InterMedia: Towards Truly User-Centric Convergence of Multimedia

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Abstract. In this paper, we present an interactive media with personal networked devices (InterMedia) which aims to progress towards truly user-centric convergence of multimedia system. Our vision is to make the user as a multimedia central to access multimedia anywhere and anytime exploiting diverse devices. To realize the user-centric convergence, we defined three key challenging issues: dynamic distributed networking, mobile and wearable interfaces, and multimedia adaptation and handling. Each field of interest investigates a transparent access to diverse networks for seamless multimedia session migration, a flexible wearable platform that supports dynamic composition of diverse wearable devices and sensors, as well as the adaptation of diverse multimedia contents based on the user's personal and device contexts. To prove our goals, we prototyped our scenario, called Chloe@University, which included interactive 3D multimedia manipulation with seamless session mobility, modular wearable interfaces with DRM, contextual bookmark with mobile interfaces, and interactive surfaces and remote displays which aim to overcome the limited output capabilities of mobile devices.

Keywords: Interactive media, Dynamic networks, mobile and wearable interface, multimedia content adaptation.

1 Introduction

Recent advances in computing devices and networks equip users with rich and interactive environment where media can be accessed, visualized and interacted with. Considerable efforts have been made in the field of audio-video systems and applications convergence for especially smart home environments [1, 5, 12] but they still have spatial limitations to access multimedia. Mobile computing, on the other hand, has focused on device-centric approach which makes a mobile device as a point of multimedia convergence to support nomadic access to multimedia [2, 15]. This, however, is still limited to the usage of a single mobile device with the limited resources.

To overcome these limitations, we address how to move beyond the home and device-centric convergence towards truly user centric convergence of multimedia. Our vision is to make a user as a multimedia central which means that "a user is a point at which services and interaction with them (devices and interfaces) converge

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across spatial boundaries". To realize the user-centric convergence, we defined three key challenging issues: dynamic distributed networking, mobile and wearable interfaces, and multimedia adaptation and handling. Dynamic distributed networking layer mainly focuses on a transparent access to diverse networks for seamless multimedia session continuity which enables a user to switch among different devices and networks with minimal manual intervention from the user. Mobile and wearable interfaces layer provides dynamic composition of wearable devices and various mobile interfaces to access multimedia contents exploiting diverse devices nearby to users, which make users free from using specific devices to access multimedia contents. Multimedia adaptation and handling layer support multimedia contents to be presented to different devices for personal manipulation which requires adaptation of multimedia to device or personal context along with seamless presentation of the multimedia for different devices.

We prototyped our proposed system and experimented with a specific scenario, called Chloe@University. Chloe@University scenario is instantiated from InterMedia vision [13] and contains all research issues including interactive 3D multimedia manipulation with seamless session mobility, modular wearable interfaces with DRM, contextual bookmark with mobile interfaces, and interactive surfaces and remote displays which aim to overcome the limited output capabilities of mobile devices.

The remainder of this paper is organized as follows. In section 2, we present research challenges and architecture. In order to clearly show our vision, section 3 describes the scenario "Chloe@University" and its prototype implementations. Conclusion and future work are discussed in section 4.

2 InterMedia Research Challenges and Architecture

The concept of user-centric convergence liberates a nomadic user from carrying a range of mobile devices by providing personalized access to multimedia regardless of devices and networks. It is accomplished not only by removing spatial constraints but also by making multimedia contents adapted to diverse devices and networks in our daily activities. An overview of the three key challenging issues (dynamic distributed networking, mobile and wearable interfaces, and multimedia content adaptation and handling) is shown in Fig. 1 with their internal components.

Dynamic distributed networking layer mainly focuses on a transparent access to diverse networks for seamless multimedia session continuity which enables a user to switch among different devices and networks with minimal manual intervention from the user. We defined two frameworks: Personal Address (PA) Framework and Sensor Abstraction and Integration Layer (SAIL). PA framework [9] provides a cross-layer user-centric mobility framework that accounts for terminal handover and session migration. It associates network addresses to the users and their sessions. It exploits context information to automate the processes of terminal handover and session migration. SAIL [3] gathers data from heterogeneous context sources and exports context information as they came from "virtual sensors"; through high-level standard interfaces (for example, HTTP and UPnP).

