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Mobile Virtual Devices for Collaborative M-Learning

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Abstract: The increasing use of mobile devices to support collaborative activities creates a need for developing new methods and perspectives to facilitate information sharing. In this paper, we present an approach for information sharing in mobile collaborative settings through the use of Mobile Virtual Devices (MVD). MVD emerges as a new conceptualization of an organization of mobile devices that supports collaborative tasks. The use of MVD allows designers and users to interact with and through mobile devices in novel ways, considering the aggregation of mobile devices as a single entity. The notion of MVD has been conceptualized on the idea of multirole devices, using components to provide and consume resources.

Keywords: mobile device organization, shared resources, collaborative learning

1. Introduction

The increasing use of mobile technologies in our daily life and improved mobile device performance allow for a wide range of solutions that support various learning activities [2]. The increased adoption of mobile learning (M-learning) solutions allows for learning activities to be performed in indoors and outdoors settings in ways that were not possible before. This provides provisioning for design and implementation of learning activities in a wide range of authentic environments that go beyond the traditional classroom. Providing mobile support in these changing settings means that mobile applications must be adaptive to the environment, thus facilitating the flow of information, provision of services and collaboration in new complex situations.

Mobile devices have several limitations in comparison to regular desktop computers. For example, Ally [2] mentions *display limitation* as a central issue for mobile learning applications and Jones & Marsden [9] point out the unavoidable constraint of the size of the viewable screen. Beside the screen issue, the diversity of mobile devices is large, for instance, regarding available resources (e.g., camera, GPS, connectivity features, etc). Some projects that utilize mobile technologies address this diversity by combining different devices and their resources in order to provide extended functionalities to the users [3]. For instance, Ballard [3] mentions that sharing information can be performed by the use of Pico Nets, Home Servers, and Shared Displays. Sharing data sets belonging to a first device with a second one in order to support mobile collaboration is one possible solution.

In this paper we introduce the concept of MVD and describe the potential benefits of this approach in the field of mobile learning. A MVD may be considered as an alternative approach to mobile sharing, where aggregated devices constitute a MVD, which allows for resource sharing within this aggregation. Our approach may be contrasted to the more traditional approaches where mobile devices, acting as separate units, collaborate and share resources (described in section II). In section III, we present the MVD approach in more detail, including the main notions behind the concept. Some benefits of using the MVD approach are illustrated in two scenarios in Section IV. Finally we conclude and present future avenues of research in Section V.

2. Related Efforts

Recent efforts in the field of M-Learning have explored potential benefits of information and resource sharing in a variety of settings. Several projects have investigated how data between mobile devices can be exchanged in order to accomplish different types of learning tasks and where the display is shared as a resource as well [1, 3, 4, 11].

One of the goals of the Mobile Notes project is to "*support classroom discussions with mobile devices and electronic whiteboards*" [5]. Mobile Notes aims to bring technology advances to the classroom by providing PDAs and one Shared Space in a digital whiteboard. Sharing information between students is supported by a centralized database. A centralized solution that allows for asynchronous information exchange is convenient in some scenarios. However, sometimes data is highly volatile, making direct communications in a synchronous manner more suitable [7]. Another effort in this direction is Collpad [1], where a central repository is located in the teacher's mobile device, and responses from students are sent to this central node using WiFi communications. Even if this approach is closer to a mobile-to-mobile information exchange, it is still dependent on WiFi communications, making it difficult to deploy in outdoors settings. Moreover, resource sharing is limited to student response exchange while support for more complex resource sharing is lacking. Camaleon-RT [4] illustrates how device interface sharing let users interact seamlessly to a multi-display device. Pick-and-Drop is another example of a system that provides functionality to pick and drop objects between devices [11].

The solutions described above are particular for sharing specific types of information and resources and were conceived for environments with unrestricted communication channels. An outdoors-learning environment that employs a GSM network is something completely different [12]. Moreover, our approach should not be limited to one-project goals, such as display or GPS sharing. We envision a solution which is scalable and extendible with respect to future requirements. In the following section, we introduce the MVD and its goal to bring multiple roles to mobile devices [7], in order to address all possible situations for information and resources sharing present in M-learning activities.

