# ANALYSIS AND APPLICATIONS OF MOBILE VIRTUAL COMMUNITIES FOR TELEMEDICINE

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# Abstract

In Telemedicine, the patient is usually equipped with body sensors, which collects bio-signals and other patient and environmental signals and uses mobile and wireless technologies to send these signals remotely to a data center for analysis and monitoring. The result of the analysis and monitoring determines the level of patient support to be enforced. During the chain of events, the patients stay fully mobile and continue to do their daily activities. In the preceding scenario, other actors are involved aside from the patient. Formal caregivers such as medical specialists are involved as well as informal caregivers either to interpret the vital signs, to give feedback or to give some other form of assistance. These actors are also relatively mobile and are notified when there is a need to provide aid for the patient.

In essence, the telemedicine scenario may be viewed as a virtual community (VC) and the systems that support the realization of the scenarios may be viewed as virtual community platform. The inclusion of the mobility aspect in the scenario and thus in the virtual community correspond to a mobile virtual community (MVC) and the system that supports the MVC is referred to as MVC platform. In MVC, community members who are mobile users behave differently than non-mobile users since they are always on the move and thus also affect the roles that can be conducted in the community [12]. However, only few studies or projects have been identified to carry out this type of research and by far to our knowledge, none of them is purposely intended for Telemedicine.

This study is focused on exploring how MVC concepts can be applied in the analysis and design of an MVC platform that supports realization of the Telemedicine scenario. The salient concepts identified include purpose, roles, services and policies. Telemedicine can be considered the umbrella term for the purpose to be achieved and thus supported by the MVC. In this context the WHO's ICF model or taxonomy is used as a starting point to indentify the goals and tasks to be achieved and the reason about the requirements that must be fulfilled by a MVC for Telemedicine. Getting a clear picture of Telemedicine needs based on these concepts led to the identification of requirements that must be met by an MVC platform to be suitable for Telemedicine.

To demonstrate how the MVC platform can fulfill these requirements, a scenario in epilepsy monitoring is analyzed to identify specific requirements. Based on these requirements, a design for the creation of a MVC is proposed. In creating a MVC, it showed that a MVC platform should support role-based access in the MVC as well as assignment of policies as to the participation of a role relative to a certain service.

The conceptual model and design specifications are used to evaluate an existing community platform designed by [24] to identify platform enhancements that are required. The result of the evaluation showed that the existing community platform has limited support for role-based access and assignment of policies. Thus, platform enhancements are proposed. However, the enhancements cover the required changes relative to the scenario used in identifying the requirements. Future research can make use of the conceptual model and design elements in other scenarios to confirm the applicability of this study in a different setting.

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# 1. Introduction to the Study

In this thesis, we will look at how mobile virtual community (MVC) concepts can be applied in doing Telemedicine. Our goal is to identify the requirements that must be met by a MVC platform to be suitable for Telemedicine. These requirements will be used to assess an existing MVC platform in order to identify platform enhancements.

This chapter provides an introduction of the most relevant domains related to this study: Telemedicine (Section 1.1), mobility (Section 1.2), and mobile virtual communities (Section 1.3). The motivation for the study based on the intersection of these domains will be discussed (Section 1.4). Next, the research objectives, research questions, and study framework is presented (Section 1.5). This chapter concludes with the outline of the rest of the chapters (Section 1.6).

## 1.1. Telemedicine

Telemedicine in its basic form is the practice of delivering health care services from a distance [1]. Within this context, two important aspects can be recognized: distance is a constraint and the need to deliver health care services despite this constraint. Distance in this context is usually associated with a location barrier but in J. Reids definition of Telemedicine [2], it is stressed that aside from geographic (location) barrier, temporal, social and cultural barriers are also aspects that Telemedicine should cover when delivering health care services. Information and Communication Technologies (ICT) are explicitly mentioned as the mode of delivery considering the distance constraint. According to [3], Telemedicine should not be taken as a single technology but rather as part of a wider chain of care wherein it posts to improve this chain in order to provide quality health care efficiently. They further assert that with the accessibility of health services, especially in remote areas, there is an expected increase in fairness and equality of the distribution of services.

