# A SEAMLESS MOBILE COMMUNITY SUPPORT SYSTEM

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**Abstract.** *Ubiquitous community support systems have the potential to ease daily life through delivering valuable interactive information and member contacts right in the place where they are needed. Since in real life humans move permanently between communities, we aim at building an interoperable community infrastructure which focuses on seamless switching between different community types. We show how federation can support environment adaptation, how we achieve common member understanding based on a global community ontology and how authentication based on digital certificates can enforce security amongst the community members without loss of privacy.*

## 1. Introduction

Most people use their phones to maintain relationships, but more and more take advantage of spontaneously accessing remote data at any time using their mobile devices. For instance people who travel use mobile services for gaining location relevant information or want to know who is around to assist them in certain situations. *Communities* offer this type of location based or personalized information and additionally offer access to *other community members* in case the offered static content within the community is not sufficient. However the mobility of the user imposes restrictions on traditional community support systems, since traditional communities are either only subject oriented or are restricted to a certain location. In this paper we describe a seamless community support system which *augments* real world scenarios with digital communities. In our view users may register to global interest groups which are represented through location bound real world user communities. We especially focus on *community interoperability* and through this remove dramatically the effort for interacting with content from different communities or other community members.

As an illustrative example for the connection between *global* and *local* interest groups consider the following scenario. A person interested into sports may register to a global interest group *sports*, which represents a *class* of communities rather than a community itself. Instances of the class *sports* may then be created, for example, for a shopping mall where sports equipment is offered in various shops. Additionally, a sports community may be created for each individual sports shop of the mall. When entering the mall the person then automatically becomes member of the mall's sporting community, and additionally becomes member of the community of each sports shop he passes by or enters.

The paper is organized as follows. In section two we briefly describe typical acceptance barriers from the users point of view for existing mobile community infrastructures. In section three we

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introduce our solution framework for a seamless community support system. Here we demonstrate how seamless communities are embedded into global interest groups, how the mobile support system automatically joins and leaves available communities depending on the location of the user, how to generate situation specific meta data during the content publication process, and show how the seamless community infrastructure keeps retrieval time in a federated infrastructure to a minimum. In section four we present technical details about our prototype together with initial experiences we made during prototype development. Related work is discussed in section five and a short summary is given in section six.

## 2. The Mobile Community Acceptance Problem

Although mobile phones are extremely successful as communication tools, the broad usage of mobile community support systems is still an exception. From the user's point of view complicated user interfaces, quality of the content and significant privacy concerns have been major barriers for broader acceptance. Some early versions of mobile community support systems were simply ported to mobile devices and realized as SMS or WAP based communities [16]. However, the porting of desktop systems to mobile devices can only be successful if the offered mobile community services take into account the specific features of the device. Small screen size, memory limitations, reduced processing power, limited battery life time and low bandwidth connections have to be considered for the design of mobile community services.

Since mobile communities have different usage scenarios, the type of content offered in mobile communities in many cases is not situation specific enough. Hierarchical navigation structures as known from virtual newsgroups take to much time to detect the right information. The content should rather be *pro-actively cached* dependent on the situation of the user and be ready for immediate access if required. Communities offer many opportunities for content misuse like spamming, publishing of illegal content, alteration and the destroyal of content, or meta data manipulations. Considering that today's mobile devices advance to real mobile computers hosting extremely private data for personal information management, the infection of mobile phones with malicious codes such as viruses, worms, and spy ware is just a matter of the time. Unfortunately the security infrastructure has just begun to evolve. Nonetheless community owners cannot expect users to create value for sites where security is not granted. Additionally, many community systems are incompatible with each other due to a lack of a common underlying technological infrastructure. Usually, telecom providers and phone vendors create their own user communities, here duplicating effort in creating software commonly used by all community systems. Developers that want to offer the same service to two different communities have to develop a bridge between the communities.

## 3. The Seamless Community Support Approach

The idea of our proposed community service is to enhance the standard communication functionality of mobile phones with a *permanent community environment*. Therefore we foresee a scenario where different community types augment the real world, such that the user feels always embedded in his personal community sphere. Our definition of seamless communities indicates that the end-user is member of certain global interest communities, but has no perception that local community boundaries are crossed while moving around. The idea of seamless community mobility is desirable in many aspects, especially with respect to (1) wide area community membership and (2) access to valuable situation specific community knowledge during the entire day. This means that the end-user

is not interrupted during his daily life, but may capitalize on community support when needed. In the following we define major components of our seamless community framework:

**Global Interest Communities:** In our approach, global communities representing specific themes are realized by mapping them to existing local communities as illustrated by the above described sporting community scenario.

