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A Situated Computing Framework for Mobile and Ubiquitous Multimedia Access using Small Screen and Composite Devices

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ABSTRACT

Small screen devices, such as cellular phones or Personal Digital Assistants (PDAs), enjoy phenomenal popularity. PDAs can be used to complement traditional desktop computing systems to access personal multimedia information besides the use as typical organizers. However, due to the physical limitations accessing rich multimedia contents and diverse services using a single PDA is more difficult. Hence, the Situated Computing Framework (SCF) research project at Siemens Corporate Research (SCR) aims to develop methods that allow users a high degree of mobility and concurrent to facilitate the access of rich multimedia contents by using a small screen device. A new distributed computing concept, the *Small Screen/Composite Device (SS/CD)* approach, is introduced, which offers new classes of ubiquitous and mobile multimedia services to small screen device users without to limit the diversity and the richness of the provided services.

Keywords

Situated computing, composite devices, mobile, ubiquitous and pervasive computing, WWW

1. INTRODUCTION

The World Wide Web (WWW) has significantly changed and is still continuing to change the information society. It has never been easier to access such a giant resource of information by using just simple mouse clicks. Concurrent, Internet technologies as well as standards facilitate the representation of information in Multimedia format. Much effort was invested to build systems for one to appreciate multimedia WWW contents/services and to enhance robust infrastructures to ensure reliable high Internet traffic. However, these activities are focusing on desktop computing systems. Nowadays, small screen or pervasive computing devices, such as Personal Digital Assistants (PDAs), Handheld PC (H/PC) 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 s*ituated computing* investigates techniques to provide a more mobile user-centric computing environment by using pervasive devices. While the last two decades was marked by the *immobile* Internet, 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 is aimed to provide a framework that offers small screen device users the possibility to retrieve the same variety of multimedia information and access the same diversity of services as is given by traditional desktop systems. This paper describes an innovative distributed architecture, the *Small Screen/Composite Device (SS/CD)* architecture, that implements a more *user-centric* and small screen device focused communication system. We define composite devices as available devices that surround user's current location, such as PCs, workstations, high-resolution monitors, TV set etc. Depends upon the user's current position and situation, the *SS/CD* approach provides methods to incorporate and to outsource computing tasks to perform on computing resources in the close vicinity.

The remainder of this paper is structured as follow: Section 2 provides a brief overview about situated computing. The related work is summarized in section 3. The motivation of this research focus is discussed in section 4. Section 5 describes a SCF system user scenario. The design goals are described in section 6. Section 7 illustrates and describes the high-level SCF system architecture. Section 8 and 9 describe the core component of SCF. The status about the current stage is given in section 10. Finally, a discussion about future research directions and conclusion is given in section 11.

Also in the remainder of this paper, the PDA is used to represent the class of small screen devices.

2. SHORT OVERVIEW OF UBIQUITOUS AND SITUATED COMPUTING

The origin of ubiquitous computing derived from the idea to make any kind of computing devices invisible. That is to create an environment, in which computers are fulfilling tasks for us in the background without being the object of interest [1]. The ubiquitous environment is an environment, in which different kind of computers and devices are surrounding us. It attempts to provide computing services customized and tailored to our needs and demands.

Situated computing is one research direction within the ubiquitous computing research. By considering environmental factors such as user location, identity, profile etc. [2] situated computing is aimed to provide techniques for developing situation, context-aware and more intelligent mobile computing systems. First, these are systems, which are capable to sense and to detect resources and social events in the surrounding environment of the mobile user. Second, these systems are able to process and to interpret this information as well as to react to it. Consequently, situated computing pursues concrete application scenarios to provide new classes of mobile application and services with more personal and appropriate behavior. Concurrent, situated computing embodies new methodologies to exploit hardware resources and physical location to use in a different manner. Such systems are further characterized by a more user-centric approach.

3. RELATED WORK

This section provides a brief overview about the related work. It also aims to provide an historical view about the conducted research activities in the ubiquitous and mobile computing society, since the first discussions.