The WHO's definition of Telemedicine further extends these characteristics to include the purpose of such conduct. Their definition shows that Telemedicine goes beyond medical treatment and includes other aspects such as continuing education of healthcare providers and stressed that all these efforts are for the "interest of advancing the health of individuals and their communities." Recently, scholars [4,5] have added a new dimension on this definition to stress the availability aspect. They noted that Telemedicine "brings medical services directly to the point of need". According to [5], in this way, healthcare is brought to the patient rather than the other way around. As a result, it can empower the patient by having a direct control of his/her own health [5].

Recent advances in technology with the emergence of mobile health are redefining the definition of telemedicine to include mobility in the delivery of health care services [6]. For the purpose of this study, we define Telemedicine *as an area of healthcare that is closely associated with the use of advanced ICT to improve the health status of an individual or group of individuals anytime and anywhere wherein there is a close contact between the individual and the caregivers*. From this terminology, we highlight four (4) important aspects:

- Health status: maintaining and improving the health status is the main goal of Telemedicine
- Advanced ICT: this implies harnessing advances in different technology areas such as sensor, web, mobile, etc. in the delivery of health services
- Mobility: implies that delivery of health services is independent of time and location
- Patient focus: implies a focus on human-to-human support for the patient at a point of need

## 1.2. Mobility

One of the core characteristics brought about by mobile communication technologies is the mobility aspect. According to [7], mobility implies that "both source and destination devices, applications and people are free of the constraints imposed by physical location". In practice, most often this focus is on terminal mobility. Terminal mobility refers to the "ability of the network to route calls to the mobile terminal regardless of its point of attachment to the network [8]." This means that a user can use his/her mobile terminal (e.g. mobile phone) to move across different networks while still being reachable for incoming requests [9] as well as maintaining access to the same set of subscribed services [10]. Two major tasks while roaming across several networks include: location management and handover management. The former keeps track of the terminal while in standby mode for incoming call delivery while the latter "enables the network to maintain a user's connection as the mobile terminal continues to move and change its access point to the network" [8].

However, there are other forms of mobility as discussed below:

- *Personal Mobility*

Personal Mobility refers to the "user's ability to access mobility services from anywhere, at anytime, using any terminal [10]" (e.g. workstations, notebooks, Personal Digital Assistants (PDA), cellular phones). This is possible using a unique identifier of the user as well as his/her service profile [11]. The service profile makes it possible for the network to identify all the possible terminals associated with the user at any given time. Certain technologies (e.g. SIP, mobile agents) are known to handle this type of mobility. An example of this type of mobility is shown in Figure 1-1 below:

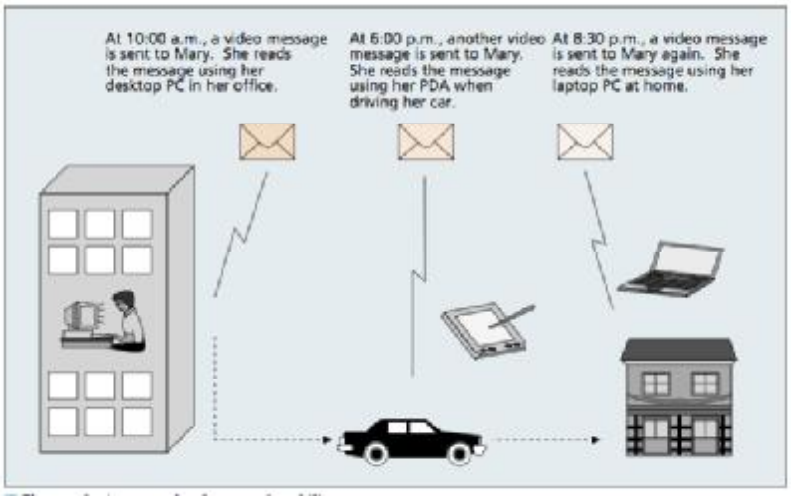



**Figure 1-1. An example of personal mobility [10]**

The figure shows that a certain message is sent to the mobile user (Mary) and she is able to receive the message correctly regardless of her location or the terminal she is using at any time of the day.

