

# XML based Wide Area Communication with Networked Appliances

Sumit Khurana, Ashutosh Dutta, Provin Gurung  
*Telcordia Technologies*

Henning Schulzrinne, *Columbia University*

## Abstract:

*A variety of technologies are available to network appliances that provide home automation and control. However, these do not support wide-area access control and interworking of these Networked Appliances (NA). This paper describes an XML based data format for conveying information pertaining to control, query and event notification functionality to Networked Appliances.*

## 1. Introduction

There are numerous technologies for networking and controlling appliances within a home. Some examples are X.10 [6], HAVi [1], VHN [2], and UPnP [3]. However, there is currently no support for wide-area access communication or control of these Networked Appliances (NAs) from the Internet, or for interworking the various home networking technologies. The ability to provide such support will radically enhance the ability to provide exciting new services [8,9].

This paper defines an XML based format, the Device Message Protocol (DMP), for conveying information pertaining to control, query and event subscription and notification functionality to networked appliances. The data format defined, captures all the requirements for communicating with networked appliances described in [9]. DMP is intended to be carried as the body of the SIP, DO Message, defined in [11] or the SUBSCRIBE, NOTIFY messages defined in [12]. However, no assumptions are made on the encapsulating protocol, therefore, any protocol, which supports MIME types, such as HTTP, may also be valid for carrying DMP messages. When a message carries a DMP payload, the MIME type should be set to "text/dmp".

This paper is organized as follows. Section 2 provides an overview of the mechanisms involved, section 3 provides detailed wide area components that are required to provide these functionalities in a networked appliance environment. Section 4 defines the XML format for DMP. Section 5 concludes the paper.

## 2. Overview

Mechanisms are required for communicating with NAs to invoke control actions, e.g. to switch on the heater in the bedroom; for querying devices, e.g. to determine the temperature in the house; for event notification, e.g., to receive notification if the temperature in the house falls below freezing point. There is also a need for returning status information associated with the success or failure of each of these functions. Other communications needs identified in [9], include support for mobility and for initiating multimedia sessions. This document defines an XML based format for conveying information pertaining to control, query and event subscription and notification functionality to networked appliances. The major design goals for DMP are flexibility and extensibility. Different devices will have varying functionality. In fact, Networked Appliances are defined as special purpose devices with a networked processor. For example, a cassette recorder has a play and record function, whereas a refrigerator has a thermostat setting. Moreover, similar devices manufactured by different companies will have varying features and capabilities. DMP is independent of functionality associated with a specific device or a class of devices. Instead, it defines a minimal set of functions specifically associated with communicating with networked appliances and a corresponding framework within which actions associated with specific devices must be cast. The capabilities and services offered by a device may not be known a-priori to a client. Moreover, the list of devices that are accessible for use (with proper authorization), within a domain, for example the users home, may also not be known. The lack of a-priori knowledge of possible services offered by a device makes the problem different from the approach used in the Service Location Protocol[13], where the client poses a query to determine a server that offers a specific service. In the case of networked appliances, a user may want to take a set of actions based on what devices are present and the set of capabilities that they offer. For example, switch on the music and dim the lights if they can be dimmed, or, find devices in the hotel room and render the alarm clock service on

one of the devices, according to say, the capabilities of the telephone, stereo or television. Mechanisms must thus be provided which enable the client to discover the devices and the services that they offer for access to the client.

1. Manual configuration of the trusted clients with a list of devices and their capabilities,
2. Extending Subscribe Notify to have a proxy for the devices, for example the residential gateway, inform the subscribed clients of the capabilities and existence of devices when they come up, register or start offering additional services,
3. An explicit discovery mechanism, wherein a client explicitly queries a proxy in order to determine the list of devices and/ or the devices' capabilities are possible mechanisms. One or more of the above may be used based on the application and the problem domain.

SIP methods for, SUBSCRIBE and NOTIFY, and OPTIONS are applicable for mechanisms 2 and 3 above respectively. The OPTIONS method, which is used to query server capabilities, used with a new MIME type for device description and discovery, is appropriate for wide area control. The discovery mechanisms and device description will be addressed in a companion document describing the Device Description Protocol (DDP), which will also be an XML based format. DMP makes no assumptions on the precise discovery mechanism used to find devices and their capabilities. The only assumption is that devices and their capabilities are known to the invoking client. The question of discovery is not addressed further in this document. The scope of DMP is limited to functions specific for communicating only with NAs. Some other communication functions such as initiating a multi-media session, which may be applicable for communicating with NAs, but have much wider scale applicability, are not addressed by DMP. Existing mechanisms should be used for such communication. The data format defined uses XML (eXtensible Markup Language). XML helps provide the flexibility and extensibility that DMP requires, for supporting a variety of existing and possible, devices and services. The data format is similar and complimentary to the XML formats defined by the UP&P forum in the UP&P Device Architecture[4]. DMP captures the communication needs associated with NAs. The device specific functionality and services can be captured using the XML schemas defined by the UP&P forum Device Descriptions and cast in the framework defined by DMP for wide