Many research activities have been conducted since the first discussions and the pioneer work of mobile and ubiquitous computing were published in the early 90s [1,3,4,5]. While the contributions by Weiser [1,3,4] expressed the vision of using computing devices as natural as using pen and paper, the Active Badge System [5] is a system that allows to track the current position of people wearing badges in an office environment. Due to the lack of available handy- and pocket-sized computing hardware, many succeeding works are focused on wearable computing systems, such as the Touring Machine by Feiner *et al* [6] or the Metronaut system by Smailagic *et al* [7]. A typical wearable computing system consists of a backpack computer, a handheld computer and a head mounted display (HMD). Feiner *et al* incorporates position tracking and augmented reality technologies to provide virtual urban information on HMD that is overlaid on the actual view of the environment to guide people through university campus [6]. Similar, Smailagic's Metronaut system offers users guidance service and scheduling negotiating possibility [7], but without using augmented reality technology and HMD. The combination of wearable computers and augmented reality is further explored by the research activities of Rekimoto [8,9,10] and Billinghurst [11]. Both researchers investigate methodologies for mobile virtual collaborative working space that is to allow users to interact with the real world [8,9,10] and to communicate and collaborate with each other in virtual conference spaces via wearable computers [11]. Therefore, Rekimoto develops a technique that allows attaching of digital information to physical devices [9]. In Billinghurst's virtual conference space [11] people equipped with wearable computers and HMD can walk around and discuss about HTML contents displayed on the HMDs.

Several researchers focused on methodologies to build service and maintenance systems with more multimedia capabilities. Siewiorek *et al* [12] develops the mobile service and maintenance system Adtranz that allows mobile service technicians to communicate using media, such as digital data, image and audio, with remote help desk personnel for remote aid on repairing tasks. Technicians can access to HTML structured data manual via a standard web browser on the mobile pen based computer that even allows document annotation and collaboration capability, e.g. application sharing [12]. Audio communication is enabled over a wireless LAN network and IP based telephony software. Although more multimedia is provided, the Adtranz system as well as the above guiding systems are heavy and bulky and are therefore not very pleasant to carry.

Context-awareness issue is a further focus of ubiquitous systems. The Cyberguide system by Abowd *et al* [13] provides mobile handheld tour guides to university campus. Knowledge of physical user location at the present time and in the past, which is identified as context information, is used to provide a guiding system that aims to simulate real guide tours. Although focusing on positioning infrastructure and exploiting context information, Apple's Newton MessagePad [13] is used as the Cyberguide mobile hardware that is in comparison to above described wearable systems much smaller and more convenient to carry.

A most other recent research direction of mobile and ubiquitous computing is the intelligent home [14] and classroom practices [15,16] or in general smart spaces [17]. This group of researches aims to incorporate computing technologies and pervasive devices to enhance human daily life environment and to facilitate it. The Cyberfridge as presented in [14] would always inform users the actual content of the fridge and allows to leave virtual notes for other users on a display mounted on the fridge's door. Smart spaces can provide further services, such as to adjust certain room temperature or room light control depends upon the situation at present time and users preference

Meyers *et al* [18] describes the application Pebbles that allows multiple PDAs to connect to a PC for collaborative works. Pebbles provides a simple method for a group of people to in turn control applications running on a PC. Although, in Pebbles PDAs are simply used as an additional input device for a group of people to conduct meetings, it demonstrates a new perspective of using this class of devices other than the typical organizer functionalities, such as address book, calculator or memo pad.

With the rising popularity of pervasive devices primarily dominated by the PalmPilot, a product line by Palm Inc. [19], one research direction has been focused on developing middleware approaches to deliver multimedia information and services to thin clients, such as PDAs. Fox *et al* develops an adaptive middleware proxy and a graphical web browser for PalmPilot [20] that allow the access of multimedia content on the PalmPilot. That is achieved by adapting the contents into the format that the PalmPilot is able to perform. Smith *et al* [21] describes in Infopyramid a content adaptation framework to deliver multimedia content, such as video, image, text and audio, to pervasive devices. Infopyramid provides two methodologies, translation and summarization [21], to create different varieties of media data to fit on thin clients.

As described in the literature review many researchers have been active to develop ubiquitous and situation aware systems. However, not many activities have been conducted to build user-centric and small screen device focused systems that are pocket-sized and concurrent allowing the access of rich multimedia content. The situated computing framework with the underlined *small screen/composite device* (SS/CD) architecture approach that is presented in the remainder of this paper, is the first attempt to build such a system.

