandwidth required and connectivity maintenance. If a DHCP offer is received, the device must proceed with dynamic address allocation. Once a DHCP assigned address is in place, the device may release the auto-configured address, but may also choose to maintain this address for a period of time to maintain connectivity.

To switch over from one IP address to a new one, the device must cancel any outstanding advertisements and reissue new ones. The section on Discovery explains advertisements and their cancellations.

0.5 Addressing: Device naming and DNS interaction

Once a device has a valid IP address for the network, it can be located and referenced on that network through that address. There may be situations where the end user needs to locate and identify a device. In these situations, a friendly name for the device is much easier for a human to use than an IP address.

Moreover, names are much more static than IP addresses. Clients referring a device by name don't require any modification when IP address of a device changes. Mapping of the device's DNS name to its IP address could be entered into DNS database manually or dynamically according to RFC 2136. While computers and devices supporting dynamic DNS updates can register their DNS records directly in DNS, it is also possible to configure a DHCP server to register DNS records on behalf of these DHCP clients.

0.6 Addressing: Name to IP address resolution

A computer that needs to contact a device identified by a DNS name needs to discover its IP address. The computer submits a DNS query according to RFC1034 and 1035 to the pre-configured DNS server(s) and receives a response from a DNS server containing the IP address of the target device. A computer can be statically pre-configured with the list of DNS servers. Alternatively a computer could be configured with the list of DNS server through DHCP, or after the address assignment through a DHCPINFORM message.

0.7 Addressing references

Auto-IP
: Automatically Choosing an IP Address in an Ad-Hoc IPv4 Network. IETF draft. <http://search.ietf.org/internet-drafts/draft-ietf-dhc-ipv4-autoconfig-05.txt>.

RFC1034
: Domain Names - Concepts and Facilities. IETF request for comments. <http://search.ietf.org/rfc/rfc1034.txt?number=1034>.

RFC1035
: Domain Names - Implementation and Specification. IETF request for comments. <http://search.ietf.org/rfc/rfc1035.txt?number=1035>.

RFC 2131
: Dynamic Host Configuration Protocol. IETF request for comments. <http://search.ietf.org/rfc/rfc2131.txt?number=2131>.

RFC 2136
: Dynamic Updates in the Domain Name System. IETF request for comments. <http://search.ietf.org/rfc/rfc2136.txt?number=2136>.

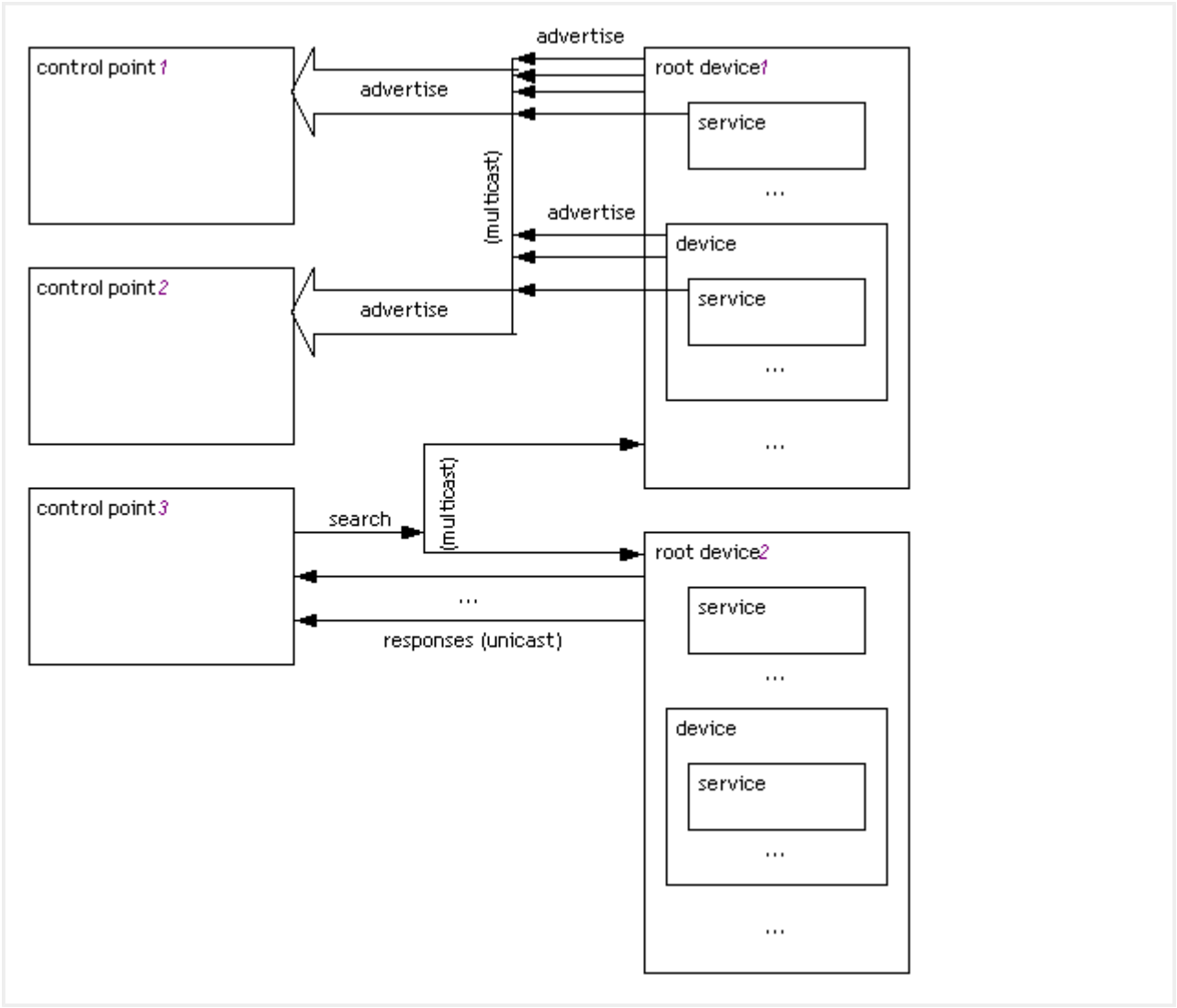
Dynamic DNS Updates by DHCP Clients and Servers
: Interaction between DHCP and DNS. IETF Draft. <http://search.ietf.org/internet-drafts/draft-ietf-dhc-dhcp-dns-12.txt>.

1. Discovery

Discovery is Step 1 in UPnP networking. Discovery comes after addressing (Step 0) where devices get a network address. Through discovery, control points find interesting device(s). Discovery enables description (Step 2) where control points learn about device capabilities, control (Step 3) where a control point sends commands to device(s), eventing (Step 4) where control points listen to state

changes in device(s), and presentation (Step 5) where control points display a user interface for device(s).

Discovery is the first step in UPnP networking. When a device is added to the network, the UPnP discovery protocol allows that device to advertise its services to control points on the network. Similarly, when a control point is added to the network, the UPnP discovery protocol allows that control point to search for devices of interest on the network. The fundamental exchange in both cases is a discovery message containing a few, essential specifics about the device or one of its services, e.g., its type, identifier, and a pointer to more detailed information.



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

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

To reiterate, a control point may learn of a device of interest because that device sent discovery messages advertising itself or because the device responded to a discovery message searching for devices. In either case, if a control point is interested in a device and wants to learn more about it, the control point must use the information in the discovery message to send a *description* query message. The section on Description explains description messages in detail.

When a device is removed from the network, it should multicast a number of discovery messages revoking it's earlier announcements,

effectively declaring that it's embedded devices and services will not be available.

To limit network congestion, the time-to-live (TTL) of each IP packet for each multicast message must default to 4 and should be configurable.

Discovery plays an important role in the interoperability of devices and control points using different versions of UPnP networking. The UPnP Device Architecture (defined herein) is versioned with both a major and a minor version, usually written as *major.minor*, where both *major* and *minor* are integers. Advances in minor versions must be a compatible superset of earlier minor versions of the same major version. Advances in major version are not required to be supersets of earlier versions and are not guaranteed to be backward compatible. Version information is communicated in discovery and description messages. In the former, each discovery message includes the version of UPnP networking that the device supports. As a backup, the latter also includes the same information. This section explains the format of version information in discovery messages and specific requirements on discovery messages to maintain compatibility with advances in minor versions.

The standard multicast address, as well as the mechanisms for advertising, searching, and revoking, are defined by the Simple Service Discovery Protocol (SSDP). The remainder of this section explains SSDP in detail, enumerating how devices advertise and revoke their advertisements as well as how control points search and devices respond.

1.1 Discovery: Advertisement

When a device is added to the network, the UPnP discovery protocol allows that device to advertise its services to control points. It does this by multicasting discovery messages to a standard address and port. Control points listen to this port to detect when new capabilities are available on the network. To advertise the full extent of its capabilities, a device multicasts a number of discovery messages corresponding to each of its embedded devices and services. Each message contains information specific to the embedded device (or service) as well as information about its enclosing device. Messages should include duration until the advertisements expire; if the device remains available, the advertisements should be re-sent with (with new duration). If the device becomes unavailable, the device should explicitly cancel its advertisements, but if the device is unable to do this, the advertisements will expire on their own.

1.1.1 Discovery: Advertisement protocols and standards

To send (and receive) advertisements, devices (and control points) use the following subset of the overall UPnP protocol stack. (The overall UPnP protocol stack is listed at the beginning of this document.)

<table>
<tr><td>UPnP vendor [purple]</td></tr>
<tr><td>UPnP Forum [red]</td></tr>
<tr><td>UPnP Device Architecture [green]</td></tr>
<tr><td>HTTPMU (multicast) [black] GENA [navy] SSDP [blue]</td></tr>
<tr><td>HTTPMU (multicast) [black]</td></tr>
<tr><td>UDP [black]</td></tr>
<tr><td>IP [black]</td></tr>
</table>

At the highest layer, discovery messages contain vendor-specific information, e.g., URL for the device description and device identifier. Moving down the stack, vendor content is supplemented by information from a UPnP Forum working committee, e.g., device type. Messages from the layers above are hosted in UPnP-specific protocols, defined in this document. In turn, the above messages are delivered via a multicast variant of HTTP that has been extended using General Event Notification Architecture (GENA) methods and headers and Simple Service Discovery Protocol (SSDP) headers. The HTTP messages are delivered via UDP over IP. For reference, colors in [square brackets] above indicate which protocol defines specific headers and values in discovery messages listed below.

1.1.2 Discovery: Advertisement: Device available -- NOTIFY with ssdp:alive

When a device is added to the network, it multicasts discovery messages to advertise its root device, to advertise any embedded devices, and to advertise its services. Each discovery message contains four major components:

1. a potential search target (e.g., device type), sent in an NT header,
2. a composite identifier for the advertisement, sent in a USN header,
3. a URL for more information about the device (or enclosing device in the case of a service), sent in a LOCATION header, and
4. a duration for which the advertisement is valid, sent in a CACHE-CONTROL header.

To advertise its capabilities, a device multicasts a number of discovery messages. Specifically, a root device must multicast:

- Three discovery messages for the root device.

	NT	USN *
1	root device UUID **	root device UUID
2	device type : device version	root device UUID and :: and device type : device version
3	upnp:rootdevice	root device UUID and :: and upnp:rootdevice

- Two discovery messages for each embedded device.

	NT	USN *
1	embedded device UUID **	embedded device UUID
2	device type : device version	embedded device UUID and :: and device type : device version

- Once for each service.

	NT	USN *
1	service type : service version	enclosing device UUID and :: and service type : service version

* Note that the prefix of the USN header (before the double colon) must match the value of the UDN element in the device description. (The section on Description explains the UDN element.)

** Note that the value of this NT header must match the value of the UDN element in the device description.

If a root device has *d* embedded devices and *s* embedded services but only *k* distinct service types, this works out to 3+2*d*+*k* requests. This advertises the full extend of the device's capabilities to interested control points. These messages must be sent out as a series with roughly comparable expiration times; order is unimportant, but refreshing or canceling individual messages is prohibited.

Choosing an appropriate duration for advertisements is a balance between minimizing network traffic and maximizing freshness of device status. Relatively short durations close to the minimum of 1800 seconds will ensure that control points have current device status at the expense of additional network traffic; longer durations, say on the order of a day, compromise freshness of device status but can significantly reduce network traffic. Generally, device vendors should choose a value that corresponds to expected device usage: short durations for devices that are expected to be part of the network for short periods of time, and significantly longer durations for devices expected to be long-term members of the network.

Due to the unreliable nature of UDP, devices should send each of the above discovery messages more than once. As a fallback, to guard against the possibility that a control point might not receive an advertisement for a device or service, the device should re-send its advertisements periodically (cf. CACHE-CONTROL below). Note that UDP packets are also bounded in length (perhaps as small as 512 Bytes in some implementations) and that there is no guarantee that the above 3+2*d*+*k* messages will arrive in a particular order.

When a device is added to the network, it must send a multicast request with method NOTIFY and ssdp:alive in the NTS header in the following format. Values in *italics* are placeholders for actual values.

```
NOTIFY * HTTP/1.1
HOST: 239.255.255.250:1900
CACHE-CONTROL: max-age = seconds until advertisement expires
LOCATION: URL for UPnP description for root device
NT: search target
NTS: ssdp:alive
SERVER: OS/version UPnP/1.0 product/version
USN: advertisement UUID
```

(No body for request with method NOTIFY, but note that the message must have a blank line following the last HTTP header.)

The TTL for the IP packet must default to 4 and should be configurable.

Listed below are details for the request line and headers appearing in the listing above. All header values are case sensitive except where noted.

Request line

NOTIFY
: Method defined by GENA for sending notifications and events.

*
: Request applies generally and not to a specific resource. Must be *.

HTTP/1.1
: HTTP version.

Headers

HOST
: Required. Multicast channel and port reserved for SSDP by Internet Assigned Numbers Authority (IANA). Must be 239.255.255.250:1900.

CACHE-CONTROL
: Required. Must have max-age directive that specifies number of seconds the advertisement is valid. After this duration, control points should assume the device (or service) is no longer available. Should be > 1800 seconds (30 minutes). Specified by UPnP vendor. Integer.

LOCATION
: Required. Contains a URL to the UPnP description of the root device. In some unmanaged networks, host of this URL may contain an IP address (versus a domain name). Specified by UPnP vendor. Single URL.

NT
: Required header defined by GENA. Notification Type. Must be one of the following. (cf. table above.) Single URI.
  upnp:rootdevice
  : Sent once for root device.
  uuid:*device-UUID*
  : Sent once for each device, root or embedded. Device UUID specified by UPnP vendor.
  urn:**schemas-upnp-org**:**device**:*deviceType*:*v*
  : Sent once for each device, root or embedded. Device type and version defined by UPnP Forum working committee.
  urn:**schemas-upnp-org**:**service**:*serviceType*:*v*
  : Sent once for each service. Service type and version defined by UPnP Forum working committee.

NTS
: Required header defined by GENA. Notification Sub Type. Must be ssdp:alive. Single URI.

SERVER
: Required. Concatenation of OS name, OS version, **UPnP/1.0**, product name, and product version. Specified by UPnP vendor. String.

USN
: Required header defined by SSDP. Unique Service Name. Must be one of the following. (cf. table above.) The prefix (before the double colon) must match the value of the UDN element in the device description. (The section on Description explains the UDN element.) Single URI.
  uuid:*device-UUID*::**upnp:rootdevice**
  : Sent once for root device. Device UUID specified by UPnP vendor.
  uuid:*device-UUID*
  : Sent once for every device, root or embedded. Device UUID specified by UPnP vendor.
  uuid:*device-UUID*::urn:**schemas-upnp-org**:**device**:*deviceType*:*v*
  : Sent once for every device, root or embedded. Device UUID specified by UPnP vendor. Device type and version defined by UPnP Forum working committee.
  uuid:*device-UUID*::urn:**schemas-upnp-org**:**service**:*serviceType*:*v*
  : Sent once for every service. Device UUID specified by UPnP vendor. Service type and version defined by UPnP Forum working committee.

(No response for a request with method NOTIFY.)

1.1.3 Discovery: Advertisement: Device unavailable -- NOTIFY with ssdp:byebye

When a device and its services are going to be removed from the network, the device should multicast a ssdp:byebye message corresponding to each of the ssdp:alive messages it multicasted that have not already expired. If the device is removed abruptly from the network, it might not be possible to multicast a message. As a fallback, discovery messages must include an expiration value in a CACHE-CONTROL header (as explained above); if not re-advertised, the discovery message eventually expires on its own and must be removed from any control point cache.

(Note: when a control point is about to be removed from the network, no discovery-related action is required.)

When a device is about to be removed from the network, it should explicitly revoke its discovery messages by sending one multicast request for each ssdp:alive message it sent. Each multicast request must have method NOTIFY and ssdp:byebye in the NTS header in the following format. Values in *italics* are placeholders for actual values.

```
NOTIFY * HTTP/1.1
HOST: 239.255.255.250:1900
NT: search target
NTS: ssdp:byebye
USN: advertisement UUID
```

(No body for request with method NOTIFY, but note that the message must have a blank line following the last HTTP header.)

The TTL for the IP packet must default to 4 and should be configurable.

Listed below are details for the request line and headers appearing in the listing above. All header values are case sensitive except where noted.

Request line

NOTIFY
: Method defined by GENA for sending notifications and events.

*
: Request applies generally and not to a specific resource. Must be *.

HTTP/1.1
: HTTP version.

Headers

HOST
: Required. Multicast channel and port reserved for SSDP by Internet Assigned Numbers Authority (IANA). Must be 239.255.255.250:1900.

NT
: Required header defined by GENA. Notification Type. (See list of required values for NT header in NOTIFY with ssdp:alive above.) Single URI.

NTS
: Required header defined by GENA. Notification Sub Type. Must be ssdp:byebye. Single URI.

USN
: Required header defined by SSDP. Unique Service Name. (See list of required values for USN header in NOTIFY with ssdp:alive above.) Single URI.

(No response for a request with method NOTIFY.)

Due to the unreliable nature of UDP, devices should send each of the above messages more than once. As a fallback, if a control point fails to receive notification that a device or services is unavailable, the original discovery message will eventually expire yielding the same effect.