area communication with NAs. DDP and DMP, follow a minimalist approach, as exposing detailed descriptions for devices is likely not to scale well and nor be appropriate for security reasons, when used for the wide area. Only a subset of the devices within a home and a subset of the complete device capabilities are likely to be exposed. Moreover, the scope of the actions taken is not necessarily limited to a single device. Protocol bridges are required between DMP and the various disparate technologies X.10, UP&P etc., that may exist within the house for communication between devices that are not directly SIP enabled, but are physically enabled for X.10, Bluetooth etc., and the SIP User Agent associated with the device. The initial application of DMP is intended as constituting the message body of the SIP, DO message and of the SUBSCRIBE/NOTIFY messages when used for event notification with NAs.

Figure 1 shows a scenario where a user in the internet can control the appliances connected to an internal LAN within a home using the methods described above.

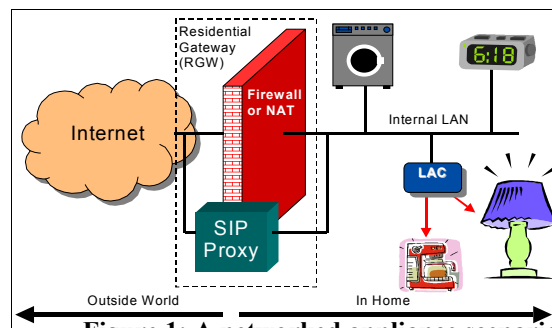


Figure 1: A networked appliance scenario

### 3. Components of Wide Area Device Communication

The core components of wide area device communication are Control, Query and Event notification. The requirements and scenarios associated with these actions are as follows

#### Control

1. Control one function on a device. For example, switch on the lamp.
2. Control in parallel more than one function on a device. For example, set the temperature on the AC to cooler and open its vent.
3. Control in sequence more than one function on a device. For example, tilt the camera and then focus it.
4. Control a class of devices. For example, switch on all ACs in the home.

5. Control more than one device to execute one user action. For example, close the windows and switch on the AC.

### Query

1. Query a single state variable on a device. For example, get the temperature setting in the bedroom.

2. Query a set of state variables associated with a single device. For example, get the volume, balance and fade settings on the stereo audio player.

3. Query a class of devices. For example, get the status of all lamps in the house.

### Events

1. Subscribe to an event on a device where an event is defined as change in state of a variable. For example, inform me, if the temperature goes below 32F.

2. Notification should convey enough information about what has changed. For example, the temperature changed and now is 31F.

3. Associate a validity period for the subscription. Should be able to specify this in various forms for example, till next Tuesday, for the next 5 days, till 5pm, etc.

4. Subscribe to a set of events constituting one user subscription. For example, inform me in the office, if the temperature changes or the door bell rings.

5. Possibly associate a different expiry time with each event, if a set of events is defined as in 4 above.

These scenarios can be realized depending on the combination of addresses, headers and message body used. For example, the SIP URI may refer to a class of devices rather than a single device, for example, acs@examplehome.net for all ACs in the home and the message body may contain an action which is to be applied to all ACs. In the extreme case there could be but one UA associated with all devices in the home, possibly at the Residential Gateway, or, a separate UA for every single device. The validity or appropriateness of the granularity of device addressing and the different approaches is not addressed here and is most likely application dependant. DMP, however, is flexible enough to make it possible for all of these requirements and scenarios to realized.

## 4. XML Definitions

This section defines an XML format for some parts of DMP that captures the requirements stated in section 2.

