Towards Business Model and Technical Platform for the Service Oriented Context-Aware Mobile Virtual Communities

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Abstract

The focus of existing virtual communities is centered on a particular product or social interaction and the role of mobile devices is restricted to exchange a limited amount of contents. Herewith we envisage that the upcoming virtual communities will exploit the potential of social interaction and context information to offer personalized services to its members and mobile devices will play a significant role in this process. As a step towards this direction, in this paper we propose a business model for the mobile virtual communities in which the mobile device takes on the role of a content producer and content consumer. Though there are a number of research issues which need to be addressed to realize such virtual communities, in this paper we focus on the service requirements, architecture and open source software implementation of a technical platform for the content producer and consumer mobile devices.

1. Introduction

A *virtual community* is a technology-supported cyberspace, centered upon communication and interaction of participants, resulting in a social relationship being built up [1]. The world of online virtual communities is experiencing a phenomenal growth and popularity by capitalizing on the ubiquitous Internet connectivity and the contemporary technologies comprising Web2.0. Complimentary to these technologies and due to the recent advances in the mobile hardware, software and communication technologies, the world has seen the rise of *mobile virtual communities* where the members use mobile devices to participate in the virtual community [2].

The existing day virtual communities are particularly *social networking oriented* (e.g. MySpace), *product oriented* (e.g. BMW-forum) and consumer *services oriented* (e.g. eBay). In principle, these communities are decoupled from each other depending on their focus. We believe that *context-awareness* would enable us to design and develop a virtual community which cleverly combines the social interaction and commercial functions to enhance social interaction aspects, offer personalized services and products to its members.

In the existing virtual communities, mobile devices play the role of a *content consumer* to access the services available in the fixed network. For example, the hybrid community environment proposed in [3] is composed of a web-based part (the platform and member profiles) which can be managed from the fixed computer and a mobile part of the community is focused on communication via a mobile device. However, recently the role of mobile devices is evolving from the content consumer to *content producer* [4]. The information obtained from the contents produced (e.g. user preferences and profile, user generated content) by these mobile devices could be of possible use to other members of the community. Moreover, the user context information (e.g. real-time location information, user agenda) obtained from these devices is important to realize the context-awareness and personalization aspects of the virtual community.

It has been observed that a concrete *business model* is necessary to financially sustain the virtual community [5]. Hence, firstly, in this paper, we outline

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the business model for the mobile virtual communities in which the mobile devices assume a content producer role along with the content consumer role. Another feature of the proposed business model is that the community platform provides the necessary *context-aware matchmaking functions* based on community member's profile, interactions and the context information (e.g. location) of these members to recommend relevant sub-communities, products, services and displaying community support content (e.g. advertisements).

To realize the virtual community based on the proposed business model, along-with the technical challenges, a number of issues such as legal issues, social issues, user generated content copyrights, user interface, security and trust concerns need to be addressed. In this paper we limit our focus to the architecture of the virtual community and participating mobile devices based on the principles of *Service Oriented Architecture* (SOA) [6] and the services implementation for the content exchange on the mobile devices. We also motivate our choices for the community platform and mobile services implementation, provide the current implementation status and analyze a case study in the mobile health domain.

Section 2 of the paper discusses the related work in this area. Section 3 presents the proposed business model. Section 4 elicits the service requirements for the virtual community technical platform and presents the high level architecture. Section 5 is on the case study in the m-health domain. Section 6 summarizes the work and discusses the future work.

2. Related Work

The existing virtual communities broadly fall into the *commercial* and *non-commercial* communities [7]. Further analysis in [7] classifies the virtual communities along two dimensions: *profit* and *non-profit*, *company* and *non-company*. A comprehensive state of the art of virtual communities is reported in [1] where the existing research on virtual communities is classified into basic research, technology development, functions derived and adoption, implementation and outcome assessment and institutionalization. A number of directions for the future work are recommended in [8] which include topics such as the Meta-analysis of research in the virtual community, impact of Informatics to support communication in virtual community and knowledge transfer in virtual community.

The work reported in [2] groups current research interests in the mobile virtual communities into *technology-centered interest*, *user-centered interest* and *business-centered interest* and analyses inter-dependence between them.