1.2 Discovery: Search

When a control point is added to the network, the UPnP discovery protocol allows that control point to search for devices of interest on the network. It does this by multicasting a search message with a pattern, or target, equal to a type or identifier for a device or service. Responses from devices contain discovery messages essentially identical to those advertised by newly connected devices; the former are unicast while the latter are multicast.

1.2.1 Discovery: Search protocols and standards

To search for devices (and be discovered by control points), control points (and devices) use the following subset of the overall UPnP protocol stack. (The overall UPnP protocol stack is listed at the beginning of this document.)

UPnP vendor [purple]	
UPnP Forum [red]	
UPnP Device Architecture [green]	
HTTPU (unicast) [black] SSDP [blue]	HTTPMU (multicast) [black] SSDP [blue]

UDP [black]
IP [black]

At the highest layer, search messages contain vendor-specific information, e.g., the control point, device, and service identifiers. Moving down the stack, vendor content is supplemented by information from a UPnP Forum working committee, e.g., device or service types. Messages from the layers above are hosted in UPnP-specific protocols, defined in this document. In turn, search requests are delivered via a multicast variant of HTTP that has been extended using Simple Service Discovery Protocol (SSDP) methods headers. Search responses are delivered via a unicast variant of HTTP that has also been extended with SSDP. (GENA is not involved when control points search for devices.) Both kinds of HTTP messages are delivered via UDP over IP. For reference, colors in [square brackets] above indicate which protocol defines specific headers and values in discovery messages listed below.

1.2.2 Discovery: Search: Request with M-SEARCH

When a control point is added to the network, it should send a multicast request with method M-SEARCH in the following format. Values in *italics* are placeholders for actual values.

```
M-SEARCH * HTTP/1.1
HOST: 239.255.255.250:1900
MAN: "ssdp:discover"
MX: seconds to delay response
ST: search target
```

(No body for request with method M-SEARCH, but note that the message must have a blank line following the last HTTP header.)

The TTL for the IP packet must default to 4 and should be configurable.

Listed below are details for the request line and headers appearing in the listing above. All header values are case sensitive except where noted.

Request line

M-SEARCH
: Method defined by SSDP for search requests.

*
: Request applies generally and not to a specific resource. Must be *.

HTTP/1.1
: HTTP version.

Headers

HOST
: Required. Multicast channel and port reserved for SSDP by Internet Assigned Numbers Authority (IANA). Must be 239.255.255.250:1900.

MAN
: Required. Unlike the NTS and ST headers, the value of the MAN header is enclosed in double quotes. Must be "ssdp:discover".

MX
: Required. Maximum wait. Device responses should be delayed a random duration between 0 and this many seconds to balance load for the control point when it processes responses. This value should be increased if a large number of devices are expected to respond or if network latencies are expected to be significant. Specified by UPnP vendor. Integer.

ST
: Required header defined by SSDP. Search Target. Must be one of the following. (cf. NT header in NOTIFY with ssdp:alive above.) Single URI.

  ssdp:all
  : Search for all devices and services.

  upnp:rootdevice
  : Search for root devices only.

  uuid:*device-UUID*
  : Search for a particular device. Device UUID specified by UPnP vendor.

  urn:schemas-upnp-org:device:*deviceType*:*v*
  : Search for any device of this type. Device type and version defined by UPnP Forum working committee.

  urn:schemas-upnp-org:service:*serviceType*:*v*

Search for any service of this type. Service type and version defined by UPnP Forum working committee.

Due to the unreliable nature of UDP, control points should send each M-SEARCH message more than once. As a fallback, to guard against the possibility that a device might not receive the M-SEARCH message from a control point, a device should re-send its advertisements periodically (cf. CACHE-CONTROL header in NOTIFY with ssdp:alive above).

1.2.3 Discovery: Search: Response

To be found, a device must send a response to the source IP address and port that sent the request to the multicast channel.

Responses to M-SEARCH are intentionally parallel to advertisements, and as such, follow the same pattern as listed for NOTIFY with ssdp:alive (above) except that the NT header there is an ST header here. The response must be sent in the following format. Values in *italics* are placeholders for actual values.

```
HTTP/1.1 200 OK
CACHE-CONTROL: max-age = seconds until advertisement expires
DATE: when response was generated
EXT:
LOCATION: URL for UPnP description for root device
SERVER: OS/version UPnP/1.0 product/version
ST: search target
USN: advertisement UUID
```

(No body for a response to a request with method M-SEARCH, but note that the message must have a blank line following the last HTTP header.)

(No need to limit TTL to 4 for the IP packet in response to a search request.)

Listed below are details for the headers appearing in the listing above. All header values are case sensitive except where noted.

Headers

CACHE-CONTROL
: Required. Must have max-age directive that specifies number of seconds the advertisement is valid. After this duration, control points should assume the device (or service) is no longer available. Should be > 1800 seconds (30 minutes). Specified by UPnP vendor. Integer.

DATE
: Recommended. When response was generated. RFC 1123 date.

EXT
: Required. Confirms that the MAN header was understood. (Header only; no value.)

LOCATION
: Required. Contains a URL to the UPnP description of the root device. In some unmanaged networks, host of this URL may contain an IP address (versus a domain name). Specified by UPnP vendor. Single URL.

SERVER
: Required. Concatenation of OS name, OS version, **UPnP/1.0**, product name, and product version. Specified by UPnP vendor. String.

ST
: Required header defined by SSDP. Search Target. Single URI. If ST header in request was,

  ssdp:all
  : Respond 3+2*d*+*k* times for a root device with *d* embedded devices and *s* embedded services but only *k* distinct service types. Value for ST header must be the same as for the NT header in NOTIFY messages with ssdp:alive. (See above.) Single URI.

  upnp:rootdevice
  : Respond once for root device. Must be **upnp:rootdevice**. Single URI.

  uuid:*device-UUID*
  : Respond once for each device, root or embedded. Must be uuid:*device-UUID*. Device UUID specified by UPnP vendor. Single URI.

  urn:**schemas-upnp-org**:**device**:*deviceType*:*v*
  : Respond once for each device, root or embedded. Must be urn:**schemas-upnp-org**:**device**:*deviceType*:*v*. Device type and version defined by UPnP Forum working committee.

  urn:**schemas-upnp-org**:**service**:*serviceType*:*v*
  : Respond once for each service. Must be urn:**schemas-upnp-org**:**service**:*serviceType*:*v*. Service type and version defined by UPnP Forum working committee.

USN
: Required header defined by SSDP. Unique Service Name. (See list of required values for USN header in NOTIFY with ssdp:alive above.) Single URI.

Due to the unreliable nature of UDP, devices should send each response more than once. As a fallback, to guard against the possibility that a control point not receive a response, a device should re-send its advertisements periodically (cf. CACHE-CONTROL header in NOTIFY with ssdp:alive above).

If there is an error with the search request, the device must send a response with one of the following errors.

Errors

MAN header != ssdp:discover
: 412 Precondition Failed. If the value of the MAN header is not equal to ssdp:discover, the device must respond with HTTP error 412 Precondition Failed.

Other errors may be returned by layers in the protocol stack below UPnP. Consult documentation on those protocols for details.

1.3 Discovery references

GENA
: General Event Notification Architecture. IETF Draft.

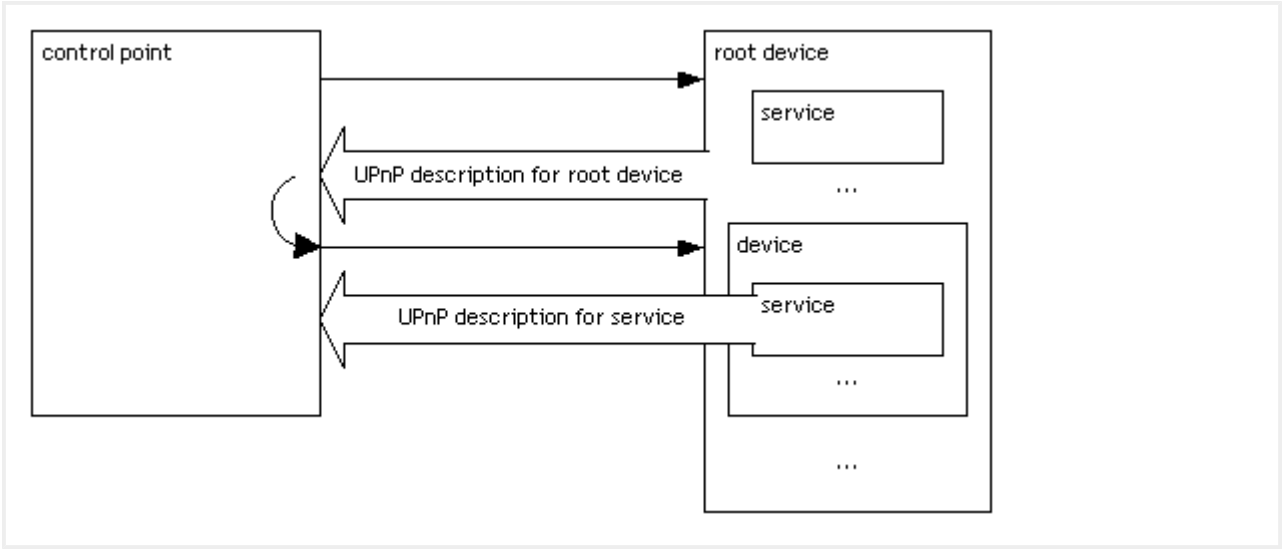
HTTPMU
HTTPU
: HTTP Multicast over UDP, HTTP Unicast over UDP. IETF Draft.

SSDP
: Simple Service Discovery Protocol. IETF Draft.

2. Description

Description is Step 2 in UPnP networking. Description comes after addressing (Step 0) where devices get a network address, and after discovery (Step 1) where control points find interesting device(s). Description enables control (Step 3) where a control points send commands to device(s), eventing (Step 4) where control points listen to state changes in device(s), and presentation (Step 5) where control points display a user interface for device(s).

After a control point has discovered a device, the control point still knows very little about the device -- only the information that was in the discovery message, i.e., the device's (or service's) UPnP type, the device's universally-unique identifier, and a URL to the device's UPnP description. For the control point to learn more about the device and its capabilities, or to interact with the device, the control point must retrieve a description of the device and its capabilities from the URL provided by the device in the discovery message.



The UPnP description for a device is partitioned into two, logical parts: a *device description* describing the physical and logical containers, and one or more *service descriptions* describing the capabilities exposed by the device. A UPnP device description includes vendor-specific, manufacturer information like the model name and number, serial number, manufacturer name, URLs to vendor-specific Web sites, etc. (details below). For each service included in the device, the device description lists the service type, name, a URL for a service description, a URL for control, and a URL for eventing. A device description also includes a description of all embedded devices and a URL for presentation of the aggregate. This section explains UPnP device descriptions, and the sections on Control, Eventing, and Presentation explain how URLs for control, eventing, and presentation are used, respectively.

Note that a single physical device may include multiple logical devices. Multiple logical devices can be modeled as a single root device with embedded devices (and services) or as multiple root devices (perhaps with no embedded devices). In the former case, there is one UPnP device description for the root device, and that device description contains a description for all embedded devices. In the latter case, there are multiple UPnP device descriptions, one for each root device.

A UPnP device description is written by a UPnP vendor. The description is in XML syntax and is usually based on a standard UPnP Device Template. A UPnP Device Template is produced by a UPnP Forum working committee; they derive the template from the UPnP Template Language, which was derived from standard constructions in XML. This section explains the format for a UPnP device description, UPnP Device Templates, and the part of the UPnP Template Language that covers devices.

A UPnP service description includes a list of commands, or *actions*, the service responds to, and parameters, or *arguments*, for each action. A service description 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. This section explains the description of actions, arguments, state variables, and the properties of those variables. The section on Eventing explains event characteristics.

Like a UPnP device description, a UPnP service description is written by a UPnP vendor. The description is in XML syntax and is usually based on a standard UPnP Service Template. A UPnP Service Template is produced by a UPnP Forum working committee; they derived the template from the UPnP Template Language, augmenting it with human language where necessary. The UPnP Template Language is derived from standard constructions in XML. This section explains the format for a UPnP service description, UPnP Service Templates, typical augmentations in human language, and the part of the UPnP Template Language that covers services.

UPnP vendors can differentiate their devices by extending services, including additional UPnP services, or embedding additional devices. When a control point retrieves a particular device's description, these added features are exposed to the control point for control and eventing. The device and service descriptions authoritatively document the implementation of the device.

Retrieving a UPnP device description is simple: the control point issues an HTTP GET request on the URL in the discovery message, and the device returns the device description. Retrieving a UPnP service description is a similar process that uses a URL within the device description. The protocol stack, method, headers, and body for the response and request are explained in detail below.

As long as the discovery advertisements from a device have not expired, a control point may assume that the device and its services are available. The device and service descriptions may be retrieved at any point since the device and service descriptions are static as long

as the device and its services are available. If a device cancels its advertisements, a control point must assume the device and its services are no longer available. If a device needs to change one of these descriptions, it must cancel its outstanding advertisements and re-advertise. Consequently, control points should not assume that device and service descriptions are unchanged if a device re-appears on the network.

Like discovery, description plays an important role in the interoperability of devices and control points using different versions of UPnP networking. As explained in the section on Discovery, The UPnP Device Architecture (defined herein) is versioned with both a major and a minor version. Advances in minor versions must be a compatible superset of earlier minor versions of the same major version. Advances in major version are not required to be supersets of earlier versions and are not guaranteed to be backward compatible. Version information is communicated in description messages as a backup to the information communicated in discovery messages. This section explains the format of version information in description messages.

The remainder of this section first explains how devices are described, explaining details of vendor-specific information, embedded devices, and URLs for control, eventing, and presentation. Second, it explains UPnP Device Templates. Third, it explains how services are described, explaining details of actions, arguments, state variables, and properties of those variables. Then it explains UPnP Service Templates, and the UPnP Template Language. Finally, this section explains in detail how a control point retrieves device and service descriptions from a device.

2.1 Description: Device description

The UPnP description for a device contains several pieces of vendor-specific information, definitions of all embedded devices, URL for presentation of the device, and listings for all services, including URLs for control and eventing. In addition to defining non-standard devices, UPnP vendors may add embedded devices and services to standard devices. To illustrate these, below is a listing with placeholders (in *italics*) for actual elements and values. Some of these placeholders would be specified by a UPnP Forum working committee (colored *red*) or by a UPnP vendor (*purple*). For a non-standard device, all of these placeholders would be specified by a UPnP vendor. (Elements defined by the UPnP Device Architecture are colored **green** for later reference.) Immediately following the listing is a detailed explanation of the elements, attributes, and values.

```
<?xml version="1.0"?>
<root xmlns="urn:schemas-upnp-org:device-1-0">
  <specVersion>
    <major>1</major>
    <minor>0</minor>
  </specVersion>
  <URLBase>base URL for all relative URLs</URLBase>
  <device>
    <deviceType>urn:schemas-upnp-org:device:deviceType:v</deviceType>
    <friendlyName>short user-friendly title</friendlyName>
    <manufacturer>manufacturer name</manufacturer>
    <manufacturerURL>URL to manufacturer site</manufacturerURL>
    <modelDescription>long user-friendly title</modelDescription>
    <modelName>model name</modelName>
    <modelNumber>model number</modelNumber>
    <modelURL>URL to model site</modelURL>
    <serialNumber>manufacturer's serial number</serialNumber>
    <UDN>uuid:UUID</UDN>
    <UPC>Universal Product Code</UPC>
    <iconList>
      <icon>
        <mimetype>image/format</mimetype>
        <width>horizontal pixels</width>
        <height>vertical pixels</height>
        <depth>color depth</depth>
        <url>URL to icon</url>
      </icon>
      XML to declare other icons, if any, go here
    </iconList>
    <serviceList>
      <service>
        <serviceType>urn:schemas-upnp-org:service:serviceType:v</serviceType>
        <serviceId>urn:upnp-org:serviceId:serviceID</serviceId>
        <SCPDURL>URL to service description</SCPDURL>
        <controlURL>URL for control</controlURL>
        <eventSubURL>URL for eventing</eventSubURL>
      </service>
      Declarations for other services defined by a UPnP Forum working committee (if any)
        go here
      Declarations for other services added by UPnP vendor (if any) go here
    </serviceList>
    <deviceList>
      Description of embedded devices defined by a UPnP Forum working committee (if any)
        go here
      Description of embedded devices added by UPnP vendor (if any) go here
    </deviceList>
    <presentationURL>URL for presentation</presentationURL>
  </device>
</root>
```

Listed below are details for each of the elements, attributes, and values appearing in the listing above. All elements and attributes are case sensitive; HTTP specifies case sensitivity for URLs; other values are not case sensitive except where noted. The order of elements is insignificant. Except where noted: required elements must occur exactly once (no duplicates), and recommended or optional elements may occur at most once.

xml
: Required for all XML documents. Case sensitive.

root
: Required. Must have urn:schemas-upnp-org:device-1-0 as the value for the xmlns attribute; this references the UPnP Template Language (described below). Case sensitive. Contains all other elements describing the root device, i.e., contains the following sub elements:

  specVersion
  : Required. Contains the following sub elements:

    major
    : Required. Major version of the UPnP Device Architecture. Must be 1.

    minor
    : Required. Minor version of the UPnP Device Architecture. Must be 0.

URLBase

Optional. Defines the base URL. Used to construct fully-qualified URLs. All relative URLs that appear elsewhere in the description are appended to this base URL. If URLBase is empty or not given, the base URL is the URL from which the device description was retrieved. Specified by UPnP vendor. Single URL.

device

Required. Contains the following sub elements:

deviceType

Required. UPnP device type.

- For standard devices defined by a UPnP Forum working committee, must begin with urn:schemas-upnp-org:device: followed by a device type suffix, colon, and an integer device version (as shown in the listing above).
- For non-standard devices specified by UPnP vendors, must begin with urn:, followed by an ICANN domain name owned by the vendor, followed by :device:, followed by a device type suffix, colon, and an integer version, i.e., urn:*domain-name*:device:*deviceType*:*v*.