### 4.1. Actions:

```
<schema
xmlns='http://www.w3.org/1999/XMLSchema' target
Namespace='http://www.w3.org/namespace/'
xmlns:t='http://www.w3.org/namespace/'>
<element name='DMPAction'>
<complexType content='elementOnly'>
<sequence maxOccurs='unbounded'>
<element ref='t:Device'>
<choice maxOccurs='unbounded'>
<element ref='t:Control'>
<element ref='t:Query'>
<element ref='t:Subscribe'>
</choice>
</sequence>
</complexType>
</element>
```

A DMP action consists of one or more of a device identifier followed by one or more of either a control, query or subscribe actions

```
<element name='Device'>
<complexType content='mixed'>
</complexType>
</element>
```

### Control Action:

```
<element name='Control'>
<complexType content='elementOnly'>
<element ref='t:Action'>
<element ref='t:Argument' minOccurs='0'
maxOccurs='unbounded'>
</complexType>
</element>
```

A control is an available control action that can be accessed on the device followed by 0 or more arguments associated with the action.

```
<element name='Action'>
<complexType content='mixed'>
</complexType>
</element>
```

```
<element name='Argument'>
<complexType content='mixed'>
</complexType>
</element>
```

### Query:

```
<element name='Query'>
<complexType content='elementOnly'>
<sequence maxOccurs='unbounded'>
<element ref='t:Variable'>
</sequence>
```

```
</complexType>
</element>
```

A query consists of a list of one or more state variables on the device that are being queried.

Similar format can be defined for actions such as event subscription, control action response, query response and event notification.

#### 4.2 Examples:

Following are some of the examples that show how DMP can be used in different contexts of network appliances. An example of DMP used in the body of the DO method to switch on a lamp is given below.

```
DO sip:[slp://d=lamp,r=bedroom,u=stanm]@home.net
From: sip:stan@co.com
To: sip:[slp://d=lamp,r=bedroom,u=stanm]@home.net
Via: SIP/2.0/UDP anypc.com
Content-function: render
Content-type: application/dmp
<?xml version="1.0"?>
<DMPAction>
<Device>lamp_device_id</Device>
<Control>
<Action> Power On</Action>
</Control>
</DMPAction>
```

An example of DMP used in the body of the DO method to **query a temperature setting**:

```
DOsip:[slp://d=thermostat,r=downstairs,u=stanm]@home.net
From: sip:stan@co.com
To:sip:[slp://d=thermostat,r=downstairs,u=stanm]@home.net
Via: SIP/2.0/UDP anypc.co.com
Content-type: application/dmp
<?xml version="1.0"?>
<DMPAction>
<Device>thermostat_device_id</Device>
<Query><Variable>
Temperature
</Variable>
</Query>
</DMPAction>
```

#### An example of a query response:

```
200 stan@co.com
From:sip:[slp://d=thermostat,r=downstairs,u=stanm]@home.net
To:sip:stan@co.com
Via: SIP/2.0/UDP stan.home.net
Via: SIP/2.0/UDP home.net
Via: SIP/2.0/UDP co.com
```

```
Via: SIP/2.0/UDP anypc.co.com
Content-type: application/dmp
<?xml version="1.0"?>
<DMPResponse>
<Device>device-id</Device>
<QueryResponse>
<Variable>Temperature</Variable>
<Value> 65F</Value>
</QueryResponse>
</DMPResponse>
```

#### 5. Conclusions

In this paper we have defined a protocol called DMP based on XML format that can be used for networked appliances. We have used the methods described in standard SIP protocol where DMP can be carried as session description payload. Several examples of DMP including DMP message format have been cited.

#### References:

- [1] HAVi, <http://www.havi.org>
- [2] 'VHN Home Network,' EIA 851, <http://www.vesa.org> for further information.
- [3] UPnP, Universal Plug and Play Device Architecture v1.0, [http://www.upnp.org/download/UPnPDA10\\_20000613.htm](http://www.upnp.org/download/UPnPDA10_20000613.htm)
- [4] Jini, <http://www.jini.org>
- [5] X.10, <http://www.x10.org>
- [6] Bluetooth, <http://www.bluetooth.com>
- [7] Salutation, <http://www.salutation.org>
- [8] S. Moyer et al, "Framework Draft or Networked Appliances using the Session Initiation Protocol", Internet Draft, Internet Engineering Task Force, July 2000. Work in progress.
- [9] S. Tsang et al, "Requirements for Networked Appliances: Wide-Area Access, Control, and Interworking", Internet Draft, Internet Engineering Task Force, September 2000. Work in progress.
- [10] <http://www.w3.org/XML>
- [11] S. Tsang et al, "SIP Extensions for Communicating with Networked Appliances", Internet Draft, Internet Engineering Task Force, November 2000. Work in progress
- [12] J. Rosenberg et al., "SIP Extensions for Presence", Internet Draft, Internet Engineering Task Force, June 2000, Work in progress, draft-rosenberg-imp-presence-00.txt
- [13] E. Guttman et al., "Service Location Protocol, Version 2" RFC 2608, Internet Engineering Task Force, June 1999