PEER PROFILE DRIVEN GROUP SUPPORT FOR MOBILE LEARNING TEAMS

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ABSTRACT
The requirements on infrastructures for digital learning are changing as learners become more and more mobile. Ad hoc interactions, dynamically changing learning teams and communication and collaboration centered learning have to be considered. In contrast to traditional digital learning environments focused on simulation, content representation and distance learning support, we focuse on collaborative learning. Using the notion of a group as a structuring element and building group hierarchies, mobile learners can be assigned to groups based on similar interests and skills, projects or location. To express the learners' attributes, peer profiles are used. Based on the peer to peer technology JXTA, a prototype capable to support spontaneous collaboration of learning teams is implemented. Finally, we demonstrate the advantages of hierarchical grouping in mobile learning environments in an example lecture.

KEY WORDS
mobile learning, collaborative learning, peer to peer architecture, JXTA

1 Introduction

During the past decade, digital learning approaches have changed significantly. Starting with computer based training, the use of simulators to explain complex system behavior and automatic testing facilities, nowadays learning platforms are broadly discussed. A variety of learning media and content representation covers various dimensions of education. To enhance lectures, Web-based learning platforms provide content delivery, organizational information and communication from anywhere using devices running a Web browser. Furthermore, personalized meta-learning information covering for example information about the learner's status and feedback facilities can be accessed [1], [2], [3].

In contrast to approaches which address digital learning from the perspective of educational theory [4], some improvements are technology driven and focus on enhancing classrooms and the whole University campus with wireless networks, like W-LAN IEEE 802.11b. Learners and students are expected to access the information networks, mainly the Internet, using mobile devices, like Personal Digital Assistats (PDAs). Accessing content using mobile devices will not change the content or the pedagogical techniques, but the representation will have to change based on the capabilities of the mobile devices.

Going beyond information access using mobile devices, mobile learning offers a new aspect of location and situation aware learning [5], [6]. In addition to traditional teacher-student scenarios or long term self-studies, new learning styles based on communication centered learning and changing learning context will emerge [7]. As a consequence, short interactions and spontaneously formed groups of interest capable of exchanging data without infrastructure support (e.g. access to servers in the Internet) have to be supported [1].

Focusing on the new learning styles, collaborative learning support is a key research area [8], [9] [10] [11]. Forming and finding teams of similar interest or identyfing other learners near by, for example while preparing for the same exam, is required. Besides materialistic motivation, which is based on improvement of living factors like money or position, and intellectual motivation focusing on the challenging subject itself, collaborative group support potentially addresses social motivation. Learning teams may be a place for cooperation or comptetition. Furthermore, teams can compete or cooperate with other teams, for example restricting access to shared files.

The paper is structured as follows: First, we introduce the notion of groups for digital learning and show how the dimensions of collaborative group support can be described using hieararchically organized groups. Furthermore, we will motivate and explain the use of peer to peer technology for spontaneous group support. Then, we describe the design and the implementation of a JXTA based peer to peer prototype. We show in detail, how meaningful interaction between learners can be achieved in a selected example and we conclude with future perspectives.

2 Peer Profiles for Mobile Learning Groups

In former and recent research work, social awareness and collaborative learning are seen as a major aspect of motivation in learning environments [12], [13]. Approving this approach, we aim at improvements of collaboration in digital learning environments. The dimensions of improvement are: to achieve a supporting lookup for findinging other learners near by or with similar interests, the support of emerging, spontaneaous and student-driven learning structures and finding new media for motivation. To cover these aspects, we state that the notion of a group together with building hierarchies leads to a sufficient model. The formation of groups is based on the learners' profiles (*peer profiles*) which includes context information, like location, meeting or lecture attendance and affiliation. The concept of profiles can also be extended in the future including information on domain and user knowledge and using this information as the basis for group formation [14], [15].

2.1 Achieving Collaborative Learning based on Grouping

Assuming social structures and collaboration to be a driving force for learning motivation, demands for building and supporting learning groups with similar interests appear naturally. Using a model of hierarchical groups to grant or restrict access to the group's ressources, leads to implicitly structuring the collaboration process. As a consequence, information distribution (like data sharing following a download-judge-forward pattern as described in [5]) and social motivation based on cooperation and competition among the group members is achieved.