The device type suffix defined by a UPnP Forum working committee or specified by a UPnP vendor must be <= 64 chars, not counting the version suffix and separating colon. Single URI.

friendlyName

Required. Short description for end user. Should be localized (cf. ACCEPT-/CONTENT-LANGUAGE headers). Specified by UPnP vendor. String. Should be < 64 characters.

manufacturer

Required. Manufacturer's name. May be localized (cf. ACCEPT-/CONTENT-LANGUAGE headers). Specified by UPnP vendor. String. Should be < 64 characters.

manufacturerURL

Optional. Web site for Manufacturer. May be localized (cf. ACCEPT-/CONTENT-LANGUAGE headers). May be relative to base URL. Specified by UPnP vendor. Single URL.

modelDescription

Recommended. Long description for end user. Should be localized (cf. ACCEPT-/CONTENT-LANGUAGE headers). Specified by UPnP vendor. String. Should be < 128 characters.

modelName

Required. Model name. May be localized (cf. ACCEPT-/CONTENT-LANGUAGE headers). Specified by UPnP vendor. String. Should be < 32 characters.

modelNumber

Recommended. Model number. May be localized (cf. ACCEPT-/CONTENT-LANGUAGE headers). Specified by UPnP vendor. String. Should be < 32 characters.

modelURL

Optional. Web site for model. May be localized (cf. ACCEPT-/CONTENT-LANGUAGE headers). May be relative to base URL. Specified by UPnP vendor. Single URL.

serialNumber

Recommended. Serial number. May be localized (cf. ACCEPT-/CONTENT-LANGUAGE headers). Specified by UPnP vendor. String. Should be < 64 characters.

UDN

Required. Unique Device Name. Universally-unique identifier for the device, whether root or embedded. Must be the same over time for a specific device instance (i.e., must survive reboots). Must match the value of the NT header in device discovery messages. Must match the prefix of the USN header in all discovery messages. (The section on Discovery explains the NT and USN headers.) Must begin with uuid: followed by a UUID suffix specified by a UPnP vendor. Single URI.

UPC

Optional. Universal Product Code. 12-digit, all-numeric code that identifies the consumer package. Managed by the Uniform Code Council. Specified by UPnP vendor. Single UPC.

iconList

Required if and only if device has one or more icons. Specified by UPnP vendor. Contains the following sub elements:

icon

Recommended. Icon to depict device in a control point UI. May be localized (cf. ACCEPT-/CONTENT-LANGUAGE headers). Recommend one icon in each of the following sizes (width x height x depth): 16x16x1, 16x16x8, 32x32x1, 32x32x8, 48x48x1, 48x48x8. Contains the following sub elements:

mimetype

Required. Icon's MIME type (cf. RFC 2387). Single MIME image type.

width

Required. Horizontal dimension of icon in pixels. Integer.

height

Required. Vertical dimension of icon in pixels. Integer.

depth

Required. Number of color bits per pixel. Integer.

url

Required. Pointer to icon image. (XML does not support direct embedding of binary data. See note below.) Retrieved via HTTP. May be relative to base URL. Specified by UPnP vendor. Single URL.

serviceList

Required. Contains the following sub elements:

service

Required. Repeated once for each service defined by a UPnP Forum working committee. If UPnP vendor differentiates device by adding additional, standard UPnP services, repeated once for additional service. Contains the following sub elements:

serviceType

Required. UPnP service type. Must not contain a hash character (#, 23 Hex in UTF-8).

- For standard service types defined by a UPnP Forum working committee, must begin with urn:**schemas-upnp-org**:**service**: followed by a service type suffix, colon, and an integer service version (as shown in the listing above).
- For non-standard service types specified by UPnP vendors, must begin with urn:, followed by an ICANN domain name owned by the vendor, followed by :**service**:, followed by a service type suffix, colon, and an integer service version, i.e., urn:*domain-name*:**service**:*serviceType*:*v*.

The service type suffix defined by a UPnP Forum working committee or specified by a UPnP vendor must be <= 64 characters, not counting the version suffix and separating colon. Single URI.

serviceId

Required. Service identifier. Must be unique within this device description.

- For standard services defined by a UPnP Forum working committee, must begin with urn:**upnp-org**:**serviceId**: followed by a service ID suffix (as shown in the listing above). (Note that **upnp-org** is used instead of **schemas-upnp-org** in this case because an XML schema is not defined for each service ID.)
- For non-standard services specified by UPnP vendors, must begin with urn:, followed by an ICANN domain name owned by the vendor, followed by :**serviceId**:, followed by a service ID suffix, i.e., urn:*domain-name*:**serviceId**:*serviceID*.

The service ID suffix defined by a UPnP Forum working committee or specified by a UPnP vendor must be <= 64 characters. Single URI.

SCPDURL

Required. URL for service description (nee Service Control Protocol Definition URL). (cf. section below on service description.) May be relative to base URL. Specified by UPnP vendor. Single URL.

controlURL

Required. URL for control (cf. section on Control). May be relative to base URL. Specified by UPnP vendor. Single URL.

eventSubURL

Required. URL for eventing (cf. section on Eventing). May be relative to base URL. Must be unique within the device; no two services may have the same URL for eventing. If the service has no evented variables, it should not have eventing (cf. section on Eventing); if the service does not have eventing, this element must be present but should be empty, i.e., <**eventSubURL**></**eventSubURL**>. Specified by UPnP vendor. Single URL.

deviceList

Required if and only if root device has embedded devices. Contains the following sub elements:

device

Required. Repeat once for each embedded device defined by a UPnP Forum working committee. If UPnP vendor differentiates device by embedding additional UPnP devices, repeat once for each embedded device. Contains sub elements as defined above for root sub element device.

presentationURL

Recommended. URL to presentation for device (cf. section on Presentation). May be relative to base URL. Specified by UPnP vendor. Single URL.

For future extensibility, when processing XML like the listing above, as specified by the Flexible XML Processing Profile (FXPP), devices and control points must ignore: (a) any unknown elements and their sub elements or content, and (b) any unknown attributes and their values.

Note that ampersand character (&, 0x26 in UTF-8) is not allowed in XML. If required as part of the value of an XML element (e.g., a URL), the ampersand character must be converted into & (HTML) or %26 (URL escape code).

XML does not support directly embedding binary data, e.g., icons in UPnP device descriptions. Binary data may be converted into text (and thereby embedded into XML) using an XML data type of either bin.base64 (a MIME-style base 64 encoding for binary data) or bin.hex (hexadecimal digits represent octets). Alternatively, the data can be passed indirectly, as it were, by embedding a URL in the XML and transferring the data in response to a separate HTTP request; the icon(s) in UPnP device descriptions are transferred in this latter

manner.

Devices standardized by UPnP Forum working committees have an integer version. Every later version of a device must be a superset of the previous version, i.e., compared to earlier versions of the device, it must include all embedded devices and services of the same or later version. The UPnP device type remains the same across all versions of a device whereas the device version must be larger for later versions.

2.2 Description: UPnP Device Template

The listing above also illustrates the relationship between a UPnP device description and a UPnP Device Template. As explained above, the UPnP device description is written by a UPnP vendor, in XML, following a UPnP Device Template. A UPnP Device Template is produced by a UPnP Forum working committee as a means to standardize devices.

By appropriate specification of placeholders, the listing above can be either a UPnP Device Template or a UPnP device description. Recall that some placeholders would be defined by a UPnP Forum working committee (colored *red*), i.e., the UPnP device type identifier, required UPnP services, and required UPnP embedded devices (if any). If these were defined, the listing would be a UPnP Device Template, codifying the standard for this type of device. UPnP Device Templates are one of the key deliverables from UPnP Forum working committees.

Taking this another step further, the remaining placeholders in the listing above would be specified by a UPnP vendor (colored *purple*), i.e., vendor-specific information. If these placeholders were specified (as well as the others), the listing would be a UPnP device description, suitable to be delivered to a control point to enable control, eventing, and presentation.

Put another way, the UPnP Device Template defines the overall type of device, and each UPnP device description instantiates that template with vendor-specific information. The first is created by a UPnP Forum working committee; the latter, by a UPnP vendor.

2.3 Description: Service description

The UPnP description for a service defines actions and their arguments, and state variables and their data type, range, and event characteristics.

Each service may have zero or more actions. Each action may have zero or more arguments. Any combination of these arguments may be input or output parameters. If an action has one or more output arguments, one these arguments may be marked as a return value. Each argument should correspond to a state variable. This direct-manipulation programming model reinforces simplicity.

Each service must have one or more state variables.

In addition to defining non-standard services, UPnP vendors may add actions and services to standard devices.

To illustrate these points, below is a listing with placeholders (in *italics*) for actual elements and values. For a standard UPnP service, some of these placeholders would be defined by a UPnP Forum working committee (colored *red*) or specified by a UPnP vendor (*purple*). For a non-standard service, all of these placeholders would be specified by a UPnP vendor. (Elements defined by the UPnP Device Architecture are colored **green** for later reference.) Immediately following the listing is a detailed explanation of the elements, attributes, and values.

```
<?xml version="1.0"?>
<scpd xmlns="urn:schemas-upnp-org:service-1-0">
  <specVersion>
    <major>1</major>
    <minor>0</minor>
  </specVersion>
  <actionList>
    <action>
      <name>actionName</name>
      <argumentList>
        <argument>
          <name>formalParameterName</name>
          <direction>in xor out</direction>
          <retval />
          <relatedStateVariable>stateVariableName</relatedStateVariable>
        </argument>
       Declarations for other arguments defined by UPnP Forum working committee (if any)
          go here
      </argumentList>
    </action>
    Declarations for other actions defined by UPnP Forum working committee (if any)
      go here
    Declarations for other actions added by UPnP vendor (if any) go here
  </actionList>
  <serviceStateTable>
    <stateVariable sendEvents="yes">
      <name>variableName</name>
      <dataType>variable data type</dataType>
      <defaultValue>default value</defaultValue>
      <allowedValueList>
        <allowedValue>enumerated value</allowedValue>
        Other allowed values defined by UPnP Forum working committee (if any) go here
      </allowedValueList>
    </stateVariable>
    <stateVariable sendEvents="yes">
      <name>variableName</name>
      <dataType>variable data type</dataType>
      <defaultValue>default value</defaultValue>
      <allowedValueRange>
        <minimum>minimum value</minimum>
        <maximum>maximum value</maximum>
        <step>increment value</step>
      </allowedValueRange>
    </stateVariable>
    Declarations for other state variables defined by UPnP Forum working committee
      (if any) go here
    Declarations for other state variables added by UPnP vendor (if any) go here
  </serviceStateTable>
</scpd>
```

Listed below are details for each of the elements, attributes, and values appearing in the listing above. All elements and attributes are case sensitive; values are not case sensitive except where noted. Except where noted, the order of elements is insignificant. Except where noted, required elements must occur exactly once (no duplicates), and recommended or optional elements may occur at most once.

xml
: Required for all XML documents. Case sensitive.

scpd
: Required. Must have urn:schemas-upnp-org:service-1-0 as the value for the xmlns attribute; this references the UPnP Template Language (explained below). Case sensitive. Contains all other elements describing the service, i.e., contains the following sub elements:

  specVersion
  : Required. Contains the following sub elements:

    major
    : Required. Major version of the UPnP Device Architecture. Must be 1.

    minor
    : Required. Minor version of the UPnP Device Architecture. Must be 0.

actionList
Required if and only if the service has actions. (Each service may have >= 0 actions.) Contains the following sub element (s):
action
Required. Repeat once for each action defined by a UPnP Forum working committee. If UPnP vendor differentiates service by adding additional actions, repeat once for each additional action. Contains the following sub elements:
name
Required. Name of action. Must not contain a hyphen character (-, 2D Hex in UTF-8) nor a hash character (#, 23 Hex in UTF-8).

- For standard actions defined by a UPnP Forum working committee, must not begin with X_ nor A_.
- For non-standard actions specified by a UPnP vendor and added to a standard service, must begin with X_.

String. Should be < 32 characters.
argumentList
Required if and only if parameters are defined for action. (Each action may have >= 0 parameters.) Contains the following sub element(s):
argument
Required. Repeat once for each parameter. Contains the following sub elements:
name
Required. Name of formal parameter. Should be name of a state variable that models an effect the action causes. Must not contain a hyphen character (-, 2D Hex in UTF-8). String. Should be < 32 characters.
direction
Required. Whether argument is an input or output parameter. Must be in xor out. Any in arguments must be listed before any out arguments.
retval
Optional. Identifies at most one out argument as the return value. If included, must be the first out argument. (Element only; no value.)
relatedStateVariable
Required. Must be the name of a state variable.

serviceStateTable
Required. (Each service must have > 0 state variables.) Contains the following sub element(s):
stateVariable
Required. Repeat once for each state variable defined by a UPnP Forum working committee. If UPnP vendor differentiates service by adding additional state variables, repeat once for each additional variable. sendEvents attribute defines whether event messages will be generated when the value of this state variable changes; non-evented state variables have sendEvents="no"; default is sendEvents="yes". Contains the following sub elements:
name
Required. Name of state variable. Must not contain a hyphen character (-, 2D Hex in UTF-8).

- For standard variables defined by a UPnP Forum working committee, must not begin with X_ nor A_.
- For non-standard variables specified by a UPnP vendor and added to a standard service, must begin with X_.

String. Should be < 32 characters.
dataType
Required. Same as data types defined by XML Schema, Part 2: Datatypes. Defined by a UPnP Forum working committee for standard state variables; specified by UPnP vendor for extensions. Must be one of the following values:
ui1
Unsigned 1 Byte int. Same format as int without leading sign.
ui2
Unsigned 2 Byte int. Same format as int without leading sign.
ui4
Unsigned 4 Byte int. Same format as int without leading sign.
i1
1 Byte int. Same format as int.
i2
2 Byte int. Same format as int.
i4
4 Byte int. Same format as int. Must be between -2147483648 and 2147483647.
int
Fixed point, integer number. May have leading sign. May have leading zeros. (No currency symbol.) (No grouping of digits to the left of the decimal, e.g., no commas.)
r4
4 Byte float. Same format as float. Must be between 3.40282347E+38 to 1.17549435E-38.
r8

8 Byte float. Same format as float. Must be between -1.79769313486232E308 and -4.94065645841247E-324 for negative values, and between 4.94065645841247E-324 and 1.79769313486232E308 for positive values, i.e., IEEE 64-bit (8-Byte) double.

number
Same as r8.

fixed.14.4
Same as r8 but no more than 14 digits to the left of the decimal point and no more than 4 to the right.

float
Floating point number. Mantissa (left of the decimal) and/or exponent may have a leading sign. Mantissa and/or exponent may have leading zeros. Decimal character in mantissa is a period, i.e., whole digits in mantissa separated from fractional digits by period. Mantissa separated from exponent by E. (No currency symbol.) (No grouping of digits in the mantissa, e.g., no commas.)

char
Unicode string. One character long.

string
Unicode string. No limit on length.

date
Date in a subset of ISO 8601 format without time data.

dateTime
Date in ISO 8601 format with optional time but no time zone.

dateTime.tz
Date in ISO 8601 format with optional time and optional time zone.

time
Time in a subset of ISO 8601 format with no date and no time zone.

time.tz
Time in a subset of ISO 8601 format with optional time zone but no date.

boolean
0, false, or no for false; 1, true, or yes for true.

bin.base64
MIME-style Base64 encoded binary BLOB. Takes 3 Bytes, splits them into 4 parts, and maps each 6 bit piece to an octet. (3 octets are encoded as 4.) No limit on size.

bin.hex
Hexadecimal digits representing octets. Treats each nibble as a hex digit and encodes as a separate Byte. (1 octet is encoded as 2.) No limit on size.

uri
Universal Resource Identifier.

uuid
Universally Unique ID. Hexadecimal digits representing octets. Optional embedded hyphens are ignored.

defaultValue
Recommended. Expected, initial value. Defined by a UPnP Forum working committee or delegated to UPnP vendor. Must match data type. Must satisfy allowedValueList or allowedValueRange constraints.

allowedValueList
Recommended. Enumerates legal string values. Prohibited for data types other than string. At most one of allowedValueRange and allowedValueList may be specified. Sub elements are ordered (e.g., see NEXT_STRING_BOUNDED). Contains the following sub elements:

allowedValue
Required. A legal value for a string variable. Defined by a UPnP Forum working committee for standard state variables; specified by UPnP vendor for extensions. string. Should be < 32 characters.

allowedValueRange
Recommended. Defines bounds for legal numeric values; defines resolution for numeric values. Defined only for numeric data types. At most one of allowedValueRange and allowedValueList may be specified. Contains the following sub elements:

minimum
Required. Inclusive lower bound. Defined by a UPnP Forum working committee or delegated to UPnP vendor. Single numeric value.

maximum
Required. Inclusive upper bound. Defined by a UPnP Forum working committee or delegated to UPnP vendor. Single numeric value.

step
Recommended. Size of an increment operation, i.e., value of *s* in the operation *v* = *v* + *s*. Defined by a UPnP Forum working committee or delegated to UPnP vendor. Single numeric value.

For future extensibility, when processing XML like the listing above, as specified by the Flexible XML Processing Profile (FXPP), devices and control points must ignore: (a) any unknown elements and their sub elements or content, and (b) any unknown attributes and their values.

Note that ampersand character (&, 26 Hex in UTF-8) is not allowed in XML. If required as part of the value of an XML element (e.g., a URL), the ampersand character must be converted into & (HTML) or %26 (URL escape code).

Note that it is logically possible for a service to have no actions but have state variables and eventing; though unlikely, such a service would be an autonomous information source. However, a service with no state variables is prohibited.

Unlike device descriptions, service descriptions and associated values should not use locale-specific values; this includes service descriptions, values of action arguments, and values of state variables. Instead, most action arguments and state variables should use values that are expressed in a locale-independent manner; applications should convert and/or format the information from a standard form into the correct language and/or format for the locale. For example, dates are represented in a locale-independent format (ISO 8601), and integers are represented without locale-specific formatting (e.g., no currency symbol, no grouping of digits). String values should be represented in either a standard 'locale' or in a locale-independent manner. Variables with an allowedValueList should use token values in the language of UPnP standards and not reflect strings intended to be displayed in a localized user interface.

However, there may be some cases where an action's behavior is locale-dependent. In this case, an argument should be defined to indicate the locale, perhaps using the same encoding as the ACCEPT-/CONTENT-LANGUAGE headers (RFC 1766). If there are multiple locale-dependent actions, the service may include an action to set a state variable to indicate the locale and eliminate the need to pass a locale identifier separately to each action.