**Location Awareness:** Local communities are always bound to a specific area on the earth surface, i.e., there may be a community for the city of Vienna (defined for the area of Vienna), one for the districts of Vienna, or one for a shopping mall within a certain district (Fig. 1). Location technology is then used to *manage community membership*, for example by using a Global Positioning System (GPS). Thus, if the current GPS coordinates are within the boundaries of existing communities, then the user automatically joins them, or leaves them once the area is left. We propose to describe the boundaries of a community with a circle, which is completely defined using a center with $(x, y)$-coordinates and a radius.

**Mobile Community Services:** Mobile devices like smart phones have the ability to handle a number of applications and host a number of built in devices like cameras, which let mobile devices behave like hand-held computers. *E-mail, messaging, calendar and contact management, photo albums and music stores* should not be seen as isolated applications, but rather be integrated into the community environment.

**Meta Data Management:** Users may specify their situation by using a meta data context, consisting of *time*, *location*, *interests*, and *related buddies* [13]. Meta data should be provided through sensors or personal profile information stored on the mobile device in a totally transparent way. Ad-hoc network connections [14] may be used to request missing sensor information from other nearby community members.

**Peer-to-Peer Infrastructure:** Communities in peer networks are groups of peers with common interests, exchanging information with other group members or performing some collaborative work together. Barriers like connection establishment and managing community services must be hidden from the user. The peer network infrastructure [15] is highly flexible and therefore best suited to handle the dynamics of mobile community access and ad-hoc community management.

**Shared Ontologies:** Our community services must allow for the semantic matchmaking of interests in community activities. In order to avoid data heterogeneity in the community domain we follow an ontology-based approach. An ontology is similar to a dictionary or glossary, but with greater detail and structure and expressed in a formal language (e.g., RDF) that enables computers to match content [9]. A single ontology can be applied to solve the integration problem and to conceptualize community activities and interests.

**Privacy Management:** Personal profiles which are commonly used to specify preferred ringtone selections may also be used to determine the degree of privacy (e.g. *private, privileged* and *public* access) a users claims for certain situations to avoid unnecessary interruptions of the daily life. Profile management in this case can be extended to allow users for individually specification of certain

community interests provided by the global community ontology. GPS-notifications may be used to automatically determine situation relevant profiles or if required manually selected by the user.

**Trust based authentication:** Two major concerns are of importance when trying to achieve seamless communities: transparent end-user *authentication* and *security* across different local community support systems. The end-user should not be bothered with technology-specific mechanisms such as providing user name/password or filling in an access code. Since mobile devices cannot store large user registries for community authentication, a public key based security system is essential. Decryption of digital certificates does not consume too many resources and revocation of privileges is achievable through limiting the lifetime of certificates.

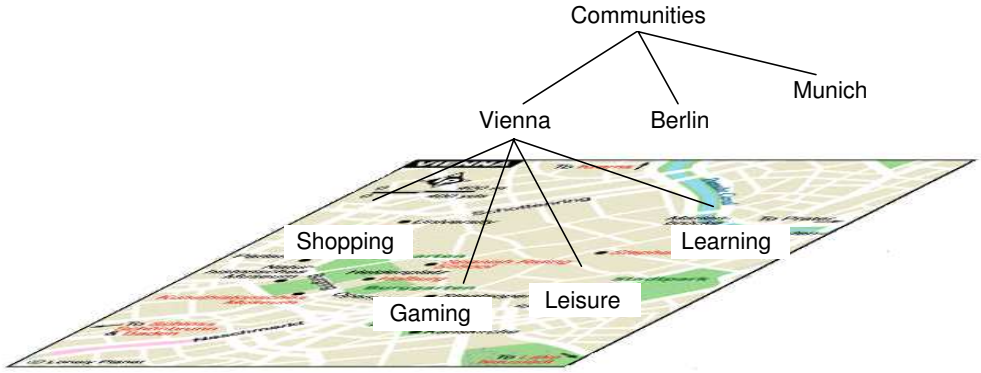


**Figure 1. Hierarchical seamless community concept.**

## 4. Content Management System Prototype

To realize the seamless community support system we choose JXTA [1] for J2ME devices (JXME) as peer-to-peer (P2P) network. JXTA is an open source project initiated from SUN Microsystems that defines a set of protocols for ad-hoc, pervasive, P2P computing. At the core, JXTA supports peer and member administration, group management, and messaging. JXME in specific is a stripped down version of JXTA to support small mobile devices with small memories and restricted processing power. Unfortunately the current JXME implementation does not support the handling of external resources like text or media files. For our research work we want to extend the core capabilities with a *ubiquitous content management system*, including functions for indexing, searching, and file sharing. The Ubiquitous Content Manager Service (UCMS) will allow JXME applications to share and retrieve *personalized content* within a peer group. Each item of locally shared file content is referenced by a unique content ID (cid) and an advertisement which provides meta-information about the content. The UCMS will also provide a protocol based on JXME pipes for pro-actively transferring and caching content advertisements to mobile peers and thereby will create environmental awareness for the end-user. Cached content advertisement then can be used to find appropriate content stored at remote peers.