Leimister et. al. [5] claim that for the virtual community to be successful, a business model should consider external factors such as technical and legal conditions as well as market and competition conditions. To motivate this claim, [5] analyses two case studies of the successful virtual communities using the proposed business model framework. As referred in [3], a business model helps to understand the fundamental components of an existing or future business activity. The business model proposed in [3], handles the social and commercial aspects of the virtual community. The community platform is established and promoted by the product and service providers (sellers) who are interested to sell their services to the individuals (buyers) in the community. Based on the information such as preferences and buddy list provided by the buyers, the sellers provide personalized services to the buyers. In terms of the mobile aspect, the hybrid community in [3] is *asynchronous* i.e. the members broadcast their messages to the buddy list and people react whenever it is convenient for them. The proposed business model in [3] is applied in a *mobile community online reservation system* in the leisure services domain. The business model proposed in this paper is an extension of the business model proposed in [3]. This extension is mainly in terms of the role of mobile users as *service and data providers* and context-aware mechanism for enhancing social interaction, services and product offering aspects.

To exploit the advantage of mobility in the scenarios such as traffic jam, [8] propose an innovative collaboration model based on the concepts of spots. This collaborative model has earlier been used in [9] to develop a community for the *public transport awareness system*. To expand the virtual communities from the fixed computers to the mobile devices, [10] propose a wireless and mobile application known as *MOOsburg++*. In combination with the positioning systems, MOOsburg++ could enable scenarios such as reminders when a member reaches a pre-configured location.

The distinguishing aspects of our work as compared to the related work are as follows: 1) The proposed business model considers the situations where the mobile device acts as a content and service provider; 2) The community platform uses the context information of the community members to recommend them relevant sub-communities, products, services and community support content; 3) SOA based approach for the architecture and implementation where the

members use their mobile devices for offering *commercial services* and the content exchange.

3. A Business Model for Mobile Virtual Communities

The most frequently cited definition of a business model is that by Timmer [11] and it is as follows: 1) *An architecture for the product, services and information flows, including a description of the various business actors and their roles; 2) a description of the potential benefits for the various business actors and their roles; 3) a description of the sources of revenues*. This section explains the elements of the proposed business model based on this definition. However, before going into the details, we would like to clarify the scope of the terms product, service, content, information and sub-community referred in the business model herewith.

The distinction between the *product* and *service* is very fuzzy. The meaning of the product and service are often associated with the context in which they are used. Herewith we consider that both, the product and service are sellable. We also consider that the product is tangible, could be owned, countable and manufactured while service is intangible, could not be owned, tailor-made, leveled (e.g. best) and could be subscribed. In this paper, the *content* is data in the form of text, files (e.g. images), and real-time streams. *Information* is a result of certain operations on the content. The *sub-community* is a community formed inside the main community and it could be based around a particular product and service. Thus, in principle, a community is comprised of all the distinct members in the sub-communities.

3.1. Business Actors

In the proposed business model, we define the following three primary types of the actors: *consumers*, *providers* and the *community platform operator*. The consumers and providers could be fixed as well as mobile. The providers are further sub-divided into the *commercial service provider*, *commercial product provider*, *social contents provider*, *community support provider* and *Internet Service Provider* (ISP). The consumers are sub-divided into the *commercial service consumer*, *commercial product consumer* and *social services consumer*. The community platform operator provides the necessary infrastructure and functionalities for the interactions between the consumers and providers.

In this paper, since we emphasize the role of mobile users as the provider of the services, product and contents as well as the consumer of services and products, we present herewith two examples to justify this role. For the additional example of this concept, we refer to the case study in the Section 6.

Mobile user as a commercial service consumer: The mobile user takes a picture of the book barcode and the barcode picture (or barcode number) is sent to the commercial product information service provider who sends the information about the product to the user.

Mobile user as a commercial service provider: The mobile user uses her mobile device to monitor the *Quality of Service* (QoS) information of the wireless network connected to and sends this information to the *QoS map service provider* [12] which will analyze the information received from multiple mobile devices to generate a QoS map showing the QoS characteristics and available networks at a particular location and time.

ISP provides the Internet connectivity so that the other actors could interact with each other. Since the role of ISP is limited only to provide connectivity, we don't consider ISP further in this business model. Figure 1 shows the business model depicting the consumers, providers, community platform operator, and ISP along with the knowledge and money flow within these actors. The following subsection explains the role of the community platform in details.