Services standardized by UPnP Forum working committees have an integer version. Every later version of a service must be a superset of the previous version, i.e., it must include all actions and state variables exactly as they are defined by earlier versions of the service. The UPnP service type remains the same across all versions of a service whereas the service version must be larger for later versions.

2.4 Description: UPnP Service Template

The listing above also illustrates the relationship between a UPnP service description and a UPnP Service Template. As explained above, the UPnP description for a service is written by a UPnP vendor, in XML, following a UPnP Service Template. A UPnP Service Template is produced by a UPnP Forum working committee as a means to standardize devices.

By appropriate specification of placeholders, the listing above can be either a UPnP Service Template or a UPnP service description. Recall that some placeholders would be defined by a UPnP Forum working committee (colored *red*), i.e., actions and their parameters, and states and their data type, range, and event characteristics. If these were specified, the listing above would be a UPnP Service Template, codifying the standard for this type of service. Along with UPnP Device Templates (cf. section on Description), UPnP Service Templates are one of the key deliverables from UPnP Forum working committees.

Taking this another step further, the remaining placeholders in the listing above would be specified by a UPnP vendor (colored *purple*), i.e., additional, vendor-specified actions and state variables. If these placeholders were specified (as well as the others), the listing would be a UPnP service description, suitable for effective control of the service within a device.

Put another way, the UPnP Service Template defines the overall type of service, and each UPnP service description instantiates that template with vendor-specific additions. The first is created by a UPnP Forum working committee; the latter, by a UPnP vendor.

2.5 Description: Non-standard vendor extensions

As explained above, UPnP vendors may differentiate their devices and extend a standard device by including additional services, embedded devices. Similarly, UPnP vendors may extend a standard service by including additional actions or state variables. UPnP vendors must not extend a standard service by modifying a standardized allowedValueList. Naming conventions for each of these are listed in the table below and explained in detail above.

Type of extension	Standard	Non-Standard
device type	urn:schemas-upnp-org:device:*deviceType*:*v*	urn:*domain-name*:device:*deviceType*:*v*
service type	urn:schemas-upnp-org:service:*serviceType*:*v*	urn:*domain-name*:service:*serviceType*:*v*
service ID	urn:upnp-org:serviceId:*serviceID*	urn:*domain-name*:serviceId:*serviceID*
action name	Does not begin with X_ or A_.	Begins with X_.
state variable name	Does not begin with X_ or A_.	Begins with X_.
XML elements in device or service description	Defined by the UPnP Template Language.	Arbitrary XML scoped by an XML namespace and nested within an element that begins with X_.

XML attributes in device or service description	Defined by the UPnP Template Language.	Arbitrary attributes scoped by an XML namespace and begin with X_.

As the last two rows of the table above indicate, UPnP vendors may also add non-standard XML to a device or service description. Each addition must be scoped by a vendor-supplied XML namespace. Arbitrary XML must be enclosed in an element that begins with X_, and this element must be a sub element of standard element that contains sub elements. Non-standard attributes may be added to standard elements provided these attributes are scoped by an XML namespace and begin with X_.

To illustrate this, below are listings with placeholders (in *italics*) for actual elements and values. Some of these placeholders would be specified by a UPnP vendor (*purple*) and some are defined by the UPnP Device Architecture (green).

```
<RootStandardElement xmlns="urn:schemas-upnp-org:device-1-0"
    xmlns:n="domain-name:schema-name">
  other XML
  <AnyStandardElement n:X_VendorAttribute="arbitrary string value">
    other XML
  </AnyStandardElement>
  other XML
</RootStandardElement>
```

RootStandardElement

Required. A standard root element. xmlns attribute defines namespaces, in this case, a standard UPnP namespace and a non-standard namespace with the prefix *n*.

- For device descriptions, must be root.
- For service descriptions, must be scpd.

AnyStandardElement

Required. Any standard element, root or otherwise, content of text or element only. Must already be included as part of the standard device or service description. X_*VendorAttribute* must begin with X_. (Prefix A_ is reserved.) May have an arbitrary string value.

```
<EltOnlyStandardElement n:X_VendorAttribute="vendor value">
  <n:X_VendorElement xmlns:n="domain-name:schema-name">
    arbitrary XML
  </n:X_VendorElement>
</EltOnlyStandardElement>
```

EltOnlyStandardElement

Required. Element with content of element only. Must already be included as part of the standard device or service description.

- For device descriptions, must be one of: root, specVersion, device, iconList, icon, serviceList, service, and/or deviceList.
- For service descriptions, must be one of: scpd, actionList, action, argumentList, argument, serviceStateTable, stateVariable, allowedValueList, and/or allowedValueRange.

X_*VendorElement*

Required. Must begin with X_. (Prefix A_ is reserved.) Must have a value for the xmlns attribute. May contain arbitrary XML.

As specified by the Flexible XML Processing Profile (FXPP), control points that do not understand these XML additions must ignore them.

2.6 Description: UPnP Template Language for devices

The paragraphs above explain UPnP device descriptions and illustrate how one would be instantiated from a UPnP Device Template. As explained, UPnP Device Templates are produced by UPnP Forum working committees, and these templates are derived from the UPnP Template Language. This template language defines valid templates for devices and services. Below is a listing and explanation of this language as it pertains to devices.

The UPnP Template Language is written in XML syntax and is derived from XML Schema (Part 1: Structures, Part 2: Datatypes). XML Schema provides a set of XML constructions that express language concepts like required vs. optional elements, element nesting, and data types for values (as well as other properties not of interest here). The UPnP Template Language uses these XML Schema constructions to define elements like specVersion, URLBase, deviceType, et al listed in detail above. Because the UPnP Template Language is constructed using another, precise language, it is unambiguous. And because the UPnP Template Language, UPnP Device Templates, and UPnP device descriptions are all machine-readable, automated tools can automatically check to ensure the latter two have all required elements, are correctly nested, and have values of the correct data types.

Below is the UPnP Template Language for devices as defined by the UPnP Device Architecture herein. The elements it defines are used in UPnP Device Templates; they are colored **green** here, and they are colored **green** in the listing above. Below is where these elements are defined; above is where they are used.

Immediately following this is a brief explanation of the XML Schema elements, attributes, and values used. The reference to XML Schema at the end of the section has further details.

UPnP Template Language for devices

```
<?xml version="1.0"?>
<Schema name="device-1-0"
    xmlns="urn:schemas-microsoft-com:xml-data"
    xmlns:dt="urn:schemas-microsoft-com:datatypes">
  <ElementType name="root" content="eltOnly">
    <element type="specVersion" />
    <element type="URLBase" minOccurs="0" maxOccurs="1" />
    <element type="device" />
  </ElementType>
  <ElementType name="specVersion" content="eltOnly">
    <element type="major" />
    <element type="minor" />
  </ElementType>
  <ElementType name="major" dt:type="int" content="textOnly" />
  <ElementType name="minor" dt:type="int" content="textOnly" />
  <ElementType name="URLBase" dt:type="uri" content="textOnly" />
  <ElementType name="device" content="eltOnly">
    <element type="deviceType" />
    <element type="friendlyName" />
    <element type="manufacturer" />
    <element type="manufacturerURL" minOccurs="0" maxOccurs="1" />
    <element type="modelDescription" minOccurs="0" maxOccurs="1" />
    <element type="modelName" />
    <element type="modelNumber" minOccurs="0" maxOccurs="1" />
    <element type="modelURL" minOccurs="0" maxOccurs="1" />
    <element type="serialNumber" minOccurs="0" maxOccurs="1" />
    <element type="UDN" />
    <element type="UPC" minOccurs="0" maxOccurs="1" />
    <element type="iconList" minOccurs="0" maxOccurs="1" />
    <element type="serviceList" />
    <element type="deviceList" minOccurs="0" maxOccurs="1" />
    <element type="presentationURL" minOccurs="0" maxOccurs="1" />
  </ElementType>
  <ElementType name="deviceType" dt:type="uri" content="textOnly" />
  <ElementType name="friendlyName" dt:type="string" content="textOnly" />
  <ElementType name="manufacturer" dt:type="string" content="textOnly" />
  <ElementType name="manufacturerURL" dt:type="uri" content="textOnly" />
  <ElementType name="modelDescription" dt:type="string" content="textOnly" />
  <ElementType name="modelName" dt:type="string" content="textOnly" />
  <ElementType name="modelNumber" dt:type="string" content="textOnly" />
  <ElementType name="modelURL" dt:type="uri" content="textOnly" />
  <ElementType name="serialNumber" dt:type="string" content="textOnly" />
  <ElementType name="UDN" dt:type="uri" content="textOnly" />
  <ElementType name="UPC" dt:type="string" content="textOnly" />
  <ElementType name="iconList" content="eltOnly">
    <element type="icon" minOccurs="1" maxOccurs="*" />
  </ElementType>
  <ElementType name="icon" content="eltOnly">
    <element type="mimetype" />
    <element type="width" />
    <element type="height" />
    <element type="depth" />
    <element type="url" />
  </ElementType>
  <ElementType name="mimetype" dt:type="string" content="textOnly" />
  <ElementType name="width" dt:type="int" content="textOnly" />
  <ElementType name="height" dt:type="int" content="textOnly" />
  <ElementType name="depth" dt:type="int" content="textOnly" />
  <ElementType name="url" dt:type="uri" content="textOnly" />
  <ElementType name="serviceList" content="eltOnly">
    <element type="service" minOccurs="1" maxOccurs="*" />
  </ElementType>
  <ElementType name="service" content="eltOnly">
    <element type="serviceType" />
    <element type="serviceId" />
    <element type="SCPDURL" />
    <element type="controlURL" />
    <element type="eventSubURL" />
  </ElementType>
  <ElementType name="serviceType" dt:type="uri" content="textOnly" />
  <ElementType name="serviceId" dt:type="uri" content="textOnly" />
  <ElementType name="SCPDURL" dt:type="uri" content="textOnly" />
```

```
  <ElementType name="controlURL" dt:type="uri" content="textOnly" />
  <ElementType name="eventSubURL" dt:type="uri" content="textOnly" />
  <ElementType name="deviceList" content="eltOnly">
    <element type="device" minOccurs="1" maxOccurs="*" />
  </ElementType>
  <ElementType name="presentationURL" dt:type="uri" content="textOnly" />
</Schema>
```

ElementType
: Defines an element in the new, derived language. name attribute defines element name. dt:type attribute defines the data type for the value of element in the new, derived language.

element
: References an element for the purposes of declaring nesting. minOccurs attribute defines minimum number of times the element must occur; default is minOccurs = 1; optional elements have minOccurs = 0. maxOccurs attribute defines maximum number of times the element must occur; default is maxOccurs = 1; elements that can appear one or more times have maxOccurs = *.

2.7 Description: UPnP Template Language for services

The paragraphs above explain UPnP service descriptions and illustrate how one would be instantiated from a UPnP Service Template. Like UPnP Device Templates, UPnP Service Templates are produced by UPnP Forum working committees, and these templates are derived from the UPnP Template Language. This template language defines valid templates for devices and services. As explained above, the UPnP Template Language is written in XML syntax and is derived from XML Schema (Part 1: Structures, Part 2: Datatypes). Below is a listing of this language as it pertains to services. The elements it defines are used in UPnP Service Templates; they are colored **green** here, and they are colored **green** in the listing above. Below is where these elements are defined; above is where they are used.

Immediately following this is a brief explanation of the XML Schema elements, attributes, and values used. The reference to XML Schema at the end of the section has further details.

UPnP Template Language for services

```
<?xml version="1.0"?>
<Schema name="service-1-0"
    xmlns="urn:schemas-microsoft-com:xml-data"
    xmlns:dt="urn:schemas-microsoft-com:datatypes">
  <ElementType name="scpd" content="eltOnly">
    <element type="specVersion" />
    <element type="actionList" minOccurs="0" maxOccurs="1" />
    <element type="serviceStateTable" />
  </ElementType>
  <ElementType name="specVersion" content="eltOnly">
    <element type="major" />
    <element type="minor" />
  </ElementType>
  <ElementType name="major" dt:type="int" content="textOnly" />
  <ElementType name="minor" dt:type="int" content="textOnly" />
  <ElementType name="actionList" content="eltOnly">
    <element type="action" minOccurs="1" maxOccurs="*" />
  </ElementType>
  <ElementType name="action" content="eltOnly">
    <element type="name" />
    <element type="argumentList" minOccurs="0" maxOccurs="1" />
  </ElementType>
  <ElementType name="name" dt:type="string" content="textOnly" />
  <ElementType name="argumentList" content="eltOnly">
    <element type="argument" minOccurs="1" maxOccurs="*" />
  </ElementType>
  <ElementType name="argument" content="eltOnly">
    <element type="name" />
    <element type="direction" />
    <element type="retval" minOccurs="0" maxOccurs="1" />
    <element type="relatedStateVariable" />
  </ElementType>
  <ElementType name="direction" dt:type="string" content="textOnly" />
  <ElementType name="retval" content="empty" />
  <ElementType name="relatedStateVariable" dt:type="string" content="textOnly" />
  <ElementType name="serviceStateTable" content="eltOnly">
    <element type="stateVariable" minOccurs="1" maxOccurs="*" />
  </ElementType>
  <ElementType name="stateVariable" content="eltOnly">
    <element type="name" />
    <element type="dataType" />
    <element type="defaultValue" minOccurs="0" maxOccurs="1" />
    <group minOccurs="0" maxOccurs="1" order="one">
      <element type="allowedValueList" />
      <element type="allowedValueRange" />
    </group>
    <AttributeType name="sendEvents" />
    <attribute default="yes" type="sendEvents" required="no" />
  </ElementType>
  <ElementType name="dataType" dt:type="string" content="textOnly" />
  <ElementType name="defaultValue" dt:type="string" content="textOnly" />
  <ElementType name="allowedValueList" content="eltOnly">
    <element type="allowedValue" minOccurs="1" maxOccurs="*" />
  </ElementType>
  <ElementType name="allowedValue" content="textOnly" />
  <ElementType name="allowedValueRange" content="eltOnly">
    <element type="minimum" />
    <element type="maximum" />
    <element type="step" minOccurs="0" maxOccurs="1" />
  </ElementType>
  <ElementType name="minimum" dt:type="number" content="textOnly" />
  <ElementType name="maximum" dt:type="number" content="textOnly" />
  <ElementType name="step" dt:type="number" content="textOnly" />
</Schema>
```

attribute

References an attribute in the new, derived language for the purposes of declaring in which elements it may appear. Like any XML element, the AttributeType element may have attributes of its own. Using the required attribute within this element

indicates whether the attribute must be present; optional attributes have required = no.

AttributeType
: Defines an attribute in the new, derived language. Like any XML element, the AttributeType element may have attributes of its own. Using the name attribute within this element defines the name of the attribute as it will be used in the derived language.

element
: References an element for the purposes of declaring nesting. minOccurs attribute defines minimum number of times the element must occur; default is minOccurs = 1; optional elements have minOccurs = 0. maxOccurs attribute defines maximum number of times the element must occur; default is maxOccurs = 1; elements that can appear one or more times have maxOccurs = *.

ElementType
: Defines an element in the new, derived language. name attribute defines element name. dt:type attribute defines the data type for the value of element in the new, derived language. model attribute indicates whether elements in the new, derived language can contain elements not explicitly specified here; when only previously specific elements may be used, model = closed. content attribute indicates what content may contain; elements that contain only other elements have content = eltOnly; elements that contain only strings have content = textOnly.

  group
  : Organizes content into a group to specify a sequence. minOccurs attribute defines minimum number of times the group must occur. maxOccurs attribute defines maximum number of times the group must occur. order attribute constrains the sequence of elements; when at most one element is allowed, order = one.

2.8 Description: Augmenting the UPnP Template Language

Some properties of services are difficult to capture in the XML Schema formalism. In particular, it is useful to describe the effect actions have on state variables. This procedural information is awkward to describe in a declarative language like XML, so below is a recommended vocabulary for UPnP Forum working committees to use when defining service actions or for UPnP vendors to use when they wish to document the effects of extra actions.

ASSIGN (*v*, *a*)
: Variable *v* becomes the value of argument *a*, i.e., *v* = *a*. *v* and *a* must be the same data type.

DECREMENT (*v*)
: Equivalent to INCREMENT (*v*) with allowedValueRange step treated as -step.

DECREMENT_BOUNDED (*v*)
: Equivalent to INCREMENT_BOUNDED (*v*) with allowedValueRange step treated as -step.

DECREMENT_WRAP (*v*)
: Equivalent to INCREMENT_WRAP (*v*) with allowedValueRange step treated as -step.

INCREMENT (*v*)
: Variable *v* becomes the value of *v* plus allowedValueRange step, i.e., *v* = *v* + step. Equivalent to DECREMENT (*v*) with allowedValueRange step treated as -step. *v* must have a numeric data type and must have an allowedValueRange definition.

INCREMENT_BOUNDED (*v*)
: Variable *v* becomes the value of *v* plus allowedValueRange step, i.e., *v* = *v* + step.
  If step is greater than 0 and if *v* plus step would be greater than allowedValueRange maximum, then *v* becomes maximum.
  If step is less than 0 and if *v* plus step would be less than allowedValueRange minimum, then *v* becomes minimum.
  Equivalent to DECREMENT_BOUNDED (*v*) with allowedValueRange step treated as -step. *v* must have a numeric data type and must have an allowedValueRange definition.

INCREMENT_WRAP (*v*, *c*)
: Variable *v* becomes the value of *v* plus allowedValueRange step, i.e., *v* = *v* + step.
  If step is greater than 0, and if *v* plus step would be greater than allowedValueRange maximum, then *v* becomes minimum plus step minus 1, i.e., *v* = minimum + step - 1; if step is 1, this simplifies to *v* = minimum.
  If step is less than 0 and if *v* plus step would be less than allowedValueRange minimum, then *v* becomes maximum plus step plus 1, i.e., *v* = maximum + step + 1; if step is -1, this simplifies to *v* = maximum.
  Equivalent to DECREMENT_WRAP (*v*) with allowedValueRange step treated as -step. *v* must have a numeric data type and must have an allowedValueRange definition.

NEXT_STRING_BOUNDED (*v*)
: Variable *v* becomes the next allowedValue after the current value of *v*. If *v* was already the last allowedValue, then *v* does not change. *v* must be a string data type and must have an allowedValueList definition.