### 4.1. Context based Advertising and Discovery

The mobile device detects the current *user context* (e.g., GPS, time, etc.) either periodically or on the user's demand, and, within the currently joined communities, regularly searches for content that matches the preferences as specified in the user profile. Content advertisements are stored locally in

a Record Management System [7], whereas media files like pictures, text or videos are stored in the local file system. Mobile phones equipped with Symbian v8.0 include the JSR-75 File Connection Package allowing local file access. For our planned experiments we will use mobile devices equipped with A-GPS receivers, such that the mobile device will be able to generate most of the meta data automatically [9]. Content advertisements provide meta-information describing the content, including the content name, length, mime type, ID, and context description like time- and location relevance, domain reference, and author information. Both the name and content ID fields are mandatory, but all other fields are optional in a content advertisement. The cid field contains the unique 128-bit MD5 checksum of the content to exactly distinguish different file versions.

### 4.2. Lightweight Ontology and Environment Modeling

Since mobile devices have restricted processing power and small memories, the ontologies used to describe shared community structures have to be lightweight. We therefore propose a flat hierarchical structure with no more than 3-5 layers (Figure 2).

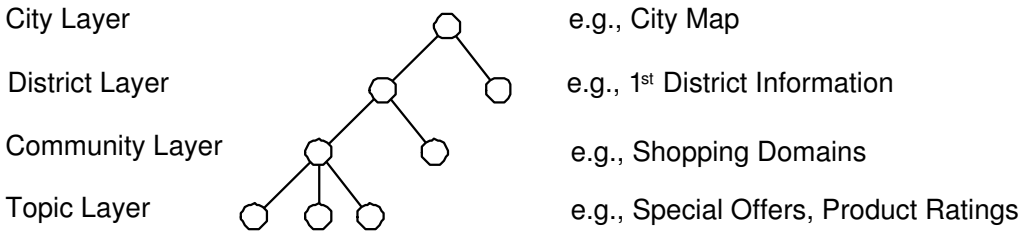


**Figure 2. Domain model and meta data structure.**

Each layer specifies a special category of terms together with a describing set of meta data attributes and values. The structure of a domain model relates to a hierarchical map, like descriptions containing the different semantically views of map objects. The resulting domain model can be formatted as machine readable RDF graph and stored on globally available domain provider peers. Peer-to-peer networks that simple flood the network for discovery do not scale well. Therefore semantic overlays are necessary to restrict the number of queries sent through the network [3]. Since we assume that communities are assigned to certain areas, the search effort can be further reduced by just forwarding queries to the *community owner*, i.e., the peer that has created the community and currently hosts the participating peers. The owner then distributes the query locally within the group. In JXME networks peers use advertisements to promote descriptions of their expertise in the network [2]. In our model, all peers need access to the domain model in order to generate matchable advertisements or forward queries to peers with better competencies. Advertisements can be used to form semantic topologies by only accepting advertisements with similar content. The advantage of this approach is that queries will not be forwarded to all peers, but only to those that have a good chance of storing appropriate content.

### 4.3. Lightweight Digital Certificates and Rights Management

To enable automatic entering and leaving of communities the community support system must offer a single sign-on authentication system similar to the Liberty Alliance [6]. In our security scenario, we foresee three different parties, each of them with certain duties. The *telecom provider* is responsible

for maintaining user authentication information. *Community owners* manage role models for community participation and grant access rights. *Mobile users* manage their profile information and store it on the mobile phone. As a format for user profiles we envision Friends-of-a-Friend (FOAF), which describes vocabularies for person profiles (like contact or CV) and dynamic information (availability, location, meetings, etc.) as often used in buddy list descriptions. The authentication process itself is separated into two major steps (Fig. 3).