4. MOTIVATION

Having acknowledged the activities of the mobile and ubiquitous research society and observing future mobile technology trends, we conclude that:

- Small screen device capabilities will change towards more processing power and high-resolution displays.
- Wireless networks and protocols will improve towards more bandwidth. That is underlined by the introduction of next generations of wireless network protocols General Packet Radio Service (GPRS) and Universal Mobile Telecommunications System UMTS [22,23,24], which offers higher bandwidth (GPRS: up to 171.2 kbps [23]; UMTS: up to 2 Mbit/s [24]) in compare to today available cellular network such as Code Division Multiple Access (CDMA) [25] with a bandwidth of 9.6 kbps.
- The multimedia content and services will change, e.g. trend from *e*-Commerce towards to *m*-Commerce (mobile commerce).
- Due to the requirement of the PDA to be pocket-sized, the maximum physical size of the small screen display will remain the same. While it is likely that the PDA screen resolution and quality will improve, the display size is anticipated to remain constant for a longer period

Being aware of the display limitations and thus the limited graphical user interface of small screen devices, at SCR one research focus has been identified to build a mobile computing and communication system, the Situated Computing Framework (SCF), that differs from previous and current activities in many ways. The SCF aims to provide a system that is:

- *User-centric*: The SCF intends to provide a system that is customized to the need and mobility of its users. That is to allow users high flexibility to access multimedia information and services while being mobile.
- *Pervasive:* The SCF is designed to use a pervasive device such as a PDA. This is significant since we intend to build a system that not abuses users by having to carry bulky and heavy devices such as wearable computing systems with HMD. Instead, we use light and pocket-sized devices as access devices.
- *Full multimedia capable:* Although, SCF is a user-centric and PDA- centric concept, it should enable users to access to rich multimedia contents and services without having to compromise much in quality and diversity.
- *To exploit composite devices:* To overcome mismatch between *full multimedia capability* and the *screen display limitations*, the SCF provides techniques and infrastructure to incorporate surrounding resources to offer rich multimedia content and services conducted by a single PDA as the proposed *SS/CD* approach by Pham *et al* [26].

The innovative *SS/CD* approach allows mobile PDA users to access rich multimedia content and services without having to shrink or to tailor the content to match the capabilities of the PDA as e.g. proposed by Fox *et al* [20]. Further, the PDA-centric approach of the *SS/CD* concept avoids users having to carry heavy and bulky equipments, e.g. wearable computing system as used by some related research activities. Hence, the SCF provides mechanisms to dynamically exploit and seek surrounding available composite devices and to outsource the requested information or services via the PDA to the most appropriate composite device, which can be used as output device, to fulfill.

5. SCF APPLICATION SCENARIO

The SCF was designed to be adaptable to different working environments depending upon the required services and composite device infrastructure. This section outlines in brief a practice area, which demonstrates the value of the SCF.

Situated Computing in Healthcare Environment

The scenario briefly describes the concept of using a small screen device and the incorporation of composite devices to enhance rich multimedia access on a small screen device. It demonstrates the use of the PDA as a unique communication and access device. Also, tasks that are not suitable for the PDA to perform are outsourced to more appropriate devices.

Multimedia and ubiquitous computing techniques can be exploited to move the paper-based structure of healthcare environment, such as hospital, towards a more digital based or hypertext based infrastructure as proposed by Hsu *et al* [27]. That is the use of hypermedia as innovative means to archive patient data record in a hypertext structure. Concurrent multimedia can be used to create multimedia reports including annotations. Such kind of dynamic multimedia annotation system is proposed by Sastry *et al* [28].

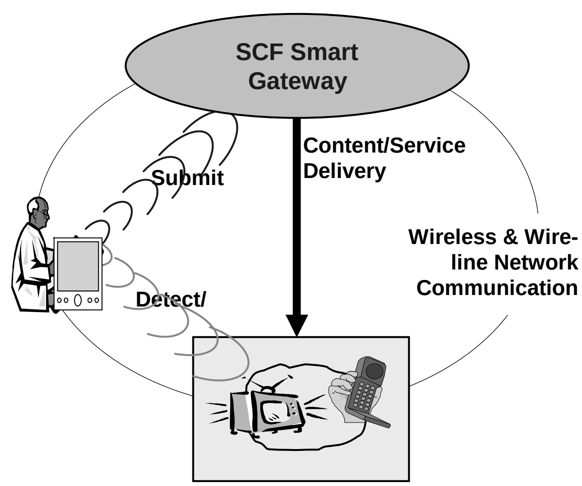

Figure 1: SCF for healthcare scenario

Complementary ubiquitous computing infrastructure provides doctors and nurses with the ability to access these data at any time while being mobile within the hospital vicinity. This kind of communication infrastructure facilitates and provides a better point of care service at patient's bed.