Figure 1 shows the categories of a peer profile describing a person. While personal information, information about the affiliation, the interest and the skills are rather static information, the current project the student attends, the learning meeting and lecture information (i.e. the information about any kind of congress, coming to-gether focused on learning) and location information are expected to change dynamically in case of roaming learners. Using the peer information for grouping allows to model the collaborative learning environment as a hierarchy of groups. A peer may be assigned to several groups and subgroups. It makes sense to assign a peer to all of its preceeding groups as well.

According to the profile entry values, groups are formed naturally on the basis of similarities. For example, peers attending the same lecture or being in the same room will form a group). Introducing hierarchies allows to arrange grouping according to a finer granularity and to restrict the access to ressources. Thus, introducing skill driven quality levels is easily achieved and might be used to motivate the learners. For example, a group hierarchy for a laboratory lecture on client/server programming using JAVA/RMI

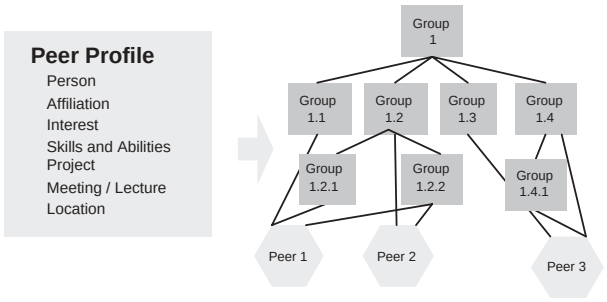

Figure 1. Peer Profile Driven Hierarchical Groups

may lead to a group of peers capable of Java programming with a sub-group of peers being real experts on Java programming.

It is expected that pro-active and automatic grouping by the collaborative learning system is not sufficient for covering all possible meaningful groups and hierachies. Furthermore, preference on the hierarchical ordering have to be introduced. When thinking about combinations of properties, like a group consisting of all Java experts near by, both location information and skills have to be considered. Allowing the learning peers to build groups and supporting the discovery of fitting peers for the new groups is necessary.

2.2 Demanding Issues in Ad-hoc Interaction, Motivation and Reliabilty

Being focused on roaming and highly mobile learners, groups and group members currently joining will change frequently. New learning peers will appear and search for other peers and peer groups using discovery and advertisement techniques. Typical mobile learning situations are described by short interactions with the learning environment, lack of bandwidth and usually lack of concentration [1]. Making advanced use of the physical surroundings, like smart rooms or identifying learners near by to start a collaboration, are major benefits of the mobile learning pattern. In our model, these aspects are addressed by peer profile entries related to context awareness.

When introducing digital media support, learners often criticize the lack of personal contact to the teacher or other learners [16]. On the other hand, new motivating factors may be introduced using cooperating and competiting groups. To give an example, groups may be used to divide learners in experts, mediocre learners or novices in a selected area. To become an expert may become a major motivating factor for a novice. In our model, peer profile based grouping can be used for introducing motivating factors. Therefore, e.g. skills are divided into the qualitative categories: perfect, good, basic.

Furthermore, supporting mobile learners assigned to groups will lead to dynamically changing assignments and changes in the group hierarchy. In case additional group

creation and joining is allowed, branches with no peers assigned any more needs garbage collection techniques and recovery strategies to support reliable collaboration. Covering these aspects will foster a dependable digital learning environment, but is not part of our basic model.

3 Design and Implementation of the Prototype

In order to implement the model of hierarchical groups based on peer profile similarities of spontaneously interacting peers we used JXTA (i.e. the reference implementation [17], [18]). JXTA provides peer to peer based interaction, using the peer as a notion for any networked device that implements JXTA protocols. All peers have the same capabilities with respect to the communication pattern. Thus, there is no a priori distinction between the role of the single peers. JXTA allows not only to discover and advertise peers, but groups and groups hierarchies may be built and peers can be assigned. The prototype application aims at providing information about each mobile participant in the learning environment and to support the basic collaboration services files sharing and synchronous communication. Furthermore, active creation and joining of groups and subgroups is implemented. In addition, grouping and building group hierarchies based on profile information is designed. This functionality has already been designed and will be implemented in the next version of the prototype.

3.1 Requirements and Design Issues

In order to achieve the outstanding functions of the prototype, a few design issues are considered. The prototype application shows pro-activity to a high degree. Information about the identity and user profiles of other participants is collected autonomously without direct manipulation of the learners involved. Furthermore, location and context information is collected frequently and accurately the same way to assist ad-hoc collaboration based on grouping. As the context and learner pool nearby changes frequently, accurate information is needed to avoid inconsistent views of the environment.