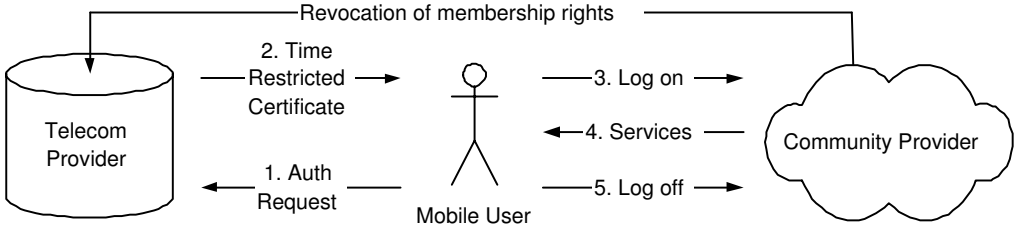


**Figure 3. Authentication, single sign-on and revocation of certificates.**

First the user issues a request to the telecom provider to get a time restricted anonymized digital certificate, which is stored on the mobile phone and updated periodically. With this certificate users can register at communities which raise their interest. During runtime, the mobile peer detects appropriate communities and automatically joins the community support system by sending the certificate to the community provider, who in return offers community services. In case users misuse the community infrastructure the community owner may send a revocation request to the telecom provider. As a consequence the telecom provider stops the renewal of digital certificates and the user is not able to use the seamless community infrastructure anymore.

## 5. Related Work

Although community support systems have been around for a while, the interoperability of community support systems is still under heavy investigation. Koch [4] noticed that users today have to register in multiple sites and cannot share content between the communities they are registered for. As a solution, Koch proposed a global user registry and a meta data based document exchange. This approach is very useful for web based community systems, but assumes a permanent connection to the user database, which can not be assumed for wireless networks. Specht [8] imagines a different scenario for ad-hoc authentication, where each owner of mobile devices automatically receives a digital certificate from the hardware manufacturer, which integrates encrypted information about the device validity. Even if the Internet connection is not available, both partners still can verify each other with no need for storing large user registries on their mobile devices. We think that complete ad-hoc networks are not the major target for mobile communities; most of the members will stay online through the traditional telecom network. However we use certificates to assure privacy between the community members, community owners and telcom providers.

There are also a number of projects [10] which aim at exploiting ontologies for knowledge integration. While the specific goals of these projects differ, they all have a common need for integrating information from different sources, and hence require a common terminology. Haase [2] described a methodology for creating semantic overlays based on similarity measurements. This procedure requires a stable peer-to-peer network, which we can only partly assume for our mobile community.

However we assume that local cache peers are necessary to provide a high availability of situation specific information. We will use this methodology for constructing overlays to integrate local cache peers into a global interest community infrastructure. Ontologies also play a major role by constructing individual community profiles. Cali et al. [17] described a scheme for constructing profiles through entities by using a description logic. In our seamless community system we will be able to generate profiles through an equivalent approach by obtaining interest descriptions from the global ontology. Koch [5] goes even one step further and argues that constructing global ontologies in real life is unrealistic, because of the immense organizational effort. He therefore proposed an automatic ontology translation mechanism for transforming semantic statements between communities. In our scenario we envision such an approach when the user migrates between telecom providers and community services have to be migrated to other telecom providers.

Zhu, Mutka and Ni [12] proposed a new service discovery protocol called *Splendor* to support mobile services. *Splendor* uses clients, mobile services, directories, and proxies to form a peer-to-peer network like infrastructure. Proxies take over computational work from clients and enable privacy by the authentication of mobile services. In their discovery protocol Zhu et al. explicitly make use of location lags to improve service discovery. However, our approach relies on the more accurate GPS positioning technology. To detect highlevel situation changes, which are worth of broadcasting discovery queries, we need an abstraction model to evaluate binary sensor data. Another article from Davis et al. [9] describes a scheme for capturing and generating meta data using a spatial, temporal, and social context. Devices may capture only a partial set of meta data, depending on the sensorial capabilities of the device. Davis proposed a method to fill the gaps by comparing meta data from other community items created in equivalent situations. De Rosa and Mezella [11] developed a prototype for shared appointment and contact management on smart phones based on a peer-to-peer communication model and GPRS technology. This application shows, how smart phone applications may become part of a community environment by putting them on top of a peer-to-peer middleware. Instead of developing a proprietary middleware we will use the existing JXME Platform to reduce the implementation effort and take advantage of built in networking technologies like TCP and Bluetooth.

## 6. Summary

In this paper we outline a seamless community infrastructure for supporting user communication, collaboration and item exchange in real mobile environments. Local community building is facilitated through peer-to-peer communication between mobile devices.

We propose a content management system to publish and exchange context sensitive content between the community members. Hierarchical ontologies play a major part in matching heterogeneous community content. Thereby the ontology defines geographic objects of interest in local communities. To ensure fast retrieval times the content advertisement will be propagated through the peer-to-peer forming overlay structures based on similarity measurements. Since people are very concerned about their privacy when using mobile phones we propose an authentication system which equivalently federates the user management responsibilities between telecom-, community providers and community members according to their duties in authentication, access right and profile management. The advantage of this approach lies in the fact that each party sees only that information necessary to manage its part of the community system. As part of our future work, we will evaluate the quality of content personalizations according to individual moving patterns and the efficiency of information search, storage and retrieval in a community management system network based on JXME.

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