ADHOC PERSONAL UBIQUITOUS MULTIMEDIA SERVICES VIA UPNP

G. Schneider C. Hoymann, S. Goose

Siemens Corporate Research
755 College Road East
Princeton, New Jersey 08540, USA

ABSTRACT

Small screen devices like cellular phones or Personal Digital Assistants (PDAs) are the artifacts of information technology almost everybody carries around today. Together with wireless networks they are the ubiquitous gateway to information and services. Especially the increasing bandwidth together with the improving processing power of these devices supply us with capabilities known only from desktop computers a couple of years ago. However, the access to rich multimedia content using these devices is almost impossible due to the physical limitations without performing lossy content reduction. An idea to overcome these limitations results from the observation that our daily life is surrounded by information technology almost everywhere, e.g. PC's, Laptops TV sets, public terminals, etc.. These "larger screen devices" can be used in conjunction with the small screen device to extend its capabilities and to provide access to rich multimedia content and services without any sacrifice. In order to do so the small screen device must be able to access these devices and to remotely control them. UPnP (Universal Plug and Play) [1] is a technology, which connects appliances on an ad-hoc basis. In this paper we will present our concept of ad-hoc personal ubiquitous multimedia services and illustrate an UPnP based implementation, which allows users a high degree of mobility and in parallel facilitates the access of rich multimedia contents by using a small screen device.

1. INTRODUCTION

The World Wide Web has significantly changed the information society. Today we are used to access all kind of information immediately from our desktop. Internet technologies and standards facilitate storing and accessing not only of text and graphics information but more and more multimedia information in general. However, these activities are focusing on desktop computing systems. Nowadays, small screen mobile computing devices, such as Personal Digital Assistants (PDAs), Handheld PC (H/PC), WAP phones or cellular phones, enjoy enormous popularity. The phenomenal growth and rising demand of users to access Internet content anywhere at any time have further driven the future of computers towards to mobile and ubiquitous computing. That is to break away from a desktop-centric world and to move into the world that surrounds the users. The discipline situated computing investigates techniques to provide a more mobile user-centric computing environment by using pervasive devices. While the Internet was of an immobile nature up-to-now, we are now witnessing the strong move towards to the mobile Internet, which rather complements and extends traditional systems than replacing it.

At Siemens Corporate Research (SCR), one research focus has been identified to investigate techniques and methodologies to provide mobile users access to rich multimedia information and diverse services by using small screen devices. This research effort aims at providing a framework that offers small screen device users the possibility to retrieve the same variety of multimedia information and to access the same diversity of services as with traditional desktop systems. This paper describes our concept of ad-hoc personal ubiquitous multimedia services and illustrates an UPnP based implementation. We refer to these ad-hoc personal ubiquitous multimedia service environments as to "Composite Devices". Hence a composite device consists of the users personal small screen device and the available devices that surround him at his current location, such as PCs, workstations, high-resolution monitors, TV sets etc.. Furthermore a key point of our approach is not only to provide methods to incorporate devices but also to outsource computing tasks to be performed on computing resources in the close vicinity in a way that each device does what it can do best. In this paper we use a PDA as a representative for the class of small screen devices.

2. RELATED WORK

Mark Weiser [2] has significantly influenced the era of ubiquitous computing with his visionary article "The Computer for the 21st Century". Weiser expressed the idea of "disappearing" computing resources that are ubiquitous and fulfill processes without being the object of interests.