Thus, the SCF can be deployed within a hospital as depicted in figure 1. Each doctor is equipped with a PDA affording wireless access to the hospital patient information system. Visiting a patient, the doctor wishes to query the patient's medical history, including symptoms, diagnoses, prescriptions and x-rays. The PDA first detects the presence of a TV and a telephone in the room using the infrared interface. The PDA then communicates the doctor's request together with details about the detected devices to the SCF gateway server. After authorizing the doctor access and verifying a secure connection, the SCF gateway routes symptoms, diagnoses, and prescriptions directly to the doctor's PDA. As SCF server is aware of the PDA physical limitations, the x-ray image is transmitted via RF to the TV for viewing. The doctor then uses the infrared capability of his PDA to annotate a region of the x-ray. SCF then establishes a telephone call to the patient's original doctor for consultation. This arrangement provides a convenient infrastructure for the doctor to access, view, interact and collaborate upon the multimedia information.

6. AIMS AND DESIGN GOALS

The conflict of physical device limitations and full multimedia capability is overcome by using the PDA and composite device approach. That is to use the PDA as mobile and unique access device to request structured multimedia information and services. The request performance is outsourced to the most appropriate composite device(s) available in the close user's vicinity to fulfill. The focus is to avoid having to use a single PDA to perform all tasks. Instead of tying users to the traditional computing environment, we actively seek to exploit it. That is possible, since our daily living environment, both working and home, is evermore equipped with electronic and computing hardware with a various number of computing and electronic resources, the composite devices such as PCs, workstations, high-resolution monitors, TV, telephones, beamer, etc. Hence, the SS/CD architecture provides techniques to "borrow" these resources and to use it in a different manner by supporting small screen devices to perform multimedia content.

A number of design goals have been identified to build the SCF that:

- has the ability to organize, arrange, manage and synchronize multimedia in order to ensure sufficient deliveries to composite devices.
- offers interactivity with multimedia content and controlling services via small screen device.
- recognizes the capabilities of composite devices and provides mechanisms to adapt media to device capabilities.
- able to detect a pool of composite devices within the close vicinity and reacts to its dynamic changing number that is when new composite devices are available to join and registered devices have to leave the device pool.
- does not require special software to be installed on the PDA and composite devices, except the prerequisites of a WWW browser and the remote invocation ability. Thus, the PDA user interface is a Web browser, which communicates with the server via standard HTTP protocol.

Overall, the research focus of the SCF can be summarized in to two major steps: First is the development of a new distributed computing infrastructure consisting of composite devices and small screen devices that enables rich multimedia access using small screen devices and allows to redirect server responses to composite devices. Second to provide smart mechanisms for media processing and delivery to composite devices. The next few sections describe the architecture and mechanisms of SCF that fulfills the design goals.

7. HIGH LEVEL SCF ARCHTECTURE

As described in the earlier section, the SCF is designed to be adaptable to different working environments. A precise system architecture relies upon the concrete application scenario that the SCF is deployed for. Figure 2 illustrates the SCF high-level architecture. As can be appreciated from this picture, the SCF is comprised of a set of components on the server side and client side. The description of each component is given in the next sections.