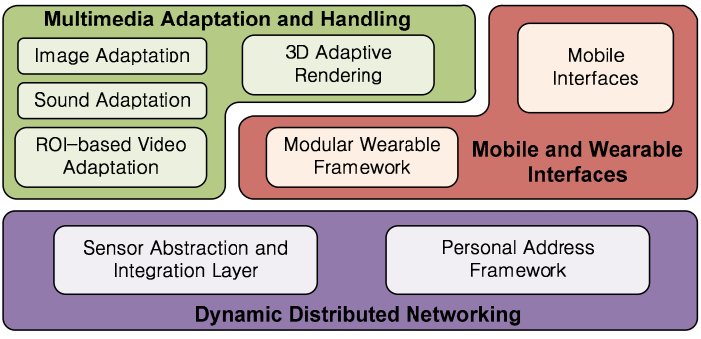

Fig. 1. InterMedia Research Challenges and Architecture

Mobile and wearable interfaces layer provides various interfaces to access multimedia contents exploiting diverse devices nearby to users which make users free from using specific devices to access multimedia contents. We use a modular approach towards a wearable interface in a sense that users do not have to decide between several garments according to their fixed respective functionalities, but they can rather select and attach modules (e.g., UI, storage, localization sensors, and communication protocols, etc.) that will suit their needs. Thus, it becomes entirely personalized as it depends on the selected wearable modules, user profile, and the available surrounding devices. To overcome the limited output capabilities of mobile devices, in particular mobile phones, new mobile interfaces are also developed such as display technologies like projector phones, interactive surfaces and remote displays. Using those interfaces, multimedia can be explored and shared in a collaborative manner using new interaction techniques.

Multimedia adaptation and handling layer support multimedia contents to be presented to different devices for personal manipulation which requires adaptation of multimedia to device or personal context along with seamless presentation of the multimedia for different devices. We provide diverse adaptation mechanisms according to multimedia types including video, image, sound, and 3D contents. We also provide a multimedia sharing architecture through dynamic networks with other users.

3 Prototype: Chloe@University

In this section, we describe our scenario, Chloe@University, and prototype implementations which contain research issues addressed in the previous section.

3.1 Scenario

Chloe attends a medical course at the university. All DRM-featured course materials are automatically downloaded to her wearable device without manual operations. On the way to the library after the class, she takes a picture of a poster on a bulletin board with her mobile device which results in a contextual bookmark. While doing so, her

wearable device identifies nearby users and exchanges comments with them about the bookmark. She notices an interactive wall in the university hall. Her wearable device is automatically connected to the interactive wall in order to see the information of the concert in a bigger size. Using pointing gestures, she can manipulate multimedia contents with personalized user interface which is automatically transferred to the interactive wall. Arriving at the library, she can interact with 3D medical data with a group of students using interactive surface. While she comes back home by a tram, she can browse 3D course materials with her wearable device which has limited rendering capabilities. Once she gets home, the session is transferred automatically on her home PC, and she can carry out her learning session with her home PC.

3.2 Implementation

Chloe@University is divided into five applications: modular wearable interfaces with DRM, interactive 3D multimedia manipulation with seamless session mobility, contextual bookmark with mobile interfaces, controlling remote display with mobile devices, and interactive table with 3D content.

3.2.1 Modular Wearable Interface with DRM

We use a jacket as a wearable device interface with distinct modules attached to it in order to store multimedia content related to the profile of the user.

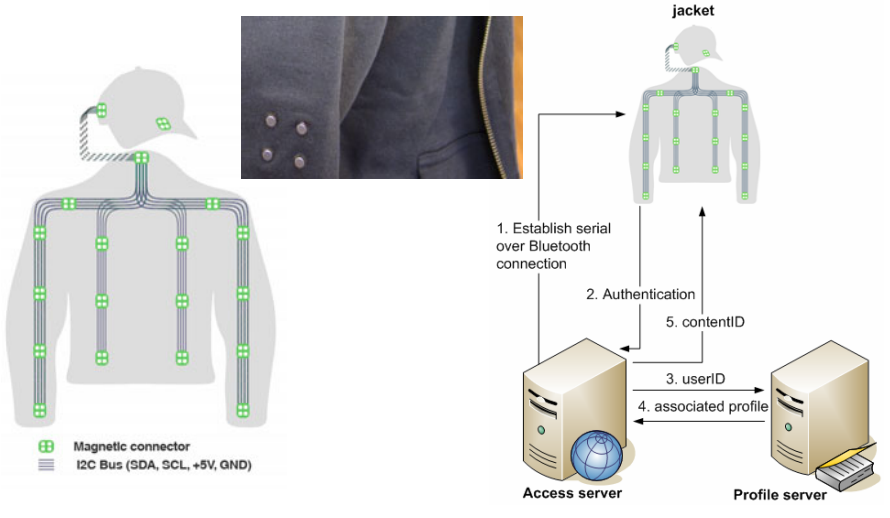

Fig. 2. The jacket with a modular I2C architecture (left), the process of the communication with the jacket (right)