Researchers have targeted the wish to access multimedia content on small screen devices in different ways. With the rising popularity of mobile devices primarily dominated by the PalmPilot [3], one research direction has been focused on developing middleware approaches to deliver multimedia information and services to such PDAs. In [4] an adaptive middleware proxy and a graphical web browser for the PalmPilot has been presented allowing to access multimedia content. This is achieved by adapting the content into a format, which the PalmPilot is able to render. In Infopyramid [5] a content adaptation framework has been described to deliver multimedia content, such as video, image, text and audio to mobile devices. Infopyramid provides two methodologies, translation and summarization to create different views on media data to fit on thin clients. Another way to achieve this goal has been followed in [6] where new methodologies are introduced that enable the use of PDAs beyond their "normal personal productivity" functionality. The Pebbles project introduces a way for collaborative work on a desktop system. Within Pebbles a number of different applications has been developed, e.g. an application that provides a method for a group of people to in turn control applications running on a PC. However,

Pebbles enables PDAs as the only mobile device that can access these applications. Yet, Pebbles demonstrates a new perspective on the use of PDAs. In [7] techniques are investigated that enable the ubiquitous access of WWW resources and the control of surrounding hardware to displaying these resources using a PDA. In order to do so the UbicompBrowser integrates surrounding devices to minimize the limitations of a single PDA. The system provides a means to select a URL using the PDA. The content of the selected web page is then rendered on an attached PC or TV. Here the possibility of using surrounding resources in combination with a small screen device is recognized. However the system does not consider sophisticated user interactivity issues or dealing with multimedia resources adapted to the capabilities of the computing resources if necessary.

Inspired by the above projects our vision is to combine a flexible ad-hoc networking approach to incorporate surrounding devices and to exploit their capabilities together with the possibility to intelligently distribute and, if necessary, adapt multimedia information.

3. AD-HOC PERSONAL UBIQUITOUS MULTIMEDIA SERVICE ENVIRONMENT

In the following we will sketch our vision of an ad-hoc personal ubiquitous multimedia service environment, which we refer to as Composite Device Computing Environment (CDCE). We will also elaborate the different challenges, especially in regard to ad-hoc device/service integration.

3.1 Exemplary CDCE Session

A typical CDCE session can be sketched as follows: A user wants to give a presentation in conjunction with a videoconference in a meeting room at a customer's site carrying exclusively his PDA with him. The PDA detects available computing/output devices in the close vicinity, like a beamer and a TV set. It then informs the Smart Gateway via wireless communication about this environment. The Gateway can offer personalized information and services to the user. In this case it offers a videoconference service and the possibility to render a presentation. Depending upon the user's selection, the Smart Gateway intelligently organizes, synchronizes and distributes the requested information and services for interactive media access. In this example the user selects the videoconference service to be displayed on the TV set and the presentation to be streamed to the beamer. Finally he controls the services remotely using his PDA.

3.2 CDCE Overview

Generally we want to support a variety of devices and different networks as well as diverse multimedia services, accessible from a small screen device. In order to deliver these services in the best possible quality we let each device perform the work, i.e. computation, output and input, what it is best suited for. Computational tasks as well as processes that require sophisticated output media are not suited for a PDA. Therefore each device must be able to describe its functionality and to provide means to exploit them. In the following we will show how UPnP can help to achieve this goal. Related to this point is the possibility to sense and access devices on a physical basis. Enabling ad-hoc device collaboration using short range sensing technologies can be accomplished using IR [8] or Bluetooth [9]. Hence, such an infrastructure enables a dynamic detection and exploitation of computing and output devices in the close vicinity of the user via PDA. However if for some reason either network capabilities or the capabilities of the detected devices are not suited to render the desired information or services, possibilities for tailoring information to the needs of the user and the environment must be provided. Finally it is vital to support interactivity between the small screen client and environmental resources. The user must be able to control and interact with the invoked processes on these resources using his small screen client. This implies that the user interface (UI) must be accessible from the different devices and be tailored to their capabilities.