3.1.1. Community Platform Operator. The community platform operator provides an infrastructure and facilities to build the social relationships and facilitate content and financial transactions between the providers and consumers. The community platform allows the commercial service (product) providers to list and offer their services (products) to the consumers. The social interaction service within the community platform provides the necessary facilities to build social relationship between the consumers and providers. The community platform is also a single point of contact for the *revenue exchange* between the service (product) providers and their consumers.

One of the features provided by the community platform operator is the *context-aware matchmaking function* which makes use of the context information (e.g. location) of the providers and consumers to recommend them services and products based on their context. E.g. if there are multiple mobile service providers offering an ambulance service, the patient requesting the ambulance is offered the nearest ambulance service. Using the context information of the mobile consumers is also helpful for offering

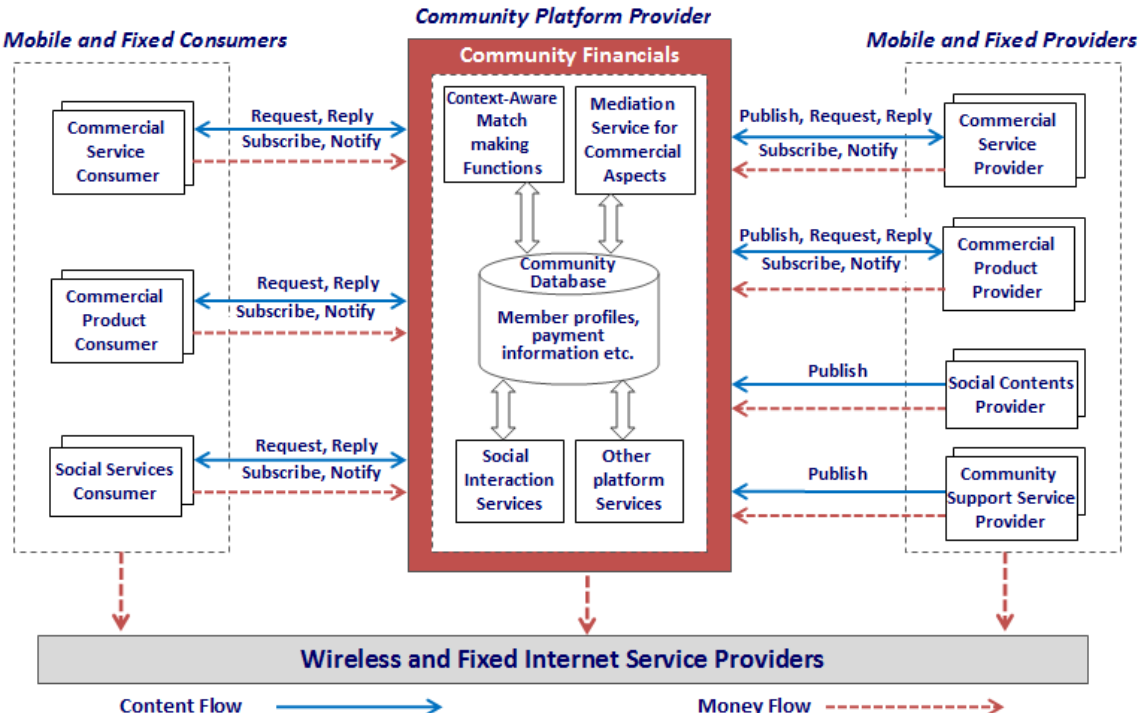

Figure 1: Business Model for Context-Aware Mobile Virtual Communities

contents (e.g. advertisements) provided by the community support provider.

3.2. Product, Service and Content Flows

We define the following three types of interaction modes for the content exchange between the actors in the proposed business model:

Publish: The interaction mode Publish is used by the commercial service provider, commercial product provider, social contents provider and the community support provider to publish offered services, products, social content and support content (e.g. advertisements) respectively. The community platform provides necessary facilities (e.g. services, product and advertisements listing in the appropriate sub-community and social content display in the member profile) to publish this information.

Request-Reply: The Request-Reply mode is used by the consumer actors and the community platform to interact with the providers. Thus the community platform essentially serves as a mediator between them. The *mediation service for the commercial aspects* offered by the community platform operator facilitates the interaction between these consumers and providers. This service processes and forwards the requests from the consumers to the providers and the reply from the providers is processed and relayed back to the consumers. The processing part at the mediation service is mainly for generating revenue for the community platform (described in the sub-section 3.4 herewith). The social services consumer uses the request-reply interaction mode to request social contents and information published by the community members using the social interaction services.