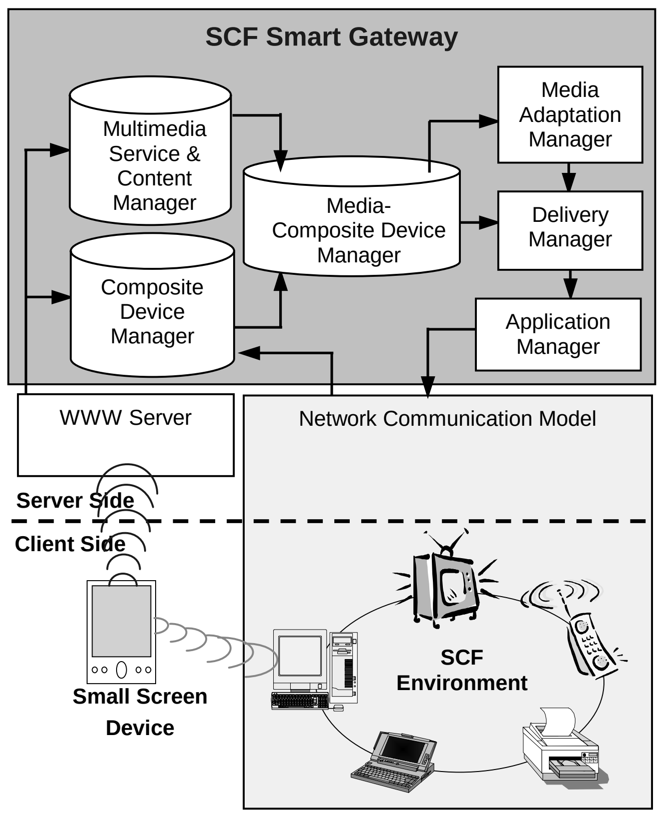

Figure 2: SCF System Architecture

The relatively short existence of the PDA and the continuous introduction of new devices and functionality prevent the definition of standards upon which to rely. Instead, we recognize the initial realization of the SCF concept requires making decisions about specific computing platform, such as a wireless IR or RF interface and HTTP/HTML or WAP/WML (Wireless Application Protocol/Wireless Markup Language) [29]. Thus, we attempt to choose as much standard or de facto standard elements as possible to design the SCF concept, which is flexible enough to adapt upcoming technologies.

7.1 Server Side Components

The SCF server side is primarily comprised of the WWW server, the SCF Smart Gateway (SCF-SG) and the SCF Network Communication Model (SCF-NCM). The following describes in brief the task of each element within the system.

7.1.1 The WWW Server

The WWW server serves as an entry point for the PDA to access services and contents provided by the SCF network. The use of HTML and HTTP protocol facilitate the access interface significantly. Thus, the WWW server offers the selection of available SCF service and information that users can choose from. Concurrent, the WWW server is able to interpret server side scripting commands that allows the PDA to dynamically update the SCF-SG with changes about available composite devices via a markup language structured interface, such as HTML. That strengthens our goal to limit the tasks running on the PDA and to outsource as much as possible to the server side.

7.1.2 SCF Smart Gateway (SCF-SG)

SCF-SG is the significant part of the SCF system and is the main research focus of our SCF research. In principal, it fulfills the task of outsourcing user requests to the most appropriate composite devices to ensure reliable performances. It is responsible for the success of the composite device communication infrastructure, which is an alternative paradigm for ubiquitous situated computing to exploit rich multimedia contents and services. The essential components of the SCF-SG are (see figure 2):

- *Composite Device Manager (CDM)*: Primarily the CDM maintains the database of available composite devices that can be used to perform certain tasks. Important for CDM is the knowledge of the capability(ies) of each composite device. E.g. if a PC is equipped with soundcard and speakers or the monitor resolution of a workstation. This is essential to support the Media-Composite Device Manager (see description below) to assign the selected services and information request to the most appropriate device for the performance. The number of composite devices and its availability is either updated by the PDA or directly by the pool of composite devices on the client side.
- *Multimedia Service & Content Manager (MSCM)*: The MSCM provides and manages the pool of multimedia services and information for SCF system users. Depending upon the selection and requested content it handles the communication with the corresponded content storage server, such as streaming media server. E.g., in the described scenario it enables specific applications based on the doctor’s location, identity and privileges.
- *Media-Composite Device Manager (MCDM)*: The MCDM is another important component of the SCF smart gateway. It is responsible for the assignment of requested services and information to the most appropriate composite device to perform the tasks. As shown in the scenario, the x-ray image is redirect to the TV for display instead sending it to the PDA. The mechanisms for decision making is described in more details in a later section.
- *Media Adaptation Manager (MAM):* In cases, when the available composite devices are not capable to handle requested contents and services, the MAM will provide a set of different techniques to adapt the media to the capabilities of the composite devices. For example, a user queries a multimedia video message via his PDA, but only a PC without speakers and a telephone are available. The MAM will split the video into a visual part for the PC and an audio part for the telephone.
- *Delivery Manager (DM):* The order and sequence of service delivery is important when multiple services are selected. This important to avoid the performance of all service requests at the same time. Therefore, the DM maintains some criteria that can be used to calculate an optimal service delivery.
- *Application Manager (AM):* The abilities of the SCF-SG to offer services to users, identifying appropriate devices for the performance of selected media, the conversion of media if necessary and the determination of an appropriate delivery order are crucial. But also the abilities to invoke processes running remotely on available composite devices and to control and interact with the invoked application (see section 9) are the important tasks of the application manager. The remote process invocation on composite devices requires the SCF-SG to be authorized to access composite devices and special security settings. Furthermore, the application manager hosts a pool of controls or helper applications that can be downloaded by composite devices to perform requested services.