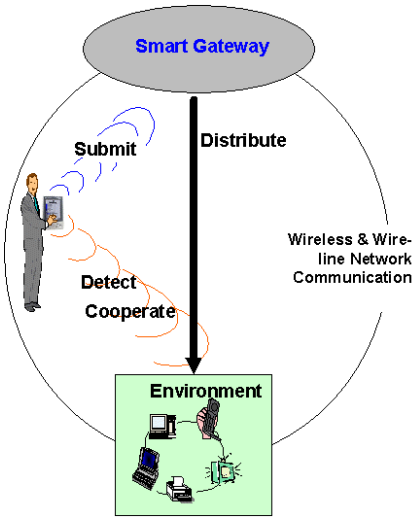

Figure 1: Architectural sketch of the ad-hoc personal ubiquitous multimedia environment.

Figure 1 illustrates our concept. It shows the different components of the system as a way to realize the multimedia service environment. It shows the clustering of the CDCE framework into three major components or functional entities: the CDCE Smart Gateway, the PDA itself and the environment. The network communication is considered by enabling wireless and wire-line communication facilities in CDCE.

4. UPNP AS AN ENABLING TECHNOLOGY FOR CDCE

In the following we will shortly introduce the UPnP technology as an enabling technology for ad-hoc device discovery and remote control. Then we will focus on how we have exploited this technology to realize the CDCE.

4.1 Introduction to UPnP

UPnP is a peer-to-peer technology for PC's, intelligent appliances and wireless devices. As a communication protocol it uses HTTP. Basically each device describes its capabilities in an XML file and advertises itself as in a network. In our case an UPnP device can be regarded as a CDCE service. Control Points

(CP's) can retrieve this information and access the device. The following steps are necessary to accomplish UPnP networking:

- *Addressing:*
  CP and device receive addresses. Both control point and device gather their IP addresses either through DHCP [10] or AutoIP [11].
- *Discovery:*
  CP detects devices. The devices advertise themselves using Multicast messages. CP's can also search for devices.
- *Description*:
  CP fetches device capabilities. The XML page, which describes the device and the services it offers are retrieved.
- *Control:*
  CP invokes actions on the device. Since the CP finally knows the services, it can control them using SOAP [12].
- *Eventing:*
  CP gets informed about the state changes of device. Therefore the CP can subscribe to events of a device. The GENA [13] protocol is used for this service.
- *Presentation:*
  The device supplies a HTML UI. Therefore the CP can remotely control device and/or view the status of it.

Another advantage of UPnP is the HTML based UI. Due to this flexible mechanism it is possible to access the devices from a broad variety of small screen devices with different capabilities through adapting it to WML [14],[15] and VoiceXML [16],[17].

4.2 UPnP in CDCE

UPnP implements the different devices in the ad-hoc multimedia service environment. Basically an UPnP device can consist of a service and/or an embedded device. The different (physical) devices we want to access on an ad-hoc basis must consequently be one/multiple UPnP device(s). The devices register with the Smart Gateway (SG), which in turn knows about the provided services and is then able to access those. The following shows a description of the "VideoConference:1" device type containing a "VCService:1" service type which is accessible through the web interface http://mylocation/VCService.html:

```
… <root xmlns="urn:schemas-upnp-org:device-1-0">
 <device>
  <deviceType>urn:schemas-upnp-
      org:device:VideoConference:1</deviceType>
           <friendlyName> Videoconference </friendlyName>
... <serviceList>
    <service>
     <serviceType>
      urn:schemas-upnp-org:service:VCService:1
     </serviceType>
     <serviceId>
      urn:upnp-org:serviceId:VCService</serviceId>
    </service>
  <presentationURL>
    http://mylocation/VCService.html</presentationURL>
 </device>
</root>
```

The appropriate service with the action "Call", initiating a videoconference with "CallerName", triggering the state variable "CallingTo", which can be used to retrieve the information that the VC application is calling to "CallerName" looks as follows:

```
… <actionList>
  <action>
  <name>Call</name>
   <argumentList>
    <argument>
     <name>CallerName</name>
     <relatedStateVariable>CallingTo</relatedStateVariable>
     <direction>in</direction>
    </argument>
   </argumentList>
  </action>
... </scpd>
```

Figure 2 illustrates the different devices registering with the Smart Gateway. The Device Finder creates a Devices Collection from all available UPnP devices in the network.