To provide a stable, reliable and scalable solution without a performance bottleneck, a decentralized solution is preferred. In general, all participants are assigned the same rights and abilities. Thus, a peer to peer solution is taken instead of a client/server approach which is followed for example in [19]. In [20], also a peer to peer architecture is presented, but the system is basically a file sharing system, not providing support for group member interaction as we are envisioning in our research. Information about profiles and group membership are periodically distributed to support a consistent view. It is expected, that temporary inconsistencies may occur according to network traffic and latencies.

Since a variety of mobile computing devices like PDAs (Personal Digital Assistants), notebooks or smart phones are used during learning meetings, portability is a major goal. A common platform and thin application runable on devices with limited capabilities like PDAs is preferred.

Furthermore, the prototype addresses awareness and ubiquity issues. Since mobile learning teams are supported, location parameters and context information are used as a trigger for the application. Awareness of location coordinates of a lecture, or changes in location parameters of individuals require an embedded sensory equipmentto track the team members. In addition, ubiquitous communication support requires an underlying wireless network connection, in our prototype connectivity is provided by W-LAN IEEE 802.11b.

3.2 Architecture and Service Description

Based on TCP/IP, the JXTA class library offers the *JXTA Core* components, services and protocols. At the start of the prototype (*Start Application*), the discovery of learning peers is realized by JXTA peer advertisments using peer profiles containing the attributes of each peer. During runtime, a thread searches periodically once within a default interval of 30 seconds to find advertisements previously published. Figure 2 shows the relation between the JXTA layer architecture and the prototype services group management, chat, and content manager.

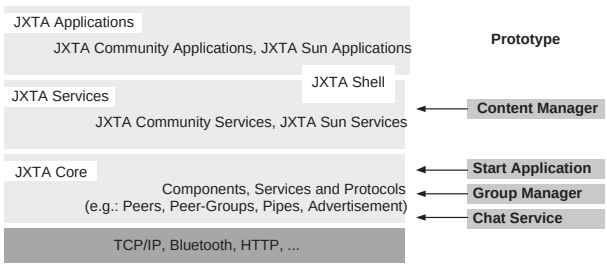

Figure 2. JXTA Layer Support related to Prototype Services'

The *Group Manager* alters the group hierarchy by using the *JXTA Core* primitives for creation and joining. The important concept of groups includes the support for group services, i.e. services running on each peer assigned to the group. The services of the learning prototype are running on each peer of the learning environment. Thus, a root group is used, where peers and are automatically assigned to and services are attached to. Whenever a peer joins a group, an advertisement is sent and a new directory is created for content sharing.

The communication between learners is supported by a *Chat Service* not included in the JXTA reference implementation but based on the JXTA pipe service of the

JXTA Core layer. To participate in a chat, access rights are granted by the group membership. A chat session is established using a request-reply pattern of JXTA advertisements.

During learning sessions, it is likely to exchange data like programming files, lecture descriptions, or technical preparations. A simple file sharing and downloading of any type of file is implemented using the JXTA extension *CMS (Content Management Service)*. The *CMS* allows to share and retrieve data within a peer group. On default, scanning for files takes place 3 times per 10 seconds. The file transfer itself uses the JXTA pipe technology for sending and receiving messages from peer to peer.

3.3 Peer Management

To manage peer data, a peer profile is defined and used to send an advertisement. The peer profile is implemented using the classes PeerProfileAdvertisement derived from net.jxta.document.Advertisement and the derived PeerProfileAdv. Figure 3 shows the main peer attributes clustered into seven categories.

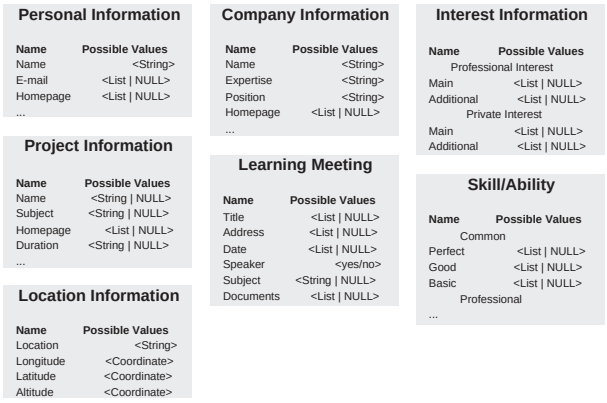

Figure 3. Peer Profile

Peer advertisements use *XML* document descriptions to publish peer profile information. Figure 4 shows an example peer advertisement. Using *XML* for advertisements is compliant with the JXTA reference implementation.