To build a modular wearable interface framework [10] as shown in Fig. 2 (left), we use I^2C protocol [14], which has a built-in addressing scheme and requires only two data lines, because it is inexpensive, easy to upgrade, and convenient for monitoring attached modules. Users can select and attach multiple modules (e.g., UI, storage,

localization sensors, and communication protocols, etc.) to the wearable jacket whereafter the modules are automatically identified and communicated to each other. The transfer and access of multimedia take licensed-content into consideration by supporting manipulation of the digital right management (DRM) client and DRM enforcement, in order to handle DRM-protected course contents as shown in Fig. 2 (right).

3.2.2 3D Adaptive Rendering with Seamless Session Mobility

To support users to interact with 3D contents seamlessly adapting to diverse devices and network situations, we implemented an adaptive rendering framework and personal address framework [9]. Adaptive rendering framework provides context-aware polymorphic visualization adaptation and dynamic interface adaptation. In order to provide perceptual real-time interaction, a micro-scale buffer based adaptation mechanism is introduced. It dynamically adjusts frame rate on a client device based on the current network situations and computational resources of the client. Data from a remote server is temporarily stored in a small buffer. If the client renderer continuously fails to consume data within a maximum tolerable latency, the client requests the remote server to decrease frame rate of the stream. Otherwise, the client requests the remote server to increase the frame rate. Interface adaptation mechanism dynamically binds operations provided by 3D application and user interfaces with pre-described device and application profiles. To manage seamless session, personal agent framework is used as shown in Fig. 3 (left). A Key characteristic of PA framework uses topologically-independent IP address based on the MIP infrastructure [8]. Session migration is managed at the application layer. The specific application includes the PA in its session context to be transferred on the new terminal. The old terminal stops the MIP operations, while the new terminal starts the MIP operations with the same IP address. From the Home Agent perspective, this appears like a standard terminal migration. No modifications are required at the MIP protocol. The signaling needed to move the session is application-specific. Fig. 3 (right) shows the snapshot of the prototype.

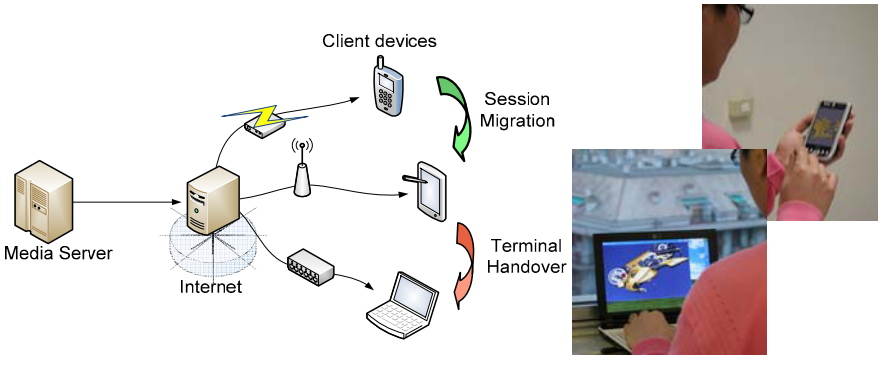

Fig. 3. 3D Adaptive Rendering with Seamless Session Mobility

3.2.3 Contextual Bookmark with Mobile Devices

The Contextual bookmarks [4] allow mobile interactions with physical objects using novel interaction techniques. Mobile devices are used to access information related to static objects such as posters and printed photos. Novel interaction techniques include pointing techniques, gestures, and Magic Lenses. It consists of the four components shown in Fig. 4 (left).

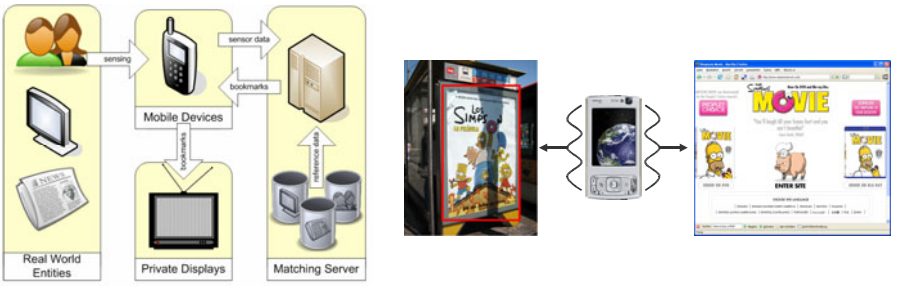

Fig. 4. The central components and their interaction within the contextual bookmark approach