NEXT_STRING_WRAP (*v*)
: Variable *v* becomes the next allowedValue after the current value of *v*. If *v* was already the last allowedValue, then *v* becomes the first allowedValue. *v* must be a string data type and must have an allowedValueList definition.

PREV_STRING_BOUNDED (*v*)
: Variable *v* becomes the previous allowedValue before the current value of *v*. If *v* was already the first allowedValue, then *v* does not change. *v* must be a string data type and must have an allowedValueList definition.

PREV_STRING_WRAP (*v*)
: Variable *v* becomes the previous allowedValue before the current value of *v*. If *v* was already the first allowedValue, then *v* becomes the last allowedValue. *v* must be a string data type and must have an allowedValueList definition.

SET (*v*, *c*)
: Variable *v* becomes the value of constant *c*, i.e., *v* = *c*. *v* and *c* must be the same data type.

TOGGLE (*v*)
: Variable *v* becomes the boolean negation of the value of *v*, i.e., *v* = NOT *v*. *v* must be boolean.

2.9 Description: Retrieving a description

As explained above, after a control point has discovered a device, it still knows very little about the device. To learn more about the device and its capabilities, the control point must retrieve the UPnP description for the device using the URL provided by the device in the discovery message. Then, the control point must retrieve one or more service descriptions using the URL(s) provided in the device description. This is a simple HTTP-based process and uses the following subset of the overall UPnP protocol stack. (The overall UPnP protocol stack is listed at the beginning of this document.)

UPnP vendor [purple]
UPnP Forum [red]
UPnP Device Architecture [green]
HTTP [black]
TCP [black]
IP [black]

At the highest layer, description messages contain vendor-specific information, e.g., device type, service type, and required services. Moving down the stack, vendor content is supplemented by information from a UPnP Forum working committee, e.g., model name, model number, and specific URLs. Messages from the layers above are hosted in UPnP-specific protocols, defined in this document. In turn, the above messages are delivered via HTTP over TCP over IP. For reference, colors in [square brackets] above indicate which protocol defines specific header and body elements in the description messages listed below.

Using this protocol stack, retrieving the UPnP device description is simple: the control point issues an HTTP GET request to the URL in the discovery message, and the device returns its description in the body of an HTTP response. Similarly, to retrieve a UPnP service description, the control point issues an HTTP GET request to the URL in the device description, and the device returns the description in the body of an HTTP response. The headers and body for the response and request are explained in detail below.

First, a control point must send a request with method GET in the following format. Values in *italics* are placeholders for actual values.

```
GET path to description HTTP/1.1
HOST: host for description:port for description
ACCEPT-LANGUAGE: language preferred by control point
```

(No body for request to retrieve a description, but note that the message must have a blank line following the last HTTP header.)

Listed below are details for the request line and headers appearing in the listing above. All header values are case sensitive except where noted.

Request line

GET
: Method defined by HTTP.

path to description
: Path component of device description URL (LOCATION header in discovery message) or of service description URL (SCPDURL element in device description). Single, relative URL.

HTTP/1.1
: HTTP version.

Headers

HOST
: Required. Domain name or IP address and optional port components of device description URL (LOCATION header in discovery message) or of service description URL (SCPDURL element of device description). If the port is empty or not given, port 80 is assumed.

ACCEPT-LANGUAGE
: Recommended for retrieving device descriptions. Preferred language(s) for description. If no description is available in this language, device may return a description in a default language. RFC 1766 language tag(s).

After a control point sends a request, the device takes the second step and responds with a copy of its description. Including expected transmission time, a device must respond within 30 seconds. If it fails to respond within this time, the control point should re-send the request. A device must send a response in the following format. Values in *italics* are placeholders for actual values.

```
HTTP/1.1 200 OK
CONTENT-LANGUAGE: language used in description
CONTENT-LENGTH: Bytes in body
CONTENT-TYPE: text/xml
DATE: when responded
```

The body of this response is a UPnP device or service description as explained in detail above.

Listed below are details for the headers appearing in the listing above. All header values are case sensitive except where noted.

Headers

CONTENT-LANGUAGE
: Required if and only if request included an ACCEPT-LANGUAGE header. Language of description. RFC 1766 language tag(s).

CONTENT-LENGTH
: Required. Length of body in Bytes. Integer.

CONTENT-TYPE
: Required. Must be text/xml.

DATE
: Recommended. When response was generated. RFC 1123 date.

SERVER
: (No SERVER header is required for description messages.)

2.10 Description references

FXPP
: Flexible XML Processing Profile. Specifies that unknown XML elements and their sub elements must be ignored. IETF draft.

ISO 8601
: ISO (International Organization for Standardization). Representations of dates and times, 1988-06-15. Available at: <http://www.iso.ch/markete/8601.pdf>.

RFC 1123
: Includes format for dates, for, e.g., HTTP DATE header. IETF request for comments.

RFC 1766
: Format for language tag for, e.g., HTTP ACCEPT-LANGUAGE header. IETF request for comments.

RFC 2387
: Format for representing content type, e.g., mimetype element for an icon. IETF request for comments.

UPC
: Universal Product Code. 12-digit, all-numeric code that identifies the consumer package. Managed by the Uniform Code Council. <http://www.uc-council.org/main/ID_Numbers_and_Bar_Codes.html>.

XML
: Extensible Markup Language. W3C recommendation.

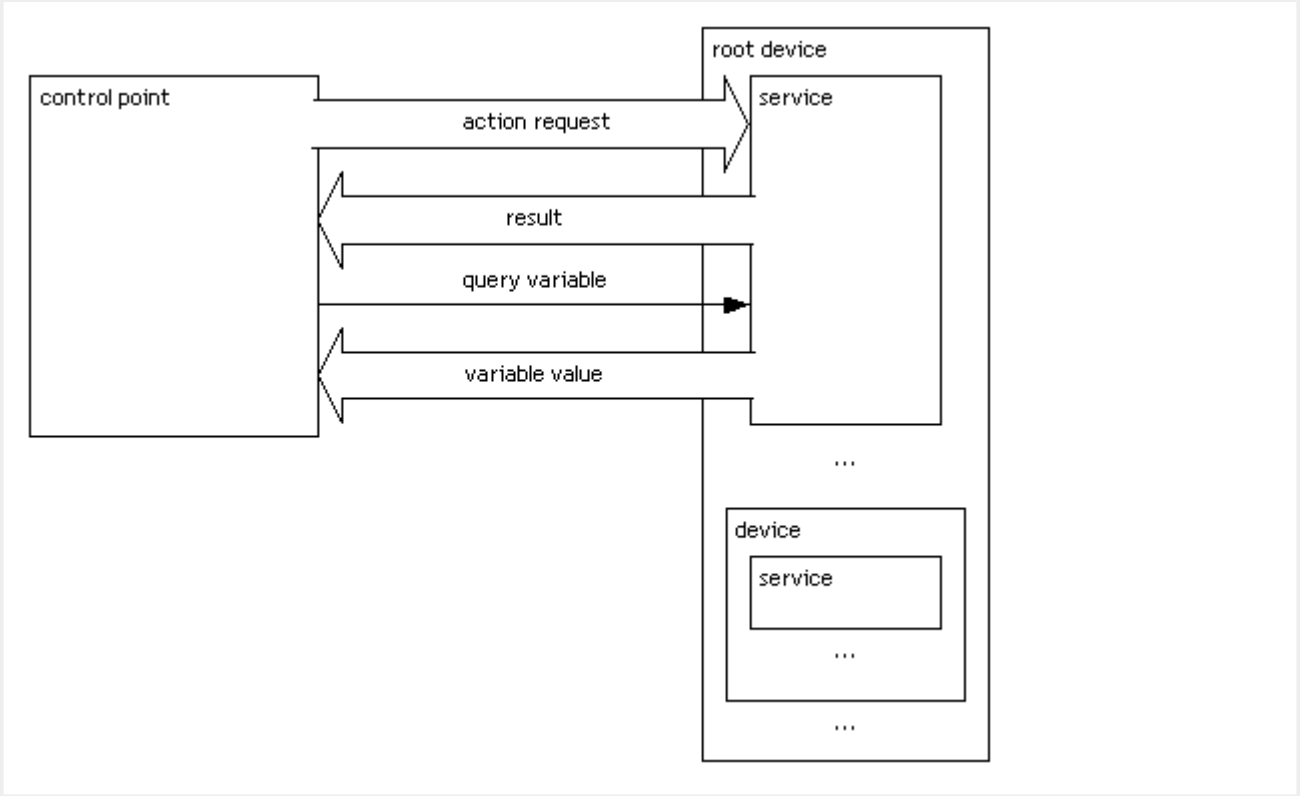
XML Schema (Part 1: Structures, Part 2: Datatypes)
: Grammar defining UPnP Template Language. Defined using XML. W3C working draft. Part 1: Structures. Part 2: Datatypes.

3. Control

Control is Step 3 in UPnP networking. Control comes after addressing (Step 0) where devices get a network address, after discovery (Step 1) where control points find interesting device(s), and after description (Step 2) where control points learn about device capabilities. Control is independent of eventing (Step 4) where control points listen to state changes in device(s). Through control, control points invoke actions on devices and poll for values. Control and eventing are complementary to presentation (Step 5) where control points display a user interface provided by device(s).

Control is the third step in UPnP networking. Given knowledge of a device and its services, a control point can ask those services to invoke actions and the control point can poll those services for the values of their state variables. Invoking actions is a kind of remote

procedure call; a control point sends the action to the device's service, and when the action has completed (or failed), the service returns any results or errors. Polling for the value of state variables is a special case of this scenario where the action and its results are predefined.



To control a device, a control point invokes an action on the device's service. To do this, a control point sends a suitable control message to the control URL for the service (provided in the controlURL sub element of service element of device description). In response, the service returns any results or errors from the action. The effects of the action, if any, may also be modeled by changes in the variables that describe the run-time state of the service. When these state variables change, events are published to all interested control points. This section explains the protocol stack for, and format of, control messages. The section on Eventing explains event publication.

To determine the current value of a state variable, a control point may poll the service. Similar to invoking an action, a control point sends a suitable query message to the control URL for the service. In response, the service provides the value of the variable; each service is responsible for keeping its state table consistent so control points can poll and receive meaningful values. This section also explains the format of these query messages. The section on eventing explains automatic notification of variable values.

As long as the discovery advertisements from a device have not expired, a control point may assume that the device and its services are available. If a device cancels its advertisements, a control point must assume the device and its services are no longer available.

While UPnP does define a means to invoke actions and poll for values, UPnP does not specify or constrain the design of an API for applications running on control points; OS vendors may create APIs that suit their customer's needs.

The remainder of this section explains in detail how control and query messages are formatted and sent to devices.

3.1 Control: Protocols

To invoke actions and poll for values, control points (and devices) use the following subset of the overall UPnP protocol stack. (The overall UPnP protocol stack is listed at the beginning of this document.)

UPnP vendor [purple]
UPnP Forum [red]

UPnP Device Architecture [green]
SOAP [blue]
HTTP [black]
TCP [black]
IP [black]

At the highest layer, control messages contain vendor-specific information, e.g., argument values. Moving down the stack, vendor content is supplemented by information from a UPnP Forum working committee, e.g., action names, argument names, variable names. Messages from the layers above are hosted in UPnP-specific protocols, defined in this document. In turn, the above messages are formatted using a Simple Object Access Protocol (SOAP) header and body elements, and the messages are delivered via HTTP over TCP over IP. For reference, colors in [square brackets] above indicate which protocol defines specific header elements in the subscription messages listed below.

3.2 Control: Action

Control points may invoke actions on a device's services and receive results or errors back. The action, results, and errors are encapsulated in SOAP, sent via HTTP requests, and received via HTTP responses.

3.2.1 Control: Action: Invoke

The Simple Object Access Protocol (SOAP) defines the use of XML and HTTP for remote procedure calls. UPnP uses SOAP to deliver control messages to devices and return results or errors back to control points.

SOAP defines additional HTTP headers, and to ensure that these are not confused with other HTTP extensions, SOAP follows the HTTP Extension Framework and specifies a SOAP-unique URI in the MAN header and prefixes the HTTP method with M-. In this case, the method is M-POST. Using M-POST requires the HTTP server to find and understand the SOAP-unique URI and SOAP-specific headers.

To provide firewalls and proxies greater administrative flexibility, SOAP specifies that requests must first be attempted *without* the MAN header or M- prefix. If the request is rejected with a response of "405 Method Not Allowed", then a second request must be sent using the MAN header and M-prefix. If that request is rejected with a response of "501 Not Implemented" or "510 Not Extended", the request fails. (Other HTTP responses should be processed according to the HTTP specification.)

Below is a listing of a control message sent using the POST method (without the MAN header) followed by an explanation of the headers and body. This is immediately followed by a listing of a control message sent using the M-POST method and MAN header.

To invoke an action on a device's service, a control point must send a request with method POST in the following format. Values in *italics* are placeholders for actual values.

```
POST path of control URL HTTP/1.1
HOST: host of control URL:port of control URL
CONTENT-LENGTH: bytes in body
CONTENT-TYPE: text/xml; charset="utf-8"
SOAPACTION: "urn:schemas-upnp-org:service:serviceType:v#actionName"

<s:Envelope
    xmlns:s="http://schemas.xmlsoap.org/soap/envelope/"
    s:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
  <s:Body>
    <u:actionName xmlns:u="urn:schemas-upnp-org:service:serviceType:v">
      <argumentName>in arg value</argumentName>
      other in args and their values go here, if any
    </u:actionName>
  </s:Body>
</s:Envelope>
```

Listed below are details for the request line, headers, and body elements appearing in the listing above. All header values and element names are case sensitive; values are not case sensitive except where noted. Except where noted, the order of elements is insignificant. Except where noted, required elements must occur exactly once (no duplicates), and recommended or optional elements may occur at most once.

Request line

POST
: Method defined by HTTP.

path control URL
: Path component of URL for control for this service (controlURL sub element of service element of device description). Single, relative URL.

HTTP/1.1
: HTTP version.

Headers

HOST
: Required. Domain name or IP address and optional port components of URL for control for this service (controlURL sub element of service element of device description). If the port is empty or not given, port 80 is assumed.

ACCEPT-LANGUAGE
: (No ACCEPT-LANGUAGE header is used in control messages.)

CONTENT-LENGTH
: Required. Length of body in bytes. Integer.

CONTENT-TYPE
: Required. Must be text/xlm. Should include character coding used, e.g., utf-8.

MAN
: (No MAN header in request with method POST.)

SOAPACTION
: Required header defined by SOAP. Must be the service type, hash mark, and name of action to be invoked, all enclosed in double quotes. If used in a request with method M-POST, header name must be qualified with HTTP name space defined in MAN header. Single URI.

Body

Envelope
: Required element defined by SOAP. xmlns namespace attribute must be "http://schemas.xmlsoap.org/soap/envelope/". Must include encodingStyle attribute with value "http://schemas.xmlsoap.org/soap/encoding/". Contains the following sub elements:

  Body
  : Required element defined by SOAP. Should be qualified with SOAP namespace. Contains the following sub element:

    actionName
    : Required. Name of element is name of action to invoke. xmlns namespace attribute must be the service type enclosed in double quotes. Must be the first sub element of Body. Contains the following, ordered sub element (s):

      argumentName
      : Required if and only if action has in arguments. Value to be passed to action. Repeat once for each in argument. (Element name not qualified by a namespace; element nesting context is sufficient.) Single data type as defined by UPnP service description.

For future extensibility, when processing XML like the listing above, as specified by the Flexible XML Processing Profile (FXPP), devices and control points must ignore: (a) any unknown elements and their sub elements or content, and (b) any unknown attributes and their values.

If a request with POST is rejected with a response of "405 Method Not Allowed", then a control point must send a second request with method M-POST and MAN in the following format. Values in *italics* are placeholders for actual values.

```
M-POST path of control URL HTTP/1.1
HOST: host of control URL:port of control URL
CONTENT-LENGTH: bytes in body
CONTENT-TYPE: text/xml; charset="utf-8"
MAN: "http://schemas.xmlsoap.org/soap/envelope/"; ns=01
01-SOAPACTION: "urn:schemas-upnp-org:service:serviceType:v#actionName"
```

(Message body for request with method M-POST is the same as body for request with method POST. See above.)

Request line

M-POST

Method defined by HTTP Extension Framework.

path of control URL
Path component of URL for control for this service (controlURL sub element of service element of device description). Single, relative URL.

HTTP/1.1
HTTP version.

Headers

HOST
Required. Domain name or IP address and optional port components of URL for control for this service (controlURL sub element of service element of device description). If the port is empty or not given, port 80 is assumed.

ACCEPT-LANGUAGE
(No ACCEPT-LANGUAGE header is used in control messages.)

CONTENT-LENGTH
Required. Length of body in bytes. Integer.

CONTENT-TYPE
Required. Must be text/xlm. Should include character coding used, e.g., utf-8.

MAN
Required. Must be "http://schemas.xmlsoap.org/soap/envelope/". ns directive defines namespace (e.g., *01*) for other SOAP headers (e.g., SOAPACTION).

SOAPACTION
Required header defined by SOAP. Must be the service type, hash mark, and name of action to be invoked, all enclosed in double quotes. If used in a request with method M-POST, header name must be qualified with HTTP name space defined in MAN header. Single URI.

3.2.2 Control: Action: Response

The service must complete invoking the action and respond within 30 seconds, including expected transmission time. Actions that take longer than this should be defined to return early and send an event when complete. If the service fails to respond within this time, what the control point should do is application-specific. The service must send a response in the following format. Values in *italics* are placeholders for actual values.

```
HTTP/1.1 200 OK
CONTENT-LENGTH: bytes in body
CONTENT-TYPE: text/xml; charset="utf-8"
DATE: when response was generated
EXT:
SERVER: OS/version UPnP/1.0 product/version

<s:Envelope
    xmlns:s="http://schemas.xmlsoap.org/soap/envelope/"
    s:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
  <s:Body>
    <u:actionNameResponse xmlns:u="urn:schemas-upnp-org:service:serviceType:v">
      <argumentName>out arg value</argumentName>
      other out args and their values go here, if any
    </u:actionNameResponse>
  </s:Body>
</s:Envelope>
```

Listed below are details for the response line, headers, and body elements appearing in the listing above. All header values and element names are case sensitive; values are not case sensitive except where noted. Except where noted, the order of elements is insignificant. Except where noted, required elements must occur exactly once (no duplicates), and recommended or optional elements may occur at most once.