3. The Proposed Approach

Many M-Learning projects rely on the use of several mobile devices utilizing their capabilities in terms of connectivity, package of sensors [12] and activity. As each M-Learning activity has different functional requirements, different mobile devices with distinct features may be included in the activity toolset in order to fulfill requirements for a particular experiment. When mobile devices are considered as individual entities, it can be costly to find a device that addresses all requirements specific to a learning activity. With the MVD we advocate another approach, where we consider organizations of mobile devices as single entities that provides the support required by the learning activity. This approach will not only allow for the combination of features provided by resources in one of the mobile devices, but also to combine resources in different mobile devices. MVDs make it possible to comply with functional requirements through the use of several simpler, cooperating, devices. Moreover, it makes possible to create unique features through the combinations of resources from a MVD, e.g. data manipulations of GPS coordinates generated by the devices that are part of the MVD can be used to perform specific calculations, or quality enhancing features such as improving the accessibility of a device using ambient networking strategies.

Sharing resources between mobile devices presents a number of challenges that need to be addressed; accessibility and communication between devices, organization mechanisms for coordination in the MVD, and mechanisms for service provisioning, discovery and consumption. Moreover, a MVD communication language is required for members in the MVD to define, form, and coordinate according to specific activity requirements. Fig. 1 presents a component diagram for the devices that comprise a MVD. Device resources should be considered as service instantiations in the figure. We describe the characteristics and dependencies of the components present in our approach below.

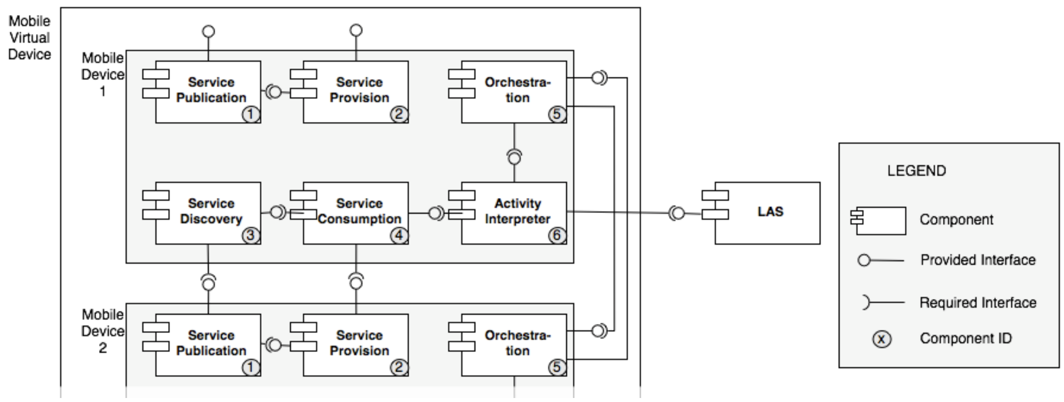

Figure 1. UML Component Diagram. Components for the MVD construction

The components in Fig. 1 provide a minimal set of functionality for resource and service sharing. Fig. 1 specifically illustrates resource sharing through services between two mobile devices in a MVD. All devices in a MVD require the 6 components depicted in Fig. 1 and described below. In one specific scenario, Device 1 retrieves the activity script from a Learning Activity Server (LAS) [7], where activity flows are located. An Activity Interpreter component (C6) analyzes the script and identifies the resources required to perform the activity. The second step to be performed is to identify the location of the required resources, if present in the MVD. Two components are involved in the lookup process; the Service Discovery (C3) and the Service Publication (C1) components. C1 publishes the services available in a mobile device, together with service description and service consumption information. This allows the C3 to identify a proper service required in the activity and to understand how it should be consumed. Consequently, the Service Consumption component (C4) can make use of the services provided by Service Provision (C2). All devices in the MVD must share knowledge of the existing organization, provided by the Orchestration component (C5), defining the role to play for each on of the devices in the MVD. A more detailed, technical, description of the MVD and its components is presented in [8].

Communication between devices in the MVD will address the channel limitations in outdoors settings. A previous solution presented in [7], permits communication over WiFi, GPRS and 3G channels, covering most of the situations for indoors and outdoors settings. In the illustrative case, the activity script is offered by the LAS, but it could also be stored locally in a MVD participant, as an available service.

4. Use Cases

In this section we present two educational scenarios where the notion of MVD has been applied in order to illustrate the potential benefits of this approach. The first case is related to the MULLE (Math edUcation and pLayful LEarning) [6] project, an effort carried out in Stockholm in November 2009 exploring how to support learning with mobile devices in the field of Mathematics. The second instance described in 4.2 is an evolution of case 1.