Recognition and matching server extracts object descriptions from images of these objects and equips the object descriptions with meaningful information, such as names, descriptions and additional services. The used recognition algorithm is a speeded up version of Lowe's SIFT algorithm [6]. The application for the mobile phone is implemented in J2ME and runs on phones supporting MIDP-2.0 CLDC-1.1such as Nokia's S60 series. Communication between the mobile phone application and remote playback devices is facilitated via the Java backend of the framework for interactive services in ambient computing. We have prototyped different use-cases. For the recognition of printed photos inside photo-books, for example, we added a two-stage recognition and support for visual markers. For testing recognition using the live camera image's to provide the user with direct feedback the image analysis was implemented on the Windows Mobile platform.

3.2.4 Controlling Remote Display with Mobile Devices

To control remote display, we use a service framework [7] which uses virtual input devices for specification of input events exchanged between the input device and the remote service. Independent of hardware and software constraints, the framework integrates common approaches from the field of distributed systems development to identify all components to be realized for further specialization of the framework. The components for implementing remote procedure calls using XML for data encoding have been identified. Fig. 5 (right) illustrates the design of a solution in an object-oriented approach. The InterMediaPlayer application and the game controls have been realized based on this design. Fig. 5 (left) shows the snapshot of the prototype for controlling remote display.

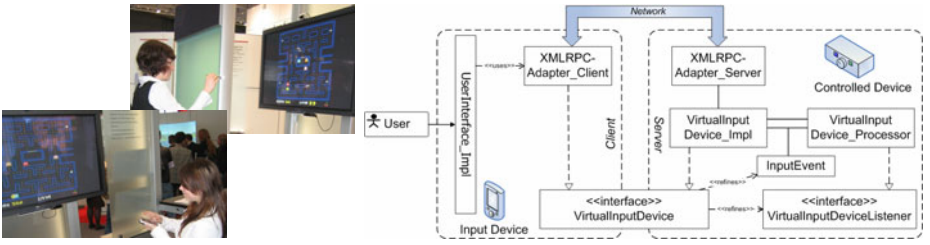

Fig. 5. Controlling remote displays (left) and the system architecture (right)

3.2.5 Interactive Table with 3D Content

To overcome the limited output and resource capabilities of mobile devices, we investigate to exploit diverse resource-rich devices, such as interactive table, if those are available nearby to user. We integrate interactive surfaces, 3D graphics library and NFC [11] as a communication tool in this prototype. The main concept is transferring data from a mobile device to the table and displaying on the table. We have implemented TUIO framework [16] which defines a protocol and API to simulate multiple pointing events on the single input system which have been integrated into OSG to replace its mouse-event handling functionalities with the multi-touch ones that are generated by interactive surface. With the integration of TUIO, OSG can translate the different interactions on the table surface to appropriate 3D manipulations of the 3D content. Also, interacting with the menu that is displayed along the model on the table is achieved through separate event handling mechanism that can detect 2D interaction apart from the 3D interaction.

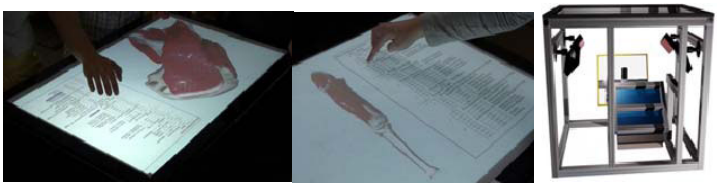

Fig. 6. Mobile Interaction with Interactive Surfaces

4 Conclusion and Future Work

InterMedia project aims to support truly user-centric convergence of multimedia beyond device-centric convergence. It enables users to exploit diverse devices nearby for continuous consumption of multimedia anywhere and anytime. Advances in mobile devices, networks and sensors have lessened temporal and spatial constraints to access multimedia with diverse devices. In this paper, we introduced interactive media with personal networked devices and its preliminary results. Our goal is to provide technologies beyond the home network and device-centric media convergence enabling seamless multimedia services anywhere and anytime exploiting diverse devices nearby to users. To accomplish this goal, we challenged three main research issues: dynamic distributed networking, mobile and wearable interfaces, and multimedia content adaptation. As a case study, we prototyped Chloe@University

system as a proof of our vision and concept. Although we currently integrated some parts of our main research modules, we plan to continuously extend our system to support truly user-centric convergence of multimedia.

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