Response line

HTTP/1.1
HTTP version.

200 OK
HTTP success code.

Headers

CONTENT-LANGUAGE
: (No CONTENT-LANGUAGE header is used in control messages.)

CONTENT-LENGTH
: Required. Length of body in bytes. Integer.

CONTENT-TYPE
: Required. Must be text/xlm. Should include character coding used, e.g., utf-8.

DATE
: Recommended. When response was generated. RFC 1123 date.

EXT
: Required. Confirms that the MAN header was understood. (Header only; no value.)

SERVER
: Required. Concatenation of OS name, OS version, **UPnP/1.0**, product name, and product version. String.

Body

Envelope
: Required element defined by SOAP. xmlns namespace attribute must be "http://schemas.xmlsoap.org/soap/envelope/". Must include encodingStyle attribute with value "http://schemas.xmlsoap.org/soap/encoding/". Contains the following sub elements:

  Body
  : Required element defined by SOAP. Should be qualified with SOAP namespace. Contains the following sub element:

    *actionName*Response
    : Required. Name of element is action name prepended to Response. xmlns namespace attribute must be service type enclosed in double quotes. Must be the first sub element of Body. Contains the following sub element:

      argumentName
      : Required if and only if action has out arguments. Value returned from action. Repeat once for each out argument. If action has an argument marked as retval, this argument must be the first element. (Element name not qualified by a namespace; element nesting context is sufficient.) Single data type as defined by UPnP service description.

For future extensibility, when processing XML like the listing above, as specified by the Flexible XML Processing Profile (FXPP), devices and control points must ignore: (a) any unknown elements and their sub elements or content, and (b) any unknown attributes and their values.

If the service encounters an error while invoking the action sent by a control point, the service must send a response within 30 seconds, including expected transmission time. Out arguments must not be used to convey error information; out arguments must only be used to return data; error responses must be sent in the following format. Values in *italics* are placeholders for actual values.

```
HTTP/1.1 500 Internal Server Error
CONTENT-LENGTH: bytes in body
CONTENT-TYPE: text/xml; charset="utf-8"
DATE: when response was generated
EXT:
SERVER: OS/version UPnP/1.0 product/version

<s:Envelope
    xmlns:s="http://schemas.xmlsoap.org/soap/envelope/"
    s:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
  <s:Body>
    <s:Fault>
      <faultcode>s:Client</faultcode>
      <faultstring>UPnPError</faultstring>
      <detail>
        <UPnPError xmlns="urn:schemas-upnp-org:control-1-0">
          <errorCode>error code</errorCode>
          <errorDescription>error string</errorDescription>
        </UPnPError>
      </detail>
    </s:Fault>
  </s:Body>
</s:Envelope>
```

Listed below are details for the response line, headers, and body elements appearing in the listing above. All header values and element

names are case sensitive; values are not case sensitive except where noted. Except where noted, the order of elements is insignificant. Except where noted, required elements must occur exactly once (no duplicates), and recommended or optional elements may occur at most once.

Response line

HTTP/1.1
: HTTP version.

500 Internal Server Error
: HTTP error code.

Headers

CONTENT-LANGUAGE
: (No CONTENT-LANGUAGE header is used in control messages.)

CONTENT-LENGTH
: Required. Length of body in bytes. Integer.

CONTENT-TYPE
: Required. Must be text/xlm. Should include character coding used, e.g., utf-8.

DATE
: Recommended. When response was generated. RFC 1123 date.

EXT
: Required. Confirms that the MAN header was understood. (Header only; no value.)

SERVER
: Required. Concatenation of OS name, OS version, **UPnP/1.0**, product name, and product version. String.

Body

Envelope
: Required element defined by SOAP. xmlns namespace attribute must be "http://schemas.xmlsoap.org/soap/envelope/". Must include encodingStyle attribute with value "http://schemas.xmlsoap.org/soap/encoding/". Contains the following sub elements:

  Body
  : Required element defined by SOAP. Should be qualified with SOAP namespace. Contains the following sub element:

    Fault
    : Required element defined by SOAP. Error encountered while invoking action. Should be qualified with SOAP namespace. Contains the following sub elements:

      faultcode
      : Required element defined by SOAP. Value must be qualified with the SOAP namespace. Must be Client.

      faultstring
      : Required element defined by SOAP. Must be **UPnPError**.

      detail
      : Required element defined by SOAP.

        UPnPError
        : Required element defined by UPnP.

          errorCode
          : Required element defined by UPnP. Code identifying what error was encountered. See table immediately below for values. Integer.

          errorDescription
          : Recommended element defined by UPnP. Short description. See table immediately below for values. String. Recommend < 256 characters.

The following table summarizes defined error types and the corresponding value for the errorCode and errorDescription elements.

errorCode	errorDescription	Description
401	Invalid Action	No action by that name at this service.
402	Invalid Args	Could be any of the following: not enough in args, too many in args, no in arg by that name, one or more in args are of the wrong data type.
403	Out of Sync	Out of synchronization.
501	Action Failed	May be returned in current state of service prevents invoking that action.
600-699	*TBD*	Common action errors. Defined by UPnP Forum Technical Committee.
700-799	*TBD*	Action-specific errors for standard actions. Defined by UPnP Forum working committee.
800-899	*TBD*	Action-specific errors for non-standard actions. Defined by UPnP vendor.

For future extensibility, when processing XML like the listing above, as specified by the Flexible XML Processing Profile (FXPP), devices

and control points must ignore: (a) any unknown elements and their sub elements or content, and (b) any unknown attributes and their values.

3.3 Control: Query for variable

In addition to invoking actions on a device's service, control points may also poll the service for the value of a state variable by sending a query message. A query message may query only one state variable; multiple query messages must be sent to query multiple state variables.

This query message is decoupled from the service's eventing (if any). If a variable is moderated, then querying for the value of the variable will generally yield more up-to-date values than those received via eventing. The section on Eventing describes event moderation.

3.3.1 Control: Query: Invoke

To query for the value of a state variable, a control point must send a request in the following format. Values in *italics* are placeholders for actual values.

```
POST path of control URL HTTP/1.1
HOST: host of control URL:port of control URL
CONTENT-LENGTH: bytes in body
CONTENT-TYPE: text/xml; charset="utf-8"
SOAPACTION: "urn:schemas-upnp-org:control-1-0#QueryStateVariable"

<s:Envelope
    xmlns:s="http://schemas.xmlsoap.org/soap/envelope/"
    s:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
  <s:Body>
    <u:QueryStateVariable xmlns:u="urn:schemas-upnp-org:control-1-0">
      <u:varName>variableName</u:varName>
    </u:QueryStateVariable>
  </s:Body>
</s:Envelope>
```

Listed below are details for the request line, headers, and body elements appearing in the listing above. All header values and element names are case sensitive; values are not case sensitive except where noted. Except where noted, the order of elements is insignificant. Except where noted, required elements must occur exactly once (no duplicates), and recommended or optional elements may occur at most once.

Request line

POST
: Method defined by HTTP.

path of control URL
: Path component of URL for control for this service (controlURL sub element of service element of device description). Single, relative URL.

HTTP/1.1
: HTTP version.

Headers

HOST
: Required. Domain name or IP address and optional port components of URL for control for this service (controlURL sub element of service element of device description). If the port is empty or not given, port 80 is assumed.

ACCEPT-LANGUAGE
: (No ACCEPT-LANGUAGE header is used in control messages.)

CONTENT-LENGTH
: Required. Length of body in bytes. Integer.

CONTENT-TYPE
: Required. Must be text/xlm. Should include character coding used, e.g., utf-8.

MAN
: (No MAN header in request with method POST.)

SOAPACTION
: Required header defined by SOAP. Must be "urn:schemas-upnp-org:control-1-0#QueryStateVariable". If used in a request with method M-POST, header name must be qualified with HTTP name space defined in MAN header. Single URI.

Body

Envelope
: Required element defined by SOAP. xmlns namespace attribute must be "http://schemas.xmlsoap.org/soap/envelope/". Must include encodingStyle attribute with value "http://schemas.xmlsoap.org/soap/encoding/". Contains the following sub elements:
Body
: Required element defined by SOAP. Should be qualified with SOAP namespace. Contains the following sub element:
QueryStateVariable
: Required element defined by UPnP. Action name. xmlns namespace attribute must be "urn:schemas-upnp-org:control-1-0". Must be the first sub element of Body. Contains the following, ordered sub element:
varName
: Required element defined by UPnP. Variable name. Must be qualified by QueryStateVariable namespace. Values is name of state variable to be queried. String.

For future extensibility, when processing XML like the listing above, as specified by the Flexible XML Processing Profile (FXPP), devices and control points must ignore: (a) any unknown elements and their sub elements or content, and (b) any unknown attributes and their values.

If a request with POST is rejected with a response of "405 Method Not Allowed", then a control point must send a second request with method M-POST and MAN as explained above.

3.3.2 Control: Query: Response

To answer a query for the value of a state variable, the service must respond within 30 seconds, including expected transmission time. If the service fails to respond within this time, what the control point should do is application-specific. The service must send a response in the following format. Values in *italics* are placeholders for actual values.

```
HTTP/1.1 200 OK
CONTENT-LENGTH: bytes in body
CONTENT-TYPE: text/xml; charset="utf-8"
DATE: when response was generated
EXT:
SERVER: OS/version UPnP/1.0 product/version

<s:Envelope
    xmlns:s="http://schemas.xmlsoap.org/soap/envelope/"
    s:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
  <s:Body>
    <u:QueryStateVariableResponse xmlns:u="urn:schemas-upnp-org:control-1-0">
      <return>variable value</return>
    </u:QueryStateVariableResponse>
  </s:Body>
</s:Envelope>
```

Listed below are details for the response line, headers, and body elements appearing in the listing above. All header values and element names are case sensitive; values are not case sensitive except where noted. Except where noted, the order of elements is insignificant. Except where noted, required elements must occur exactly once (no duplicates), and recommended or optional elements may occur at most once.

Response line

HTTP/1.1
: HTTP version.
200 OK
: HTTP success code.

Headers

CONTENT-LANGUAGE
: (No CONTENT-LANGUAGE header is used in control messages.)

CONTENT-LENGTH
: Required. Length of body in bytes. Integer.

CONTENT-TYPE
: Required. Must be text/xlm. Should include character coding used, e.g., utf-8.

DATE
: Recommended. When response was generated. RFC 1123 date.

EXT
: Required. Confirms that the MAN header was understood. (Header only; no value.)

SERVER
: Required. Concatenation of OS name, OS version, **UPnP/1.0**, product name, and product version. String.

Body

Envelope
: Required element defined by SOAP. xmlns namespace attribute must be "http://schemas.xmlsoap.org/soap/envelope/". Must include encodingStyle attribute with value "http://schemas.xmlsoap.org/soap/encoding/". Contains the following sub elements:
  Body
  : Required element defined by SOAP. Should be qualified with SOAP namespace. Contains the following sub element:
    QueryStateVariableResponse
    : Required element defined by UPnP and SOAP. xmlns namespace attribute must be "urn:**schemas-upnp-org**:**control-1-0**". Must be the first sub element of Body. Contains the following sub element:
      return
      : Required element defined by UPnP. (Element name not qualified by a namespace; element nesting context is sufficient.) Value is current value of the state variable specified in **varName** element in request.

For future extensibility, when processing XML like the listing above, as specified by the Flexible XML Processing Profile (FXPP), devices and control points must ignore: (a) any unknown elements and their sub elements or content, and (b) any unknown attributes and their values.

If the service cannot provide a value for the variable, then the service must send a response within 30 seconds, including expected transmission time. The response must be sent in the following format. Values in *italics* are placeholders for actual values.

```
HTTP/1.1 500 Internal Server Error
CONTENT-LENGTH: bytes in body
CONTENT-TYPE: text/xml; charset="utf-8"
DATE: when response was generated
EXT:
SERVER: OS/version UPnP/1.0 product/version

<s:Envelope
    xmlns:s="http://schemas.xmlsoap.org/soap/envelope/"
    s:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
  <s:Body>
    <s:Fault>
      <faultcode>s:Client</faultcode>
      <faultstring>UPnPError</faultstring>
      <detail>
        <UPnPError xmlns="urn:schemas-upnp-org:control-1-0">
          <errorCode>error code</errorCode>
          <errorDescription>error string</errorDescription>
        </UPnPError>
      </detail>
    </s:Fault>
  </s:Body>
</s:Envelope>
```

Listed below are details for the response line, headers, and body elements appearing in the listing above. All header values and element names are case sensitive; values are not case sensitive except where noted. Except where noted, the order of elements is insignificant. Except where noted, required elements must occur exactly once (no duplicates), and recommended or optional elements may occur at most once.

Response line

HTTP/1.1
: HTTP version.

500 Internal Server Error
: HTTP error code.

Headers

CONTENT-LANGUAGE
: (No CONTENT-LANGUAGE header is used in control messages.)

CONTENT-LENGTH
: Required. Length of body in bytes. Integer.

CONTENT-TYPE
: Required. Must be text/xlm. Should include character coding used, e.g., utf-8.

DATE
: Recommended. When response was generated. RFC 1123 date.

EXT
: Required. Confirms that the MAN header was understood. (Header only; no value.)

SERVER
: Required. Concatenation of OS name, OS version, **UPnP/1.0**, product name, and product version. String.

Body

Envelope
: Required element defined by SOAP. xmlns namespace attribute must be "http://schemas.xmlsoap.org/soap/envelope/". Must include encodingStyle attribute with value "http://schemas.xmlsoap.org/soap/encoding/". Contains the following sub elements:

  Body
  : Required element defined by SOAP. Should be qualified with SOAP namespace. Contains the following sub element:

    Fault
    : Required element defined by SOAP. Why the service did not return a value for the variable. Should be qualified with SOAP namespace. Contains the following sub elements:

      faultcode
      : Required element defined by SOAP. Value should be qualified with SOAP namespace. Must be Client.

      faultstring
      : Required element defined by SOAP. Generic UPnP string describing errorCode. See table immediately below for values.

      detail
      : Required element defined by SOAP. Contains the following sub elements:

        UPnPError
        : Required element defined by UPnP. Contains the following sub elements:

          errorCode
          : Required element defined by UPnP. Code identifying what error was encountered. See table immediately below for values. Integer.

          errorDescription
          : Recommended element defined by UPnP. Short description. See table immediately below for values. String. Recommend < 256 characters.

The following table summarizes defined error types and the corresponding value for the errorCode and errorDescription elements.

errorCode	errorDescription	Description
404	Invalid Var	No state variable by that name at this service.
600-624	*TBD*	Common action errors. Defined by UPnP Forum Technical Committee.
625-649	*TBD*	Reserved for future use.
650-674	*TBD*	Action-specific errors for standard actions. Defined by UPnP Forum working committee.
675-699	*TBD*	Action-specific errors for non-standard actions. Defined by UPnP vendor.

For future extensibility, when processing XML like the listing above, as specified by the Flexible XML Processing Profile (FXPP), devices and control points must ignore: (a) any unknown elements and their sub elements or content, and (b) any unknown attributes and their values.

3.4 Control references

FXPP
: Flexible XML Processing Profile. Specifies that unknown XML elements and their sub elements must be ignored. IETF draft.

HTTP Extension Framework
: Describes a generic extension mechanism for HTTP. W3C request for comments.

RFC 1123
: Includes format for dates, for, e.g., HTTP DATE header. IETF request for comments.

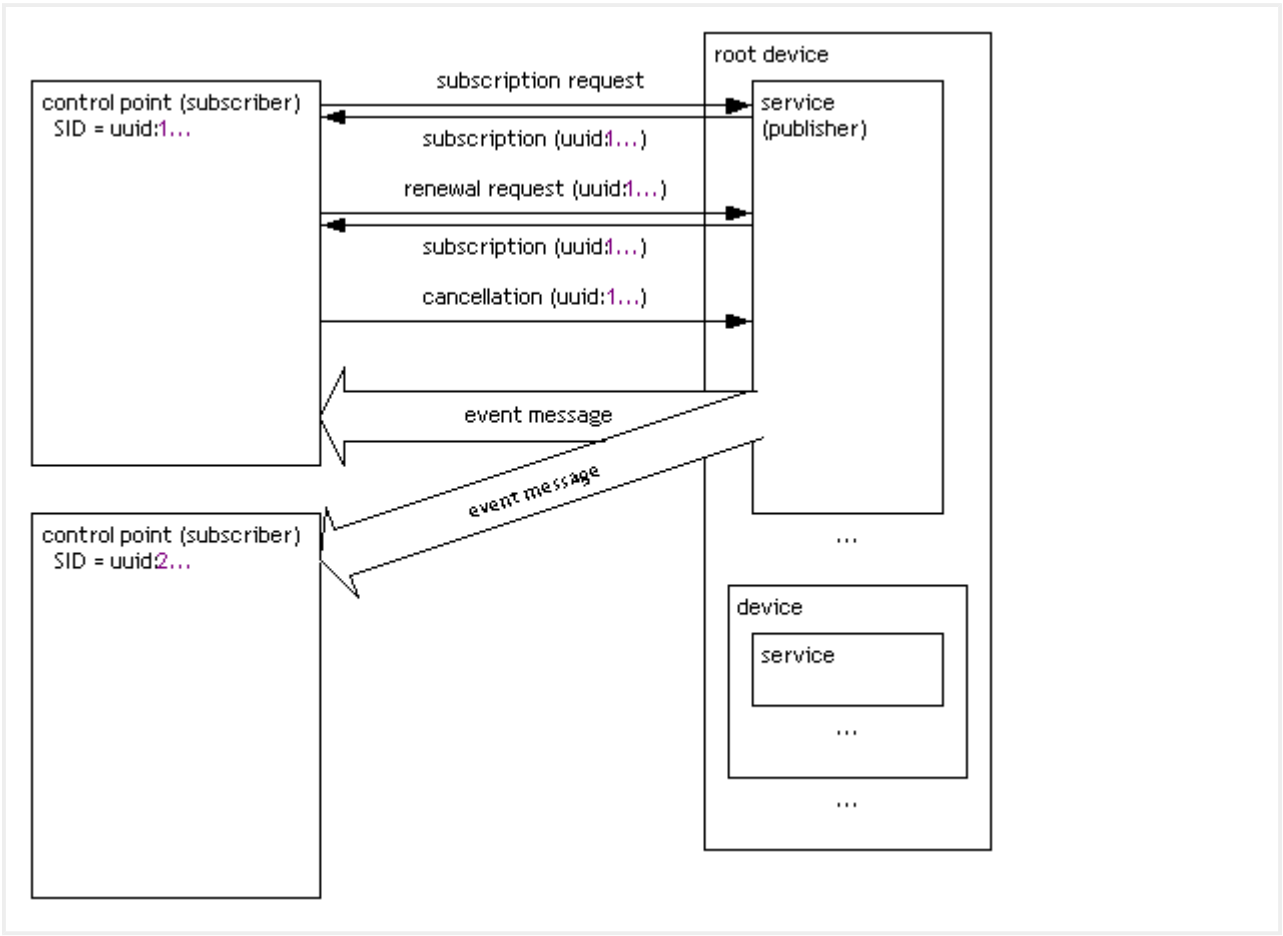
SOAP
: Simple Object Access Protocol. Defines a protocol in XML, over HTTP, for remote procedure calls. IETF draft and W3C Technical Report.