Subscribe-Notify: The interaction mode Subscribe-Notify is similar to the Request-Reply mode. However, additionally this mode lets the consumer subscribe to certain information and receive the updated information on its change. E.g. A social services consumer subscribes to the social interaction service to be notified when a certain member comes online. The commercial product consumer could subscribe to the additional products being listed by a particular commercial product provider.

3.3. Description of Potential Benefits

The proposed business model is beneficial to all of its stakeholders because of a number of factors listed as follows:

Consideration of mobility: The consideration of the mobility of both, the consumers and the providers results in the provisioning and utilization of the products and services anytime and anywhere. Moreover, the members of the community could access the social interaction services on their mobile devices.

Matchmaking functions: The matchmaking function provided by the community platform matches the interests of the community members to the services and products offered by the providers. The community platform also proposes appropriate sub-communities for their members and suggests to them to the other members for the social interaction. The context-awareness in the matchmaking function finds the best matching services to the consumer based on the consumer and provided context. The consumer also receives the community support contents based on their context; hence it is more likely to be appreciated by the consumer.

Mediation Service for the Commercial Aspects: The mediation service for the commercial aspects handles the commercial transactions on behalf of the consumers and alleviates them from entering the financial information multiple times.

3.4. Source of Revenues

The proposed model has a potential of revenue generation from the membership fees, revenue sharing between the commercial providers and the community platform as well as revenue from the community support providers. For the detailed information on the revenue generation aspect, we refer to [5] and [13].

4. Service Requirements for the Mobile Community Platform

Nowadays, SOA is a popular choice for the application development because it facilitates the development, deployment and usage of (composite) services which are well defined, loosely coupled, flexible, reusable and have implementation independent interfaces. Hence we choose to use SOA paradigm as a basis for the design of the mobile virtual community platform. To be viable, a mobile community platform based on the proposed business model has a plethora of requirements including services, user interface, and detailed matchmaking functionality. However, in this paper, we present our requirements mainly in terms of the basic services provided by the community platform and the services to be hosted on the mobile device to take on a consumer and producer role. Please note that the definition of service in this section is different from that in the business model described in the Section 3. Herewith, we consider a service to be a unit of well-defined functional behavior (in syntax and semantics) that is offered by a software entity for use by other software entities. A service could be a composite service in that it can consist of one or more constituent services [14].

4.1. Service Requirements at the Community Platform

We describe here the services requirements regarding to the community platform, as depicted in the figure 1.

Member Management Service: This service provide functions such as registration of the new members, managing member profiles, their roles (e.g. commercial service provider), login, and session handling.

Directory Service: The directory service provides functionality for the commercial service (product) providers and community support providers to list the offered services (products) and content. Thus, it basically results in the creation of yellow pages.

Community Management Service: This service consists of the functionalities required to create, join, access and search sub-communities, publish, get and subscribe information in the existing sub-communities.

Social Interaction Service: This service handles the one-to-one, one-to-many or many-to-many interactions between the community members. This includes interaction functions such as live chat, notifications, and subscription to the member information.

Context-Aware Matchmaking Service: The matchmaking functionality of this service is used to find potential members for the new sub-community automatically by providing the semantic description of the community. The matchmaking service is vital to support the business model described herewith. If a community member is interested in a particular type of the service, the matchmaking service performs the final selection of the services based on context information of the members and services using the approach proposed in [14].

Mediation Service for Commercial Aspects: The role of the mediation service is to provide access for the members to the listed services and products through the community platform and to handle financial transactions on behalf of the members. For this purpose, the mediation service consists of a *centralized billing module*. The Community Platform provisions a database which stores information such as the member profiles, services and product listings and billing information. The social interaction between the community members is also stored in this database along with their profiles.

Due to the choice of SOA paradigm for the community platform design, it is possible that the

services interact between themselves to achieve a composite functionality. For example, the combined use of the social interaction service, context-aware matchmaking service and mediation service lets a community member have an interaction with the commercial service provider, select the service and use the service. For more information on how to use the service composition we refer to [14].

4.2. Service Requirements on the Mobile Device

The following basic services are required at the mobile device to be able to successfully make use of the community platform services:

Content Exchange Service: The content exchange service on the mobile device is aimed at sending the contents (e.g. text, images, and streams) generated at the mobile device to the community platform so that this content could be published in the relevant communities the user is a member of. Similarly, this service also requests/subscribes the community contents the user is interested in and sends these contents for user viewing. This service enables a mobile device to be a social content provider, social services consumer and commercial services consumer.