Section 8 describes some aiding components that assist the SCF-SG fulfilling its tasks.

7.1.3 SCF Network Communication Model (SCF-NCM)

As depicted in figure 2, the SCF-NCM is an overlapping component between server and client side. In principal, the role of the SCF-NCM is to manage the convergence of wireless and wire line networks, as well as the corresponding communication protocols. This is necessary to ensure a seamless device communication and data transmission. The SCF-NCM includes short-range wireless communication used by the PDA to detect available composite devices in the close vicinity, cellular or wireless network to support the interaction between the PDA and the SCF-SG. In addition, the SCF-NCM provides a network infrastructure to enable SCF-SG and composite devices communication for the distribution of requested information as well as remotely invoking processes on composite devices to deliver requested services.

7.2 Client Side Components

The client side of the SCF system consists mainly of the PDA, SCF Environment (SCF-E) and a network communication infrastructure that is part of the SCF-NCM.

Three main and important functions are primarily designated to the PDA. First, the PDA is used as a unique device to access information and services provided by the SCF system. Second, the PDA detects and reserves available composite devices in the close vicinity and informs the SCF-SG. Third the PDA's task is to control the invoked services or to offer alternatives in order to provide users possibilities to interact with requested information and services.

The SCF-E primarily describes the current physical location of the SCF service user and a pool of available composite devices. Due to the diverse number of hardware devices as well a variety of standard communication and network protocols, we recognize the need to predefine virtual and collaborative environments (the SCF-E) in order to facilitate the development of SCF systems. Therefore, SCF-E represents typical composite devices available at certain location, whereby the number and type of devices are varying significantly from physical location to location. E.g. the office environment typically consists of high performance computing devices and high-resolution monitors. Whereas, the home area is more likely equipped with entertainment devices, such as TV or VCR

At the client side, the SCF-NCM covers the short-range sensing and communication to allow two-ways *PDA-Device-Communication* in order to detect composite devices. A wireless bi-directional *PDA-Gateway-Communication* is further prerequisite for the PDA to update the SCF-SG with location information (available composite devices) and to submit user's requests.

8. DECISION SUPPORTING COMPONENTS

A key focus of the SCF research project is to develop sophisticated methods for intelligent information distribution to such a distributed system that comprises of the PDA and composite devices. The characteristic of the distributed PDA–Composite-Device-Architecture is the fact that the PDA initiates the server requests and the composite devices fulfilling the responses. At first sight, a typical client server communication is not taking place. The high-level SCF system architecture presented above highlights the importance of the SCF Smart Gateway that is responsible for the smart media preparation and distribution to composite devices. Therefore, this section describes the components that assist the SCF-SG fulfills its tasks. Figure 3 illustrates the essential steps of the SCF Smart Gateway workflow.

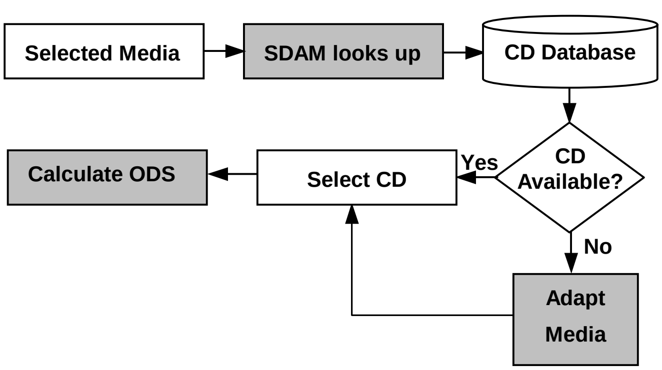

Figure 3: High-Level Flow Diagram of SCF Smart Gateway

The components support the SCF-SG to make decisions are Selection-Device-Assignment-Matrix (SDAM), the Media Adaptation component and the Optimal Delivery Sequence (ODS). The descriptions of these aiding components are given in the following.