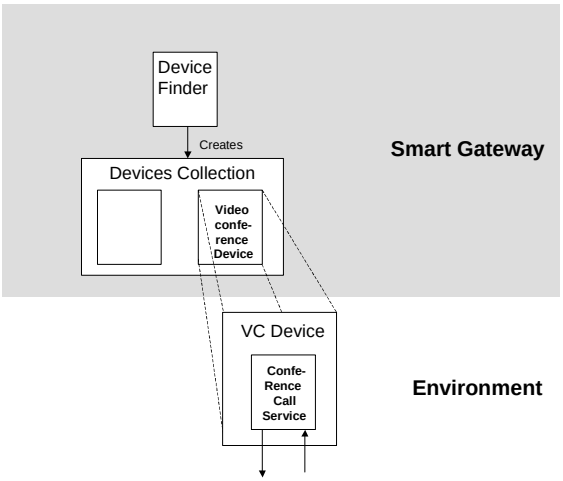

Figure 2: Different devices registering with the Smart Gateway

The Smart Gateway abstracts from the devices and offers a single access point to the user. The Smart Gateway is consequently both, an UPnP device and a Control Point. It provides the possibility to dynamically adapt and/or combine "basic" devices to "higher-level" devices or device collections according to the realities. Consequently the Smart Gateway can offer more sophisticated (UPnP) devices to the user.

It also assigns (CDCE) services requested by the user to available (physical) devices by selecting the appropriate (UPnP) devices. When it cannot find appropriate (physical) devices to execute requested (CDCE) services, it can adapt them or split and distribute the requested (CDCE) services over a group of (UPnP and/or physical) devices. An example for this is. a "composite" videoconference device that can be created using a graphics terminal without audio capabilities and a cell phone. This functionality can only be achieved using the abstractions described above. Therefore a two-layered architecture is necessary. How this architecture can be implemented using the UPnP technology is depicted in figure 3.

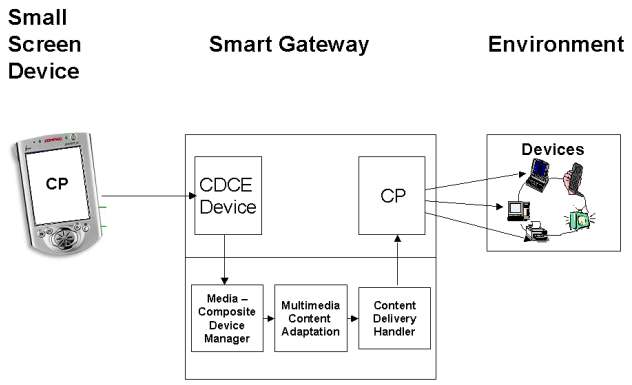

Figure 3: Overall UPnP architecture of CDCE.

The different modules "Media Composite Device Manager", "Multimedia Content Adaptation" and "Content Delivery Handler" achieve the adaptability of the multimedia framework. The "Media Composite Device Manager" is responsible to assign requested (CDCE) services to the appropriate (UPnP) devices. The "Multimedia Content Adaptation" adapts multimedia content in the case there is no appropriate device or network available. The "Content Delivery Handler" deals with the control of the remote devices. Further details can be found in [18].

Consequently the CDCE device does not simply act as a proxy for the user requests, it intelligently analyzes, processes and dispatches these requests to one or more devices.

5. ACCESSING THE CDCE

A user can only access the devices through the Smart Gateway. The Control point belonging to the small screen device discovers the CDCE device. The CP on the SG discovers and controls the devices in the environment. However the SG discovers all UPnP devices in the network and not only those in the users vicinity. Since the devices do not necessarily know where they are located the SG consequently does not know either.