3.4 User Interface

The user interface is based on a directory structure which allows presenting hierarchical groups together with their peers clearly. Figure 5 assumes two peers, Robert and Karin with test profiles. Robert and Karin have joined the

```
<?xml version="1.0"?>

<!DOCTYPE PeerProfileAdvertisement>

<PeerProfileAdvertisement>
        <GENERICAdvType>
                PeerProfile
        </GENERICAdvType>
        <GENERICPeerID>
                urn:jxta:uuid-
59616261646162614A787461503250338A80FB1448DF4F6AA1498E72466CE75803
        </GENERICPeerID>
        <GENERICPeerName>
                Robert
        </GENERICPeerName>
        <PEERPeerName>
                Robert Kopecny
        </PEERPeerName>
        <PEERPeerCity>
                Vienna
        </PEERPeerCity>
        <COMPANYCompanyName>
                Robert Kopecny AG
        </COMPANYCompanyName>
        <INTERESTMainInterest>
                JXTA
        </INTERESTMainInterest>
</PeerProfileAdvertisement>
```

Figure 4. Peer Advertisement

Standard Test Group and may use the peer to peer application concurrently. The current group hierarchie consisting of the *NetPeerGroup* being root, the subgroup *Standard Test Group* created on default and its subgroup *mobile learning group*.

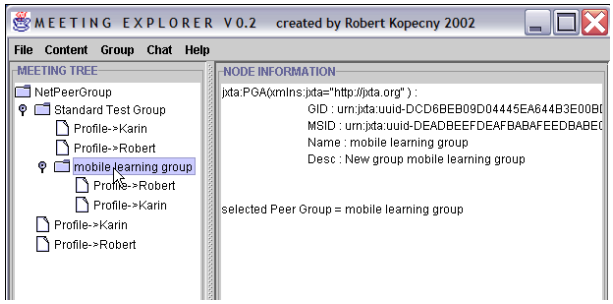

Figure 5. Prototype User Interface Building Groups

Furthermore, Figure 5 shows the menu items corresponding to the implemented functions. Using *File*, the prototype may be quit. The item *Content* allows to share files containing various types of data actively with group members. Figure 6 shows the user interface of the *Content Manager*, where files may be selected and stored to a local directory. Selecting item *Group*, new groups may be created actively or existing groups can be joined. The current version of the prototype allows every peer to join every peer group available. Finally, item *Chat* implements the communication facilities of the application, which is restricted to synchronous communication. The peer starting the chat session invites a peer related to his or her group. The chat is not recordable, since we focus on spontaneous interaction rather than on persistence.

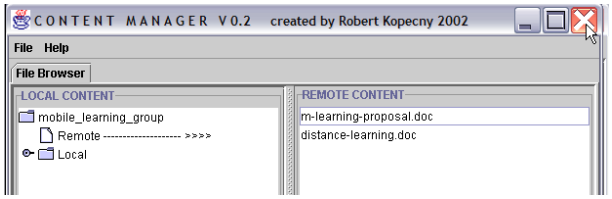

Figure 6. Prototype User Interface Sharing Files

4 Example Concept of a University Lecture

To explain the benefits of hierarchical groups, we now apply the model to a University lecture on software engineering of mobile applications. Assuming programming teams consisting of four students working on one selected topic with mobile devices and networks, the teams will be mobile and collaborating by nature.

In addition to the well-defined tasks assigned to each team, the students will consult each other to benefit from the skills and abilities of other students. It is expected that the collaboration amongst all students follows patterns of cooperation rather than competitive patterns to solve the tasks assigned to them in the areas of location awareness, mobile multimedia, mobile coordination and mobile learning.

Let us consider the implementation of location aware services as one of the tasks assigned to a team of students. To complete the task the students need expertise in mathematics and geometry, a basic physical background, experiences with device drivers using Linux and skript programming like programming in Perl. In addition, for building a topological representation of the environment some skills using graphical tools are required. In contrast, a task on mobile multimedia requires skills in using multimedia devices, streaming, capturing and coding. More abstraction is needed to solve the problems of mobile coordination patterns. Here, modeling using UML or experience with middleware like JavaSpaces together with programming skills in Java are required. Finally, mobile learning software engineering addresses a pedagogical background and programming skills. We will use these examples to illustrate possible inter- and intra-team interaction scenarios in the following.