4.1 MULLE (Sharing GPS and Display resources)

An initial implementation of the proposed MVD approach was tested in the MULLE project with two groups of young learners [6]. From a mobile infrastructure viewpoint, each group was given two mobile devices that formed the MVD that combined two screens and two GPS modules. One of the mobile devices in the MVD communicated with the LAS to receive the activities and to submit the students´ answers. This is presented in Fig. 2 below with the “Perform Learning Task” use case. Fig. 2 also depicts how components from in Fig. 1 are involved. This use case requires from the Activity Interpreter component (C6) to retrieve and interpret the task scripts from a LAS. In this case, two devices formed the MVD. This configuration enables students to calculate distances using two GPS receivers, one per mobile device. Moreover, the fact that the students had two mobile devices allowed for the application to split the visual information along the two mobile phone displays and let the students visualize more information simultaneously. It should be noticed that calculating the distances, as illustrated in Fig. 2, requires discovery of GPS modules (C3), a device to publish and offer the GPS service (C1, C2) and the consumption of this service (C4).

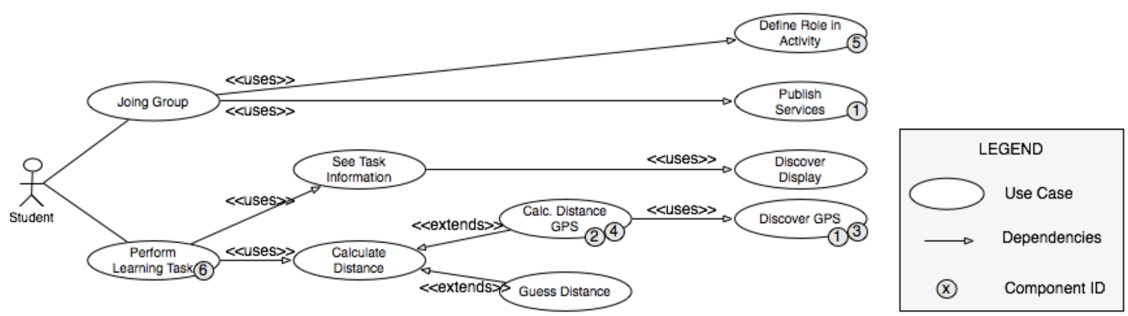

Figure 2. UML Use Case diagram. Numbers link Use Cases to required Component

4.2 MULLE v.2 (dynamism in student group creation)

A new use case was added to the preceding MULLE system. To decrease the centralized control of how pupils solve the tasks, they are allowed to create teams on the fly, instead of having them defined prior to the activity. This introduces new dynamics in the composition of students´ groups, therefore devices in the MVD, which requires the identification of the new existing services. In Fig. 2, this is captured in the “Join Group” use case that requires Orchestration (C5) and publication of the offered services to the MVD (C1). Based on the two cases described abover, we identify two main benefits in the use of MVDs in mobile collaborative scenarios. (1) Resources can be shared between devices by consuming them through the implemented interfaces. In comparison to previous solutions, MVD can be expanded to allow not only display sharing, but new resources as well. (2) The possibility of dynamic creation of teams, thanks to the facilities provided by the orchestration and service publication components.

5. Discussion and Future Efforts

In this paper we have introduced the notion of Mobile Virtual Devices (MVD) and its use in the field of M-Learning. A MVD clusters devices and tools in a learning activity into a single entity and promotes the use of their full capabilities in order to offer new ways for user interaction and resource utilization. The implementation of MVD generates a set of challenges, such as connectivity issues, dynamic configurations, and a MVD communication language. Our current results indicate how some of these challenges could be tackled and how scalability from the technological point of view can be achieved by extending the offered services. We believe that our approach opens up a new door to M-Learning activity designers that deals with settings and activities where multiple devices can be inter connected conceptually and share a MVD space, thus creating new ways of interaction and, in turn, facilitate the activity design phase.

The potential benefits identified in the scenarios encourage us to continue exploring how to utilize MVDs in mobile collaborative environments. Future research efforts include analysis and design of more generic cases which requires a deeper understanding of the roles of mobile devices in relation to the learning activity system, the learners, and the activities along other components in the software ecosystem [10].

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