XML
: Extensible Markup Language. W3C recommendation.

4. Eventing

Eventing is Step 4 in UPnP networking. Eventing comes after addressing (Step 0) where devices get a network address, after discovery (Step 1) where control points find interesting device(s), and after description (Step 2) where control points learn about device capabilities. Eventing is intimately linked with control (Step 3) where control points send actions to devices. Through eventing, control points listen to state changes in device(s). Control and eventing are complementary to presentation (Step 5) where control points display a user interface provided by device(s).

After a control point has (1) discovered a device and (2) retrieved a description of the device and its services, the control point has the essentials for eventing. As the section on Description explains, a UPnP service description includes a list of actions the service responds to and a list of variables that model the state of the service at run time. If one or more of these state variables are evented, then the service publishes updates when these variables change, and a control point may subscribe to receive this information. Throughout this section, *publisher* refers to the source of the events (typically a device's service), and *subscriber* refers to the destination of events (typically a control point).



To subscribe to eventing, a subscriber sends a *subscription message*. If the subscription is accepted, the publisher responds with a duration for the subscription. To keep the subscription active, a subscriber must renew its subscription before the subscription expires. When a subscriber no longer needs eventing from a publisher, the subscriber should cancel its subscription. This section explains subscription, renewal, and cancellation messages in detail below.

The publisher notes changes to state variables by sending *event messages*. Event messages contain the names of one of more state variables and the current value of those variables, expressed in XML. A special *initial event message* is sent when a subscriber 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 scenarios with multiple control points, eventing is designed to keep all subscribers equally informed about the effects of any action. Therefore, all subscribers are sent all event messages, subscribers receive event messages for all evented variables (not just some), and event messages are sent no matter why the state variable changed (either in response to a requested action or because the state the service is modeling changed). This section explains the format of event messages in detail below.

Some state variables may change value too rapidly for eventing to be useful. One alternative is to filter, or moderate, the number of event messages sent due to changes in a variable's value. Some state variables may contain values too large for eventing to be useful; for this, or other reasons, a service may designate one or more state variables as *non evented* and never send event messages to subscribers. To determine the current value for such non-evented variables, control points must poll the service explicitly. This section explains how variable eventing is described within a service description. The section on Control explains how to poll a service for a variable value.

To send and receive subscription and event messages, control points and services use the following subset of the overall UPnP protocol stack. (The overall UPnP protocol stack is listed at the beginning of this document.)

<table>
<tr><td>UPnP vendor [purple]</td></tr>
<tr><td>UPnP Forum [red]</td></tr>
<tr><td>UPnP Device Architecture [green]</td></tr>
<tr><td>HTTP [black] GENA [navy]</td></tr>
<tr><td>TCP [black]</td></tr>
<tr><td>IP [black]</td></tr>
</table>

At the highest layer, subscription and event messages contain vendor-specific information like URLs for subscription and duration of subscriptions or specific variable values. Moving down the stack, vendor content is supplemented by information from a UPnP Forum working committee, like service identifiers or variable names. Messages from the layers above are hosted in UPnP-specific protocols, defined in this document. In turn, the above messages are delivered via HTTP that has been extended using General Event Notification Architecture (GENA) methods and headers. The HTTP messages are delivered via TCP over IP. For reference, colors in [square brackets] above indicate which protocol defines specific header elements in the subscription messages listed below.

The remainder of this section first explains subscription, including details of subscription messages, renewal messages, and cancellation messages. Second, it explains in detail how event messages are formatted and sent to control points, and the initial event message. Finally, it explains the UPnP Template Language as it pertains to eventing.

4.1 Eventing: Subscription

A service has eventing if and only if one or more of the state variables are evented.

If a service has eventing, it publishes event messages to interested subscribers. The publisher maintains a list of subscribers, keeping for each subscriber the following information.

unique subscription identifier
: Required. Must be unique over the lifetime of the subscription, however long or short that may be. Generated by publisher in response to subscription message. Recommend universally-unique identifiers to ensure uniqueness. Single URI.

delivery URL for event messages
: Required. Provided by subscriber in subscription message. Single URL.

event key
: Required. Key is 0 for initial event message. Key must be sequentially numbered for each subsequent event message; subscribers can verify that no event messages have been lost if the subscriber has received sequentially numbered event keys. Must wrap to 1. Should be 4 Bytes (32 bits). Single integer.

subscription duration

Required. Amount of time, or duration until subscription expires. Single integer or keyword infinite.

The publisher should accept as many subscriptions as it can reasonably maintain and deliver.

The publisher may wish to persist subscriptions across power failures. While control points can recover from complete network failure, if the problem is brief and localized to the device, reusing stored subscriptions may speed recovery.

The list of subscribers is updated via subscription, renewal, and cancellation messages explained immediately below and event messages explained later in this section.

To subscribe to eventing for a service, a subscriber sends a *subscription message* containing a URL for the publisher, a service identifier for the publisher, and a delivery URL for event messages. The subscription message may also include a requested duration for the subscription. The URL and service identifier for the publisher come from a description message. As the section on Description explains, a description message contains a device description. A device description contains (among other things), for each service, an eventing URL (in the eventSubURL element) and a service identifier (in the serviceId element); these correspond to the URL and service identifier for the publisher, respectively. The URL for the publisher must be unique to a particular service within this device.

The subscription message is a request to receive all event messages. No mechanism is provided to subscribe to event messages on a variable-by-variable basis. A subscriber is sent all event messages from the service. This is one factor to be considered when designing a service.

If the subscription is accepted, the publisher responds with unique identifier for this subscription and a duration for this subscription. A duration should be chosen that matches assumptions about how frequently control points are removed from the network; if control points are removed every few minutes, then the duration should be similarly short, allowing a publisher to rapidly deprecate any expired subscribers; if control points are expected to be semi-permanent, then the duration should be very long, minimizing the processing and traffic associated with renewing subscriptions.

As soon as possible after the subscription is accepted, the publisher also sends the first, or *initial* event message to the subscriber. This message includes the names and current values for all evented variables. (The data type and range for each variable is described in a service description. The section on Description explains this in more detail.)

To keep the subscription active, a subscriber must renew its subscription before the subscription expires by sending a renewal message. The renewal message is send to the same URL as the subscription message, but the renewal message does not include a delivery URL for event messages; instead the renewal message includes the subscription identifier. The response for a renewal message is the same as one for a subscription message.

If a subscription expires, the subscription identifier becomes invalid, and the publisher stops sending event messages to the subscriber and can clean up its list of subscribers. If the subscriber tries to send any message other than a subscription message, the publisher will reject the message because the subscription identifier is invalid.

When a subscriber no longer needs eventing from a particular service, the subscriber should cancel its subscription. Canceling a subscription generally reduces service, control point, and network load. If a subscriber is removed abruptly from the network, it might be impossible to send a cancellation message. As a fallback, the subscription will eventually expire on its own unless renewed.

Subscribers should monitor discovery messages from the publisher. If the publisher cancels its advertisements, subscribers should assume that their subscriptions have been effectively cancelled.

Below is an explanation of the specific format of requests, responses, and errors for subscription, renewal, and cancellation messages.

4.1.1 Eventing: Subscribing: SUBSCRIBE with NT and CALLBACK

For each service in a device, a description message contains an eventing URL (eventSubURL sub element of service element in the device description) and the UPnP service identifier (serviceId sub element in service element in device description). To subscribe to eventing for a particular service, a subscription message is sent to that service's eventing URL. (Note that the eventing URL may be relative to the base URL.) The message contains that service's identifier as well as a delivery URL for event messages. A subscription message may also include a requested subscription duration.

To subscribe to eventing for a service, a subscriber must send a request with method SUBSCRIBE and NT and CALLBACK headers in the following format. Values in *italics* are placeholders for actual values.

```
SUBSCRIBE publisher path HTTP/1.1
HOST: publisher host:publisher port
CALLBACK: <delivery URL>
NT: upnp:event
TIMEOUT: Second-requested subscription duration
```

(No body for request with method SUBSCRIBE, but note that the message must have a blank line following the last HTTP header.)

Listed below are details for the request line and headers appearing in the listing above. All header values are case sensitive except where noted.

Request line

SUBSCRIBE
: Method defined by GENA. Initiate or renew a subscription.

publisher path
: Path component of eventing URL (**eventSubURL** sub element in **service** element in device description). Single, relative URL.

HTTP/1.1
: HTTP version.

Headers

HOST
: Required. Domain name or IP address and optional port components of eventing URL (**eventSubURL** sub element in **service** element in device description). If the port is missing or empty, port 80 is assumed.

CALLBACK
: Required header defined by GENA. Location to send event messages to. Defined by UPnP vendor. If there is more than 1 URL, when the service sends events, it will try these URLs in order until one succeeds. One or more URLs separated by angle brackets.

NT
: Required header defined by GENA. Notification Type. Must be **upnp:event**.

SID
: (No SID header is used to subscribe.)

TIMEOUT
: Recommended. Requested duration until subscription expires, either number of seconds or infinite. Recommendation by a UPnP Forum working committee. Defined by UPnP vendor. Keyword Second- followed by an integer (no space) or keyword infinite.

If there are enough resources to maintain the subscription, the publisher should accept it. To accept the subscription, the publisher assigns a unique identifier for the subscription, assigns a duration for the subscription, and sends an initial event message (explained in detail later in this section). To accept a subscription request, a publisher must send a response in the following format within 30 seconds, including expected transmission time. Values in *italics* are placeholders for actual values.

```
HTTP/1.1 200 OK
DATE: when response was generated
SERVER: OS/version UPnP/1.0 product/version
SID: uuid:subscription-UUID
TIMEOUT: Second-actual subscription duration
```

(No body for response to a request with method SUBSCRIBE, but note that the message must have a blank line following the last HTTP header.)

Listed below are details for headers appearing in the listing above. All header values are case sensitive except where noted.

Headers

DATE
: Recommended. When response was generated. RFC 1123 date.

SERVER
: Required. Concatenation of OS name, OS version, UPnP/1.0, product name, and product version. String.

SID
: Required header defined by GENA. Subscription identifier. Must be universally unique. Must begin with uuid:. Defined by UPnP vendor. Single URI.

TIMEOUT
: Required. Actual duration until subscription expires, either number of seconds or infinite. Recommendation by a UPnP Forum working committee. Defined by UPnP vendor. Should be > 1800 seconds (30 minutes). Keyword Second- followed by an integer (no space) or keyword infinite.

If a publisher cannot accept another subscriber, or if there is an error with the subscription request, the publisher must send a response with one of the following errors. The response must be sent within 30 seconds, including expected transmission time.

Errors

Incompatible headers
: 400 Bad Request. If SID header and one of NT or CALLBACK headers are present, the publisher must respond with HTTP error 400 Bad Request.

Missing or invalid CALLBACK
: 412 Precondition Failed. If CALLBACK header is missing or does not contain a valid HTTP URL, the publisher must respond with HTTP error 412 Precondition Failed.

Invalid NT
: 412 Precondition Failed. If NT header does not equal upnp:event, the publisher must respond with HTTP error 412 Precondition Failed.

Unable to accept subscription
: 5xx. If a publisher is not able to accept a subscription, it must respond with a HTTP 500-series error code.

Other errors may be returned by layers in the protocol stack below UPnP. Consult documentation on those protocols for details.

4.1.2 Eventing: Renewing a subscription: SUBSCRIBE with SID

To renew a subscription to eventing for a particular service, a renewal message is sent to that service's eventing URL. (Note that the eventing URL may be relative to the base URL.) However, unlike an initial subscription message, a renewal message does not contain either the service's identifier nor a delivery URL for event messages. Instead, the message contains the *subscription* identifier assigned by the publisher, providing an unambiguous reference to the subscription to be renewed. Like a subscription message, a renewal message may also include a requested subscription duration.

The renewal message uses the same method as the subscription message, but the two messages use a disjoint set of headers; renewal uses SID and subscription uses NT and CALLBACK. A message that includes SID and either of NT or CALLBACK headers is an error.

To renew a subscription to eventing for a service, a subscriber must send a request with method SUBSCRIBE and SID header in the following format. Values in *italics* are placeholders for actual values.

```
SUBSCRIBE publisher path HTTP/1.1
HOST: publisher host:publisher port
SID: uuid:subscription UUID
TIMEOUT: Second-requested subscription duration
```

(No body for method with request SUBSCRIBE, but note that the message must have a blank line following the last HTTP header.)

Listed below are details for the request line and headers appearing in the listing above. All header values are case sensitive except where noted.

Request line

SUBSCRIBE
: Method defined by GENA. Initiate or renew a subscription.

publisher path
: Path component of eventing URL (eventSubURL sub element in service element in device description). Single, relative URL.

HTTP/1.1

HTTP version.

Headers

HOST
: Required. Domain name or IP address and optional port components of eventing URL (**eventSubURL** sub element in **service** element in device description). If the port is missing or empty, port 80 is assumed.

CALLBACK
: (No CALLBACK header is used to renew an event subscription.)

NT
: (No NT header is used to renew an event subscription.)

SID
: Required header defined by GENA. Subscription identifier. Must be the subscription identifier assigned by publisher in response to subscription request. Must be universally unique. Must begin with uuid:. Defined by UPnP vendor. Single URI.

TIMEOUT
: Recommended. Requested duration until subscription expires, either number of seconds or infinite. Recommendation by a UPnP Forum working committee. Defined by UPnP vendor. Keyword Second- followed by an integer (no space) or keyword infinite.

To accept a renewal, the publisher reassigns a duration for the subscription and must send a response in the same format as a response to a request for a new subscription. (No initial event message.)

If a publisher cannot accept the renewal, or if there is an error with the renewal request, the publisher must send a response with one of the following errors. The response must be sent within 30 seconds, including expected transmission time.

Errors

Incompatible headers
: 400 Bad Request. If SID header and one of NT or CALLBACK headers are present, the publisher must respond with HTTP error 400 Bad Request.

Invalid SID
: 412 Precondition Failed. If a SID does not correspond to a known, un-expired subscription, the publisher must respond with HTTP error 412 Precondition Failed.

Missing SID
: 412 Precondition Failed. If the SID header is missing or empty, the publisher must respond with HTTP error 412 Precondition Failed.

Unable to accept renewal
: 5xx. If the publisher is not able to accept a renewal, it must respond with a HTTP 500-series error code.

Other errors may be returned by layers in the protocol stack below UPnP. Consult documentation on those protocols for details.

4.1.3 Eventing: Canceling a subscription: UNSUBSCRIBE

When eventing is no longer needed from a particular service, a cancellation message should be sent to that service's eventing URL. (Note that the eventing URL may be relative to the base URL.) The message contains the subscription identifier. Canceling a subscription generally reduces service, control point, and network load. If a control point is removed abruptly from the network, it might be impossible to send a cancellation message. As a fallback, the subscription will eventually expire on its own unless renewed.

To cancel a subscription to eventing for a service, a subscriber should send a request with method UNSUBSCRIBE in the following format. Values in *italics* are placeholders for actual values.

```
UNSUBSCRIBE publisher path HTTP/1.1
HOST: publisher host:publisher port
SID: uuid:subscription UUID
```

(No body for request with method UNSUBSCRIBE, but note that the message must have a blank line following the last HTTP header.)

Listed below are details for the request line and headers appearing in the listing above. All header values are case sensitive except where noted.

Request line

UNSUBSCRIBE
: Method defined by GENA. Cancel a subscription.

publisher path
: Path component of eventing URL (**eventSubURL** sub element in **service** element in device description). Single, relative URL.

HTTP/1.1
: HTTP version.

Headers

HOST
: Required. Domain name or IP address and optional port components of eventing URL (**eventSubURL** sub element in **service** element in device description). If the port is missing or empty, port 80 is assumed.

CALLBACK
: (No CALLBACK header is used to cancel an event subscription.)

NT
: (No NT header is used to cancel an event subscription.)

SID
: Required header defined by GENA. Subscription identifier. Must be the subscription identifier assigned by publisher in response to subscription request. Must be universally unique. Must begin with uuid:. Defined by UPnP vendor. Single URI.

TIMEOUT
: (No TIMEOUT header is used to cancel an event subscription.)

To cancel a subscription, a publisher must send a response in the following format within 30 seconds, including expected transmission time.

```
HTTP/1.1 200 OK
```

If there is an error with the cancellation request, the publisher must send a response with one of the following errors. The response must be sent within 30 seconds, including expected transmission time.

Errors

Incompatible headers
: 400 Bad Request. If SID header and one of NT or CALLBACK headers are present, the publisher must respond with HTTP error 400 Bad Request.

Invalid SID
: 412 Precondition Failed. If a SID does not correspond to a known, un-expired subscription, the publisher must respond with HTTP error 412 Precondition Failed.

Missing SID
: 412 Precondition Failed. If the SID header is missing or empty, the publisher must respond with HTTP error 412 Precondition Failed.

Other errors may be returned by layers in the protocol stack below UPnP. Consult documentation on those protocols for details.

4.2 Eventing: Event messages

A service publishes changes to its state variables by sending event messages. These messages contain the names of one or more state variables and the current value of those variables. Event messages should be sent as soon as possible to get accurate information about the service to subscribers and allow subscribers to display a responsive user interface. If the value of more than one variable is changing at the same time, the publisher should bundle these changes into a single event message to reduce processing and network traffic.