8.1 Selection-Device-Assignment-Matrix

A crucial part of the SCF system is the determination of the most appropriate composite device to perform selected media. To support the SCF-SG calculating the best assignment schema, we introduce the Selection-Device-Assignment-Matrix (SDAM) $M_{sd} = S \times D$, which consists of users selections S and available composite devices D. The selections S represents the media and services that are requested by the users, whereas D summarizes the available composite devices are submitted via the PDA by users:

$$M_{sd} = \begin{bmatrix} m_{11} & \cdots & m_{1d} \\ \vdots & \ddots & \vdots \\ m_{s1} & \cdots & m_{sd} \end{bmatrix}$$

Through the selection S the type of media is determined. Concurrent, the MCDM searches the database of CDM for the most appropriate device to perform the selected media type and calculate the assignment. That is possible since the CDM maintains the data about the capabilities of each composite device. The MCDM dynamically generates the matrix any time a selection is made. In cases when the user selects another service or the number of available composite devices has changed, it recalculates the matrix again to ensure a precise assignment schema. This can happen when e.g. the device is occupied by its owner or new devices are detected and are available as output devices.

The result of the calculation process is then presented to the users via a HTML based interface on their PDA. Users can either accept system suggestion or can manually make their own assignment.

8.2 Media Adaptation

We recognize the ability of the system to have the flexibility and intelligence to offer alternatives of calculating appropriate media device schema. As described above in 7.1.2, in some cases no appropriate device is available to perform the selected media types. That can happen when its owner meanwhile occupies the composite device or running other processes and thus drops out the pool of available output devices. Before generating the SDAM, the SCF Smart Gateway will adapt the selected media type to the capabilities of available output devices. Although, the specific adaptation methods rely upon the concrete application scenario, we incorporate three different techniques to adapt the media type to multiple output devices with varying capabilities as well as the changing number of devices (see figure 4):

- *Splitting*: Intelligent content separation. E.g. a user wants to view a video message in an environment where only a PC without sound card and a telephone exist. In this case the MAM would prepare the content and split video into audio and video part that then can be individually redirected it to the available telephone and the PC.

- *Conversion*: Media conversion techniques, such as text to speech [30], can be offered when no appropriate devices are available.
- *Filtering*: Content extraction and delivery of the sub-content, which can be rendered by the output device. E.g. delivery of only the audio part of the video message to a telephone.

To make the decision, which of the techniques has to be deployed, the MAM can refer to the device capability and media type database as depicted in figure 4. Depends upon the capabilities of available composite devices, the MAM can select the most appropriate technique to prepare and adapt the media for further processing. The results will then use by the SDAM to assign the adapted media type to a particular output device for the performance.

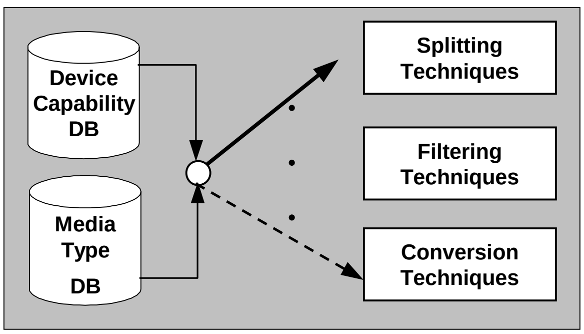

Figure 4: Media Adaptation Techniques

8.3 Media Delivery Sequence

We acknowledged the need of having a smart service delivery order. That is important for SCF system users and facilitates the process of editing the requested services on output devices. As mentioned above, the SCF system differs from typical distributed systems in the client-server communication schema. The initiator of server requests is not the recipient of server responses. Instead, the server needs to distribute the responses to multiple clients. That complicates the situation for the user to appreciate the services, when all the responses are distributed simultaneously. Thus, we consider different standard values to calculate an Optimal Delivery Sequence (ODS) to assist the SCF-SG delivery manager:

- *Frequency of service request*: The frequency a service is requested can be used as a standard value for the order of service delivery.
- *Urgency:* Urgent messages shall be displayed first.
- *Type of media:* Time critical media (e.g. live streaming media) shall be displayed before static media (e.g. Email).
- *Type of output device:* Converted media shall be displayed before unconverted media. This is useful to gain computing time for computing intensive media conversion.