We have chosen a "lightweight" realization for exploiting only these devices that are in close vicinity of the user by implementing a sensing mechanism on the small screen device. After the sensing phase the device can inform the SG on its own which devices are nearby. Therefore the SG does not necessarily need to track the users location and the location of the (physical) devices. For (physical) devices that have no sensing capabilities like a "simple" cell phone, this information has to be supplied, e.g. manually or by additional sensors.

6. SUMMARY

In this paper we have described a solution to realize the ad-hoc personal ubiquitous multimedia service environment using the UPnP technology. The goals like discovery of surrounding devices, finding out about the capabilities of these devices and remote controlling them have been accomplished by implementing two layers of UPnP devices and CP's. Using this two-layered approach we leverage the possibilities of single devices by introducing a Smart Gateway. The SG provides a way to intelligently assign user requests to appropriate devices and to adapt these requests to the various realities. The ad-hoc multimedia service environment can therefore be established and exploited in almost arbitrary realities. Additionally it can be accessed through a variety of small screen devices.

7. AKNOWLEDGEMENTS

A prototype system has been realized within the Siemens Corporate Technology project "Enterprise On Air (EoA)" offering a videoconference, remote mouse and remote keyboard input device. We thank our colleagues of the EoA project for their support, especially for providing the java based UPnP implementation.

8. REFERENCES

[1] Universal Plug and Play Forum http://www.upnp.org
[2] M. Weiser, The Computer for the 21st Century, Scientific American 1991
[3] PalmPilot product series, http://www.palm.com/
[4] A. Fox, I. Goldberg, S. Gribble, D. Lee, A. Polito, E. Brewer, Experience With Top Gun Wingman: A Proxy-based Graphical Web Browser for the 3Com PalmPilot, Proc. of IFIP Intl. Conference on Distributed Systems Platforms and Open Distributed Processing, 1998
[5] J. Smith, R. Mohan, C-S. Li, Scalable Multimedia Delivery for Pervasive Computing, Proc. of ACM Multimedia Conference '99, pp. 131-140
[6] B. A. Myers, H. Stiel, R. Garggiulo, Collaboration Using Multiple PDAs Connected to a PC, Proc. CSCW 98: ACM Conference on Computer-Supported Cooperative Work, November, 1998, pp. 285-294
[7] M. Beigl et al., UbicompBrowser, 4th ERCIM Workshop on User Interfaces for All, October 1998, Stockholm, Sweden
[8] IrDA, The Infrared Data Association, http://www.irda.org/
[9] Bluetooth Forum, http://www.bluetooth.com
[10] Dynamic Host Configuration Protocol http://www.dhcp.org/
[11] DHCP Option to Disable Stateless Auto-Configuration in IPv4 Clients http://www.ietf.org/rfc/rfc2563.txt
[12] Simple Object Access Protocol (SOAP) 1.1 http://www.w3.org/TR/SOAP/
[13] General Event Notification Architecture (GENA) http://www.upnp.org/draft-cohen-gena-client-01.txt
[14] Wireless Application Protocol http://www.wapforum.org/
[15] S. Djennane, S. Goose, H. Molenhauer, WAP Collaboration using WAP devices, in Proc. Mobile Web Workshop, WWW9 Intl. Conference, Amsterdam, 2000
[16] VoiceXML http://www.voicexml.org/
[17] S. Goose, M. Newman, C. Schmidt, L. Hue, Enhancing Web accessibility via the Vox Portal and a Web-hosted dynamic HTML to or from VoxML converter, Computer Networks: the International Journal of Distributed Informatique, Vol.33, no.1-6, June 2000, p.583-92.
[18] T.-L. Pham, G. Schneider, S. Goose, A Situated Computing Framework for Mobile and Ubiquitous Multimedia Access Using Small Screen and Composite Devices, in Proc. of ACM Intl Conference on Multimedia; Los Angeles, USA, October, 2000