Commercial Mobile Service: The commercial mobile service enables a mobile device to be a commercial service provider. This service could make use of the content exchange service for exchanging commercial content and apart from this, the additional functionalities required to provide the hosted commercial service need to be provisioned.

Context Information Service: This service obtains the context information (such as location) of the mobile user and sends this information and subsequent context changes in real-time to the community platform. This information is further used by the matchmaking function.

5. Technical Platform

Our technology choice for implementing the services at the community platform is *Web Services*. This is because as compared to other SOA technologies (e.g. Jini), Web services technology promises interoperability in terms of the service development.

As compared to the service provisioning in the fixed network, to develop, deploy, use and maintain a service on the mobile device, a variety of concerns need to be addressed because of the issues arising from the user mobility, resource limitations of the mobile devices and intermittent connectivity. As identified in [4], there exist three infrastructures namely *Micro-Services*, *Mobile Host* and *Mobile Service Platform* (MSP) for service provisioning on the resource constrained mobile devices. Such services are referred to as the *Nomadic Mobile Service* (NMS) in [4].

As compared to Micro-Services and Mobile Host, since MSP supports streaming content delivery to/from the mobile device and also features context-awareness by exploiting multi-homing feature of the mobile device, MSP is our choice for the services on the mobile device. MSP is a proxy based middleware based on the *Jini surrogate architecture* specification. Since the service developed using MSP is able to participate only in the Jini network; it was required to develop additional components so that they could be interoperable with the web services.

A NMS realized using MSP consists of two components: 1) An application realizing a service running on the mobile device (referred to as a *device service*); and 2) A representation of the device service in the fixed network which is referred to as a *surrogate*. The surrogate functions as a proxy for the device service and participates in the service discovery network. *Surrogate Host* is responsible for the management of surrogates. The main components of MSP include the following: 1) *MSP-Input/Output* (MSP-IO) resides on a mobile device and interacts with the device service. 2) *MSP-Interconnect* is located at the surrogate host and interacts with the surrogate. 3) *MSP-Messages* specifies the structure of messages exchanged between the device service and the surrogate. MSP uses HTTP as a data transfer protocol.

The architecture of the technical platform is shown in the figure 2. The community platform is an extension of the PHP based open source community builder software called as *Dolphin* [16]. Dolphin is installed on top of *EasyPHP* toolkit which provides preconfigured and easy to install/use/configure environment for running PHP programs with *Apache webserver* and *MySQL* database. On the community platform side, the web services are implemented in PHP. For the implementation, development and testing purposes, we use the development server hosted at the University of Twente (*http://ewi217.ewi.utwente.nl/Dolphin*). The commercial mobile service, context information service and content exchange service are developed as the nomadic mobile services. For interoperability between these services and the community platform, it was required to implement adapters so that the Jini client works as a web service and the surrogate works as a web service client. Internal to these adapters, we use *Eclipse Web Tool Platform* (WTP) plugin. The