9. SYSTEM INTERACTIVITY

The PDA-Composite Device-Architecture of the SCF system requires the development of a newly user interface to control and interact with requested services. In many cases the users cannot rely upon the input possibilities of the output devices to control and interact with the invoked applications. We recognize in addition the need of providing a kind of *mobile user interface* on the PDA that enables users to interact, control and collaborate with the invoked processes. Therefore, we anticipate three situation dependent interaction and application control modes:

- *Abdicative*: In this case the PDA hands over the control to the output device. E.g. once an application is invoked on the PC mouse and keyboard can be used as input devices.
- *Cooperative*: PDA and input capabilities of the output device can jointly be used to control the application. E.g. a slideshow can be annotated either using the mouse and keyboard of the output device or through a specialized and simplified user interface for the PDA
- *Exclusive*: The only input device is the PDA. This is especially important for output devices where no input facilities are available (e.g. a TV).

The cooperative and the exclusive modes require a special *mobile user interface* on the PDA. For such a user interface, we intend to introduce two possibilities, which strongly rely upon the specific application scenario:

- *Wireless Mouse Cursor Control via PDA*

  In this case, it is anticipated that the application control interface and the application are operating on the output device. The mouse cursor of the output device is controlled wireless via the PDA. Thus, all mouse commands are entered on the PDA display using the PDA stylus. Such a solution as proposed by Meyers *et al* [18] can be deployed, but need to be modified to improve wireless communication ability.

- *Representation of the Application Control Interface on PDA*

  This user interface is a more advance interface and more challenging approach. Unlike the first approach, the application control part of the application is represented on the PDA screen. Users can directly operate the application from the PDA and all the commands are transferred wirelessly to the output client running the application, whereby these commands need to be synchronized with the running application. A challenging task is further the awareness of the SCF Smart Gateway to provide multiple application control interfaces for multiple applications at different time depend upon the delivery order of the services.

These interfaces are ideal to serve the *cooperative* and *exclusive* mode as well in general to allow a group of users to collaborate with each other and interact with the application.

10. IMPLEMENTATION

The SCF has been deployed for an office environment. We have successfully developed a demonstration system to verify the SCF concept. At the client side a PDA running Windows CE is used to represent the class of small screen devices. The pool of composite devices comprises of a PC running Windows 98, a Windows NT and a Windows 2000 workstation, and a TV, attached with a camera, connected via RF link to a Windows 98 running desktop. All composite devices are equipped with IR serial interfaces. At the server side a Windows NT server workstation hosts the system SCF-SG and the WWW server. The SCF-SG offers Microsoft

Exchange webmail services, streaming media distribution and Microsoft Netmeeting videoconferencing services. The network communication model is a combination of a LAN network, a Cellular Digital Packet Data (CDPD) network as wireless network and IR as short-range communication network.

The IR interface of the PDA enables the detection available composite devices via the IR short-range communication. The PDA and SCF-SG communication is realized using HTTP over the CDPD network. That allows the PDA to submit the detected composite devices and access to SCF system services, which is represented using a HTML interface. Depending upon the selection of the user, the SCF-SG calculates the most appropriate service-device schema, which the user can either confirm or manually modify. The demonstrator allows the user to request the streaming of media files to one workstation, to redirect the webmail service to another and to conduct a videoconferencing session on the TV. The remote invocation of the application processes running on composite devices via the SCF-SG is realized using the Distributed Component Object Model (DCOM) [31], without the requirement of using any "special" software on composite clients. The combination of HTML/HTTP as user interface and communication protocol requires only a WWW browser and additional functionality supported through the browser extension mechanisms as prerequisite on the PDA as well as on composite devices.

11. CONCLUSION AND FUTURE WORK

This paper has presented a new conceptual framework that allows the class of small screen devices to access rich multimedia information and services. In comparison to related activities the SCF concept consequently avoid the performance of heavy computing tasks on a single small screen device or to shrink and tailor services and information to match the limitations of these devices. The *SS/CD* approach solves several problems of using small screen devices for ubiquitous rich multimedia information access. First, the outsourcing of requests to appropriate devices for the performance allows offering a diverse range of services and information. Second, the user interface limitation of such devices is overcome by a better exploitation of available hardware resources.

Currently, we are working on the integration of different composite devices and using a WAP [29] cellular phone as a different small screen device to access of multimedia information. Concurrent, new technologies, such as Bluetooth [32], are investigated to improve the short-range network communication infrastructures and new standard protocols, e.g. the working draft protocol Composite Capability/Preference Profiles (CC/PP) [33], are considered to add more intelligence to the system. Further, our future activities research includes the development of methods and techniques to realize the *mobile user interfaces* as proposed in section 9 and on concepts to integrate the SCF into different application scenarios.

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