Figure 7 shows a snapshot of a group hierarchy at a given point in time. Peers with prefix *Loc* are related to the project *Location*, peers with prefix *Co* are members of the programming team in the *M-Coordination* area. For example, while the peer *Loc.1* is interested in *GPS* and is currently in the *Laboratory*, the peer profile of *Loc.3* determines, that the peer is interested in *GPS* and *RFID* technology and currently joins the learning meeting about *Awareness* in *Seminar Room 2*.

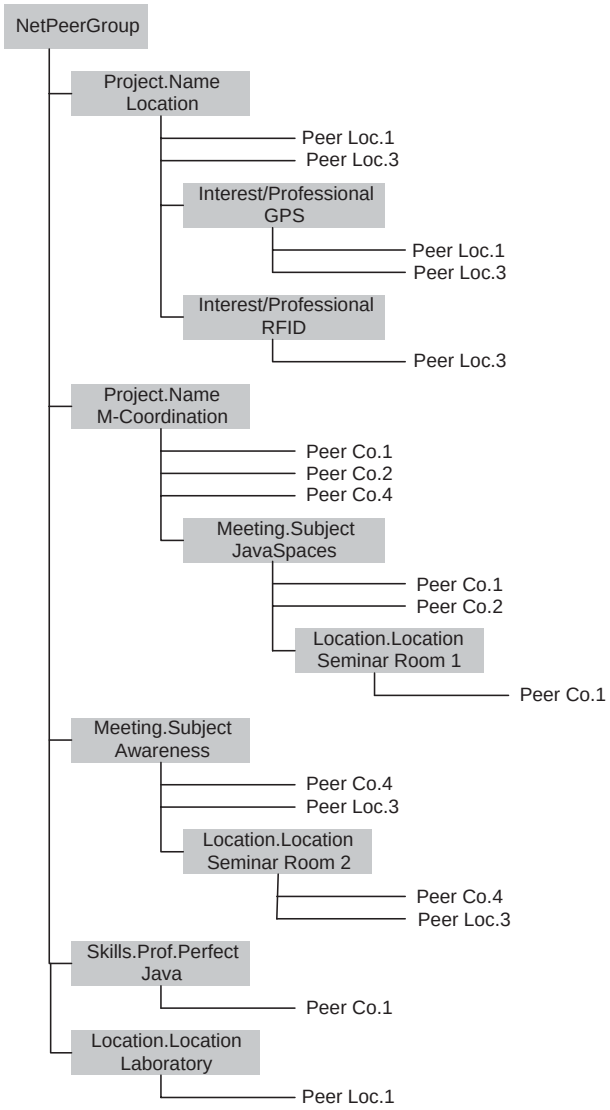

Figure 7. Example Mobile Software Engineering Lecture: Spontaneous Grouping

Assuming, a new peer *Co.3*, who is an expert in evaluating the mobility support in middleware frameworks and applications, joins the learning environment, enters *Seminar Room 2* and joins the meeting *Awareness*. In this environment, he or she may naturally find and talk with *Loc.3* about the relations between middleware and RFID technology. Concurrently, the peer may share documents related to Project *M-Coordination* with its team member *Co.4*.

5 Conclusions and Outlook

Mobile persons will become mobile learners quite naturally. The major challenges of digital learning in mobile environments are subjects addressed by ambient computing research, like location and context awareness and ubiquitous connectivity. In addition, learning styles will change

and require new services supporting the identification of other learners with similar interests or near by, short interactions with other learners or the environment and sharing of data.

Focusing on collaborative learning, we argue the benefits when using hierarchical nested groups for emerging learning communities based on interest or context information. The values describing a person's interest or context is described using learning peer profiles. Grouping is based on similarities in the peer profile information. In addition, to allow more complex combinations for grouping, learners are allowed to create and join self-determined groups. As a consequence, also social group behavior may be modeled by group hierachies and policies.

Corresponding to the demands of spontaneous grouping, a prototypical implementation using the peer to peer technology JXTA is described, which uses the notion of groups to control the access and interactions. Mobile learning teams are supported with basic grouping and subgrouping functions. Furthermore, a content manager for sharing and downloading of data, and a chat application for synchronous communication are implemented.

Finally, an example is presented applying the model to a University course. We plan to use the prototype for a course to be held in summer term 2003 at the University of Vienna. The experiences gained in using the prototype will help us in improving the system. In particular, we want to study the usability of the system as well as the performance and scalability of the proposed approach. The empirical evaluation of the prototype is currently in progress.

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