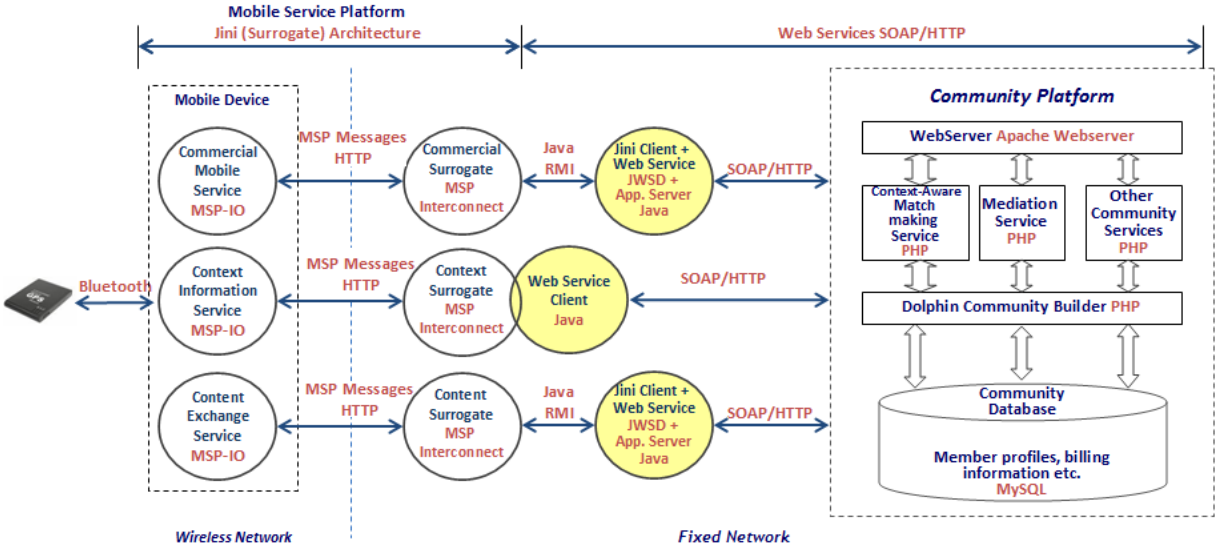

Figure 2: High Level Overview of the Technical Platform

surrogate of the context information service is extended as a web service client so that it could send the context information to the community platform. A Jini client communicates with the Jini service using Java RMI.

6. Case Study

The case study presented here lies in the *m-health* domain. Though we have not yet developed a full set of components necessary for realizing the presented case study, given our expertise in the area of context-aware service discovery [14] and mobile virtual knowledge community [17], it is quite plausible.

Bob (patient) and Alice (paramedics) join the community. The local health-care center creates a sub-community called as Health-Care Community (HCC). The community management service recommends Bob, Alice and other members to join HCC. Bob and Alice join HCC by updating their profile with information specific to HCC (e.g. the health problem the Bob is suffering from). The matchmaking service recommends the members to be a part of each other's social network based on their HCC centric profile (e.g. two patients suffering from the same problem). Bob, Alice and other members (social services consumer) of HCC including patients and paramedics socialize with each other for sharing their experiences.

Meanwhile, the Health-care center (commercial service provider) announces the offering of a tele-monitoring service for the patients suffering from epilepsy. To facilitate tele-monitoiring, various Body Area Network (BAN) manufacturers (commercial product provider) recommended by health-care center offer their BAN to the patients. Using the context-aware matchmaking service, the HCC recommends Bob a particular BAN which is compatible with his PDA. Bob (commercial product consumer) purchases the recommended BAN and subscribes (commercial service consumers) to the tele-monitoring service via the community platform.

One day after Bob suffers from a sudden epileptic seizure, the tele-monitoring service requests HCC to search for the nearest paramedics. On this request, the context-aware match-making service searches for the nearest paramedic service based on Bob's and paramedics' current location. Fortunately, Alice is the nearest paramedics to Bob. HCC invokes Alice's paramedic service on behalf of Bob so that Alice knows about the critical condition of Bob and reaches the patient for providing emergency medical assistance.

In principle, these functionalities could be provided by a specialized application for the remote patient tele-monitoring [18]. However, the advantages of using the mobile virtual community approach is that it leverages the benefits of the social interaction to create a trusted relationship within the patients, paramedics, BAN developers and the health-care center. In addition, it provides a wide and competitive choice of products and services to the patients, a platform for the paramedics to exploit their skills and an opportunity to earn money for all the product and service providers.

7. Conclusion and Future Work

In this work, we propose a business model for the mobile virtual communities whereas apart from the role of content and service consumer, the mobile devices also take on a role of the content and service provider. We have chosen Service Oriented Architecture (SOA) paradigm for the design of the

technical platform based on the proposed business model. Though there are number of research issues which need to be addressed to fully implement the virtual community based on the proposed business model, herewith we focus on the service requirements, architecture and implementation of a technical platform for the content producer and consumer mobile devices. The proposed virtual community model and the technical platform are also aimed at using context information of the community members for enhancing social interaction, service and product utilization aspects. We have assessed the feasibility of the proposed business model and technical platform in a tele-monitoring application case study. The existing implementation uses open source software and extends them for the services on the mobile devices and the community platform.

In the second phase of the implementation, we will focus on the detailed specifications and internal working of the context-aware matchmaking service and how it uses member profiles, social interactions and other context information for achieving expected functionality. For that purpose we plan to use our experience gained in the development of mobile virtual knowledge community in [17]. The third phase is the implementation of the presented case study and validation of the mobile virtual community concept in the m-health domain.

9. Acknowledgements

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