As explained above, an initial event message is sent when a subscriber 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. This message should be sent as soon as possible after the publisher accepts a subscription.

Event messages are tagged with an event key. A separate event key must be maintained by the publisher for each subscription to facilitate error detection (as explained below). The event key for a subscription is initialized to 0 when the publisher sends the initial event message. For each subsequent event message, the publisher increments the event key for a subscription, and includes that updated key in the event message. Any implementation of event keys should handle overflow and wrap the event key back to 1 (not 0). Subscribers must also handle this special case when the next event key is not an increment of the previous key. Should be implemented

as a 4 Byte (32 bit) integer.

If there is no response from a subscriber to the event message, the publisher should continue to send event messages to the subscriber until the subscription expires.

To repair an event subscription, e.g., if a subscriber has missed one or more event messages, a subscriber must unsubscribe and re-subscribe. By doing so, the subscriber will get a new subscription identifier, a new initial event message, and a new event key.

4.2.1 Eventing: Event messages: NOTIFY

To send an event message, a publisher must send a request with method NOTIFY in the following format. Values in *italics* below are placeholders for actual values.

```
NOTIFY delivery path HTTP/1.1
HOST: delivery host:delivery port
CONTENT-TYPE: text/xml
CONTENT-LENGTH: Bytes in body
NT: upnp:event
NTS: upnp:propchange
SID: uuid:subscription-UUID
SEQ: event key

<e:propertyset xmlns:e="urn:schemas-upnp-org:event-1-0">
  <e:property>
    <variableName>new value</variableName>
  </e:property>
  Other variable names and values (if any) go here.
</e:propertyset>
```

Listed below are details for the request line, headers, and body elements appearing in the listing above. All header values are case sensitive except where noted. All body elements and attributes are case sensitive; body values are not case sensitive except where noted. Except where noted, the order of elements is insignificant. Except where noted, required elements must occur exactly once (no duplicates), and recommended or optional elements may occur at most once.

Request line

NOTIFY
: Method defined by GENA. Notify client about event.

delivery path
: Path component of delivery URL (**CALLBACK** header in subscription message). Destination for event message. Single, relative URL.

HTTP/1.1
: HTTP version.

Headers

HOST
: Required. Domain name or IP address and optional port components of delivery URL (**CALLBACK** header in subscription message). If the port is missing or empty, port 80 is assumed.

ACCEPT-LANGUAGE
: (No ACCEPT-LANGUAGE header is used in event messages.)

CONTENT-LENGTH
: Required. Length of body in Bytes. Integer.

CONTENT-TYPE
: Required. Must be text/xml.

NT
: Required header defined by GENA. Notification Type. Must be **upnp:event**.

NTS
: Required header defined by GENA. Notification Sub Type. Must be **upnp:propchange**.

SID
: Required header defined by GENA. Subscription identifier. Must be universally unique. Must begin with uuid:. Defined by UPnP vendor. Single URI.

SEQ

Required header defined by UPnP. Event key. Must be 0 for initial event message. Must be incremented by 1 for each event message sent to a particular subscriber. Should be 8 Bytes long. To prevent overflow, must be wrapped to 1. Single integer.

Body

propertyset
: Required. xmlns namespace attribute must be urn:schemas-upnp-org:event-1-0. All sub elements must be qualified with this namespace. Contains the following sub element.
property
: Required. Repeat once for each variable name and value in the event message. Must be qualified by **propertyset** namespace. Contains the following sub element.
variableName
: Required. Element is name of a state variable that changed (**name** sub element of **stateVariable** element in service description). Must be qualified by **propertyset** namespace. Values is the new value for this state variable. Single data type as specified by UPnP service description.

For future extensibility, when processing XML like the listing above, as specified by the Flexible XML Processing Profile (FXPP), devices and control points must ignore: (a) any unknown elements and their sub elements or content, and (b) any unknown attributes and their values.

To acknowledge receipt of this event message, a subscriber must respond within 30 seconds, including expected transmission time. If a subscriber does not respond within 30 seconds, the publisher should abandon sending this message to the subscriber but should keep the subscription active and send future event messages the subscriber until the subscription expires or is cancelled. The subscriber must send a response in the following format.

```
HTTP/1.1 200 OK
```

(No body for a request with method NOTIFY, but note that the message must have a blank line following the last HTTP header.)

If there is an error with the event message, the subscriber must respond with one of the following errors. The response must be sent within 30 seconds, including expected transmission time.

Errors

Missing SID
: 412 Precondition Failed. If the SID header is missing or empty, the subscriber must respond with HTTP error 412 Precondition Failed.
Invalid SID
: 412 Precondition Failed. If a SID does not correspond to a known subscription, the subscriber must respond with HTTP error 412 Precondition Failed. (Service must terminate this SID when it receives this error response.)
Missing NT or NTS header
: 400 Bad Request. If the NT or NTS header is missing, the subscriber must respond with HTTP error 400 Bad Request.
Invalid NT header
: 412 Precondition Failed. If NT header does not equal **upnp:event**, the subscriber must respond with HTTP error 412 Precondition Failed.
Invalid NTS header
: 412 Precondition Failed. If NTS header does not equal **upnp:propchange**, the subscriber must respond with HTTP error 412 Precondition Failed.

Other errors may be returned by layers in the protocol stack below UPnP. Consult documentation on those protocols for details.

4.3 Eventing: UPnP Template Language for eventing

The UPnP Template Language defines well-formed templates for devices and services. To a lesser extent, it also provides a template for the body of event messages. The section on Description explains the UPnP Template Language as it pertains to devices and services. As explained in that section, the UPnP Template Language is written in XML syntax and is derived from XML Schema (Part 1: Structures, Part 2: Datatypes). Below is a listing of this language as it pertains to eventing. The elements it defines are used in event messages; they are colored **green** here, and they are colored **green** in the listing above. Below is where these elements are defined (though it is a minimal definition); above is where they are used.

Immediately following this is a brief explanation of the XML Schema elements, attributes, and values used. The reference to XML Schema at the end of this section has further details.

UPnP Template Language for eventing

```
<?xml version="1.0" ?>
<Schema name="urn:schemas-upnp-org:event-1-0"
    xmlns="urn:schemas-microsoft-com:xml-data"
    xmlns:dt="urn:schemas-microsoft-com:datatypes">
  <ElementType name="propertyset" content="eltOnly">
    <element type="property" minOccurs="1" maxOccurs="*" />
  </ElementType>
  <ElementType name="property" content="eltOnly" />
</Schema>
```

element
: References an element for the purposes of declaring nesting. maxOccurs attribute defines maximum number of times the element must occur; default is maxOccurs = 1; elements that can appear one or more times have maxOccurs = *.

ElementType
: Defines an element in the new, derived language. name attribute defines element name. model attribute indicates whether elements in the new, derived language can contain elements not explicitly specified here; when only unspecified sub elements may be included, model=open. content attribute indicates what content may contain; elements that contain only other elements have content = eltOnly.

As explained in the section on Description, the UPnP Template Language for services also specifies a sendEvents attribute for a state variable. The default value for this attribute is **yes**. To denote that a state variable is evented, the value of this attribute is **yes** (or the attribute is omitted) in a service description; to denote that a state variable is non-evented, the value is **no**. Note that if all of a service's state variables are non-evented, the service has nothing to publish, and control points cannot subscribe and will not receive event messages from the service.

4.4 Eventing: Augmenting the UPnP Template Language

It is useful to augment the description of devices and services with annotations that are not captured in the UPnP Template Language. To a lesser extent, there is value in these annotations to capture event filtering, or moderation.

As explained above, some state variables may change value too rapidly for eventing to be useful. Below is a recommended vocabulary for UPnP Forum working committees or UPnP vendors to document moderation in the number of event messages sent due to changes in a variables value.

maximumRate = *n*
: Optional. State variable *v* will not be part of an event message more often than *n* seconds. If *v* is the only variable changing, then an event message will not be generated more often than every *n* seconds. If *v* ceases to change after an event message has been sent but before *n* seconds have transpired, an event message must be sent with the new value of *v*. Recommended for variables that model continuously changing properties. Single integer.

minimumDelta = *n*
: Optional. State variable *v* will not be part of an event message unless its value has changed by more than *n* * allowedValueRange step since the last time an event message was sent that included *v*, e.g., unless *v* has been incremented *n* times. (cf. INCREMENT, INCREMENT_BOUNDED, and INCREMENT_WRAP explained in the section on Control.) Only defined variables with number and real data type. Recommended for variables that model counters. Single integer.

The publisher can send out any changed moderated variable when an event goes out. The publisher should make its best attempt to meet moderation rules described above, but the publisher can flush recent changes when it sends out events.

Note that moderation affects events only and not state table updates. Specifically, QueryStateVariable may return a more current value than published via eventing. Put another way, moderation means that not all state table changes result in events.

Decisions about which variables to event and any possible moderation is up to the appropriate UPnP Forum working committee (for standard services) or a UPnP vendor (for non-standard services).

4.5 Eventing references

FXPP
: Flexible XML Processing Profile. Specifies that unknown XML elements and their sub elements must be ignored. IETF draft.

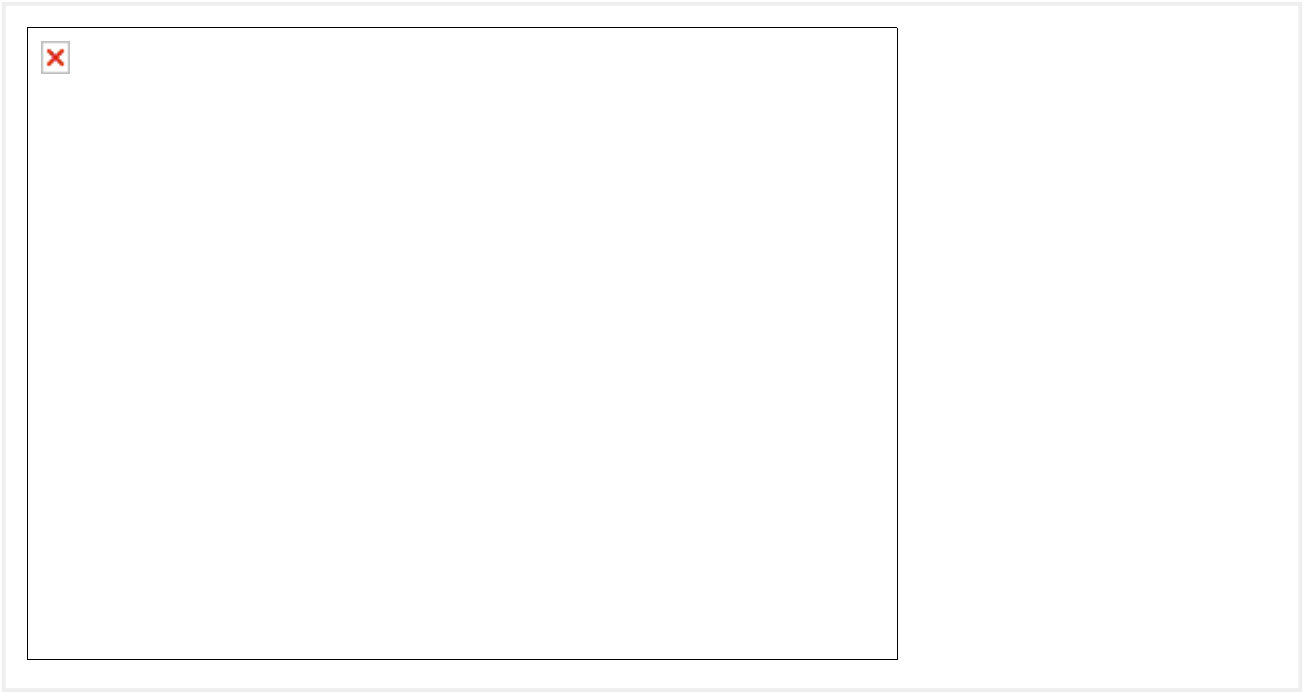
GENA
: General Event Notification Architecture. IETF draft.

XML Schema (Part 1: Structures, Part 2: Datatypes)
: Grammar defining UPnP Template Language. Defined using XML. W3C working draft. Part 1: Structures. Part 2: Datatypes.

5. Presentation

Presentation is Step 5 in UPnP networking. Presentation comes after addressing (Step 0) where devices get network addresses, after discovery (Step 1) where control points find interesting device(s), and after description (Step 2) where control points learn about device capabilities. Presentation exposes an HTML-based user interface for controlling and/or viewing device status. Presentation is complementary to control (Step 3) where control points send actions to devices, and eventing (Step 4) where control points listen to state changes in device(s).

After a control point has (1) discovered a device and (2) retrieved a description of the device, the control point is ready to begin presentation. If a device has a URL for presentation, then the control point can retrieve a page from this URL, load the page into a browser, and depending on the capabilities of the page, allow a user to control the device and/or view device status. The degree to which each of these can be accomplished depends on the specific capabilities of the presentation page and device.



The URL for presentation is contained within the presentationURL element in the device description. The device description is delivered via a description message. The section on Description explains the device description and description messages in detail.

Retrieving a presentation page is a simple HTTP-based process and uses the following subset of the overall UPnP protocol stack. (The overall UPnP protocol stack is listed at the beginning of this document.)

UPnP vendor [purple]
UPnP Device Architecture [green]
HTTP [black]
TCP [black]
IP [black]

At the highest layer, the presentation page is specified by a UPnP vendor. Moving down the stack, the UPnP Device Architecture specifies that this page be written in HTML. The page is delivered via HTTP over TCP over IP. For reference, colors in [square brackets] are included for consistency with other sections in this document.

To retrieve a presentation page, the control point issues an HTTP GET request to the presentation URL, and the device returns a presentation page.

Unlike the UPnP Device and Service Templates, and standard device and service types, the capabilities of the presentation page are completely specified by the UPnP vendor. The presentation page is not under the auspices of a UPnP Forum working committee. The page must be an HTML page; it should be version HTML 3.0 or later. However, other design aspects are left to the vendor to specify. This includes, but is not limited to, all capabilities of the control point's browser, scripting language or browser plug-ins used, and means of interacting with the device. To implement a presentation page, a UPnP vendor may wish to use UPnP mechanisms for control and/or eventing, leveraging the device's existing capabilities but is not constrained to do so.

Presentation pages should use mechanisms provided by HTML for localization (e.g., META tag with charset attribute). Control points should use the ACCEPT- / CONTENT-LANGUAGE feature of HTTP to try to retrieve a localized presentation page. Specifically, a control point may include a HTTP ACCEPT-LANGUAGE header in the request for a presentation page; if an ACCEPT-LANGUAGE header is present in the request, the response must include a CONTENT-LANGUAGE header to identify the page's language.

5.1 Presentation references

HTML
HyperText Markup Language. W3C recommendation. <http://www.w3.org/MarkUp/>.

Glossary

action
: Command exposed by a service. Takes one or more input or output arguments. May have a return value. For more information, see sections on Description and Control.

argument
: Parameter for action exposed by a service. May be in xor out. For more information, see sections on Description and Control.

control point
: Retrieves device and service descriptions, sends actions to services, polls for service state variables, and receives events from services.

device
: Logical device. A container. May embed other logical devices. Embeds one or more services. For more information, see section on Description.

device description
: Formal definition of a logical device, expressed in the UPnP Template Language. Written in XML syntax. Specified by a UPnP vendor by filling in the placeholders in a UPnP Device Template, including, e.g., manufacturer name, model name, model number, serial number, and URLs for control, eventing, and presentation. For more information, see section on Description.

device type
: Standard device types are denoted by urn:schemas-upnp-org:device: followed by a unique name assigned by a UPnP Forum working committee. One-to-one relationship with UPnP Device Templates. UPnP vendors may specify additional device types; these are denoted by urn:*domain-name*:device: followed by a unique name assigned by the vendor, where *domain-name* is a domain name registered to the vendor. For more information, see section on Description.

event
: Notification of one or more changes in state variables exposed by a service. For more information, see section on Eventing.

publisher
: Source of event messages. Typically a device's service. For more information, see section on Eventing.

root device
: A logical device that is not embedded in any other logical device. For more information, see section on Description.

service
: Logical functional unit. Smallest units of control. Exposes actions and models the state of a physical device with state variables. For more information, see section on Control.

service description
: Formal definition of a logical service, expressed in the UPnP Template language. Written in XML syntax. Specified by a UPnP vendor by filling in any placeholders in a UPnP Service Template. (Was SCPD.) For more information, see section on Description.

service type
: Standard service types are denoted by urn:schemas-upnp-org:service: followed by a unique name assigned by a UPnP forum working committee, colon, and an integer version number. One-to-one relationship with UPnP Service Templates. UPnP vendors may specify additional services; these are denoted by urn:*domain-name*:service: followed by a unique name assigned by the

vendor, colon, and a version number, where *domain-name* is a domain name registered to the vendor. For more information, see section on Description.

SOAP
: Simple Object Access Protocol. A remote-procedure call mechanism based on XML that sends commands and receives values over HTTP. For more information, see section on Control.

SSDP
: Simple Service Discovery Protocol. A multicast discovery and search mechanism that uses a multicast variant of HTTP over UDP. For more information, see section on Discovery.

state variable
: Single facet of a model of a physical service. Exposed by a service. Has a name, data type, optional default value, optional constraints values, and may trigger events when its value changes. For more information, see sections on Description and Control.

subscriber
: Recipient of event messages. Typically a control point. For more information, see section on Eventing.

UPnP Device Template
: Template listing device type, required embedded devices (if any), and required services. Written in XML syntax and derived from the UPnP Template Language. Defined by a UPnP Forum working committee. One-to-one relationship with standard device types. For more information, see section on Description.

UPnP Service Template
: Template listing action names, parameters for those actions, state variables, and properties of those state variables. Written in XML syntax and derived from the UPnP Template Language. Defined by a UPnP Forum working committee. One-to-one relationship with standard service types. For more information, see section on Description.

UPnP Template Language
: Defines the elements and attributes used in UPnP Device and Service Templates. Written in XML syntax and derived from XML Schema (Part 1: Structures, Part 2: Datatypes). Defined by the UPnP Device Architecture herein. For more information, see section on Description.

EOF