- *Service Mobility*

"Service mobility allows users to maintain access to their services even while moving or changing devices and network service providers." [9]. It can be said that this is achieved when a user can obtain subscribed and personalized services consistently. This type of mobility is also known as service portability.

- *Session Mobility*

Session mobility basically ensures that active sessions are not disrupted when changing terminals. An example is a call session that started from a mobile device and transferred on a desktop PC. "A user may also want to move parts of a session, e.g., if he has specialized devices for audio and video, such as a video projector, video wall or speakerphone."[9]

## 1.3. Mobile Virtual Community (MVC)

Mobile virtual community is a form of virtual community wherein the community members are always on the move [12]. MVCs are actually considered to be an outgrowth of virtual and online communities as a natural evolution [Fremaux, 2000 cited by 13] brought about by the proliferation of mobile devices and wireless technologies [12, 14]. Further definitions provided in [12, 14, 15] highlights the significant role of mobile devices in participating in the virtual/online community whereas [13, 16, 17] accentuate the role of mobile technology in setting up interaction spaces that serve ubiquitous needs. Nevertheless, all definitions revolved around the inclusion of mobile technology in virtual communities.

A simple definition deduced from these studies is that MVC is a fusion of virtual communities and mobile technologies. Based on this definition, it is important to take a closer look at these two aspects.

- Virtual Community (VC)

There exists vast amount of literature about VC's and yet there is still controversy on its definition [18]. This is associated with the differing perspective taken by researchers. In the context of this study, an inquiry of what constitutes an online community and what attributes can best characterize VCs are relevant. For clarity, online and virtual communities will be regarded to be similar but will be referred to base on the original term used by the referenced author.

A working definition of online community was proposed by [de Souza & Preece, 2004 cited by 18, 19, 20] wherein it consists of "people who come together for a particular purpose and who are guided by policies and supported by computer systems." This term is operationalised by these researchers in a way that it can aid in the analysis, design and evaluation of community software platforms and management practices [20]. From this definition of a virtual community, we can deduce 4 core elements of online communities: (a) interacting group of people, (b) a purpose, (c) policies governing the interaction, and (c) software supporting the interaction.

It can be said that the existence of online and virtual communities is driven by a purpose. This could be a need, a problem, a shared goal, interest, activity or a combination of these that draws the members to be part of the community [Whittaker, Isaacs, & O'Day, 1997 cited by 20]. This purpose could change over time, either because it is fulfilled or it naturally evolves [14]. Nevertheless, it is assumed that members jointly fulfill the objectives of the community. The purpose can be asserted as the starting point for virtual communities and as a result determines the initial specifications for the other core elements.

To illustrate, an example is the virtual community for cancer patients in Germany [16] created as a solution for meeting the patient's information and interaction needs. Based on this purpose, it is anticipated that the prospective members are those in the healthcare sector and that the policies to govern the interaction could impose rules that support development of trust and that the software should provide appropriate communication channels according to the anticipated members. Although there are different goals for establishing communities, it was noted in previous studies that a narrowly focused purpose contributes to the success of online communities [20].

For the adopted definition of VC, policies are concerned with governing the interactions of members and can be in the "form of tacit assumptions, rituals, protocols, rules, and laws" [20]. The notion of policies is lacking from many definitions of virtual communities [19] yet they are necessary to control the behaviour of individuals within the community. Policies are usually rules related to the purpose of the community, which could be imposed on the behaviour of roles such that they adapt to the objective of the community.

The last component is the computer system that support and mediate the social interaction. Recent studies [19] have extended this definition to acknowledge the rapid evolution of technology and thus used the term "advanced technologies" in lieu of computer systems. This is to acknowledge that virtual communities will no longer be bounded by computer systems but could be mediated by any form of technology, for instance, mobile technologies.

- Mobile Technology

Mobile technology is basically a technology that makes possible continuous access to information and other resources while moving. Moving in this sense does not only refer to changing from one physical location to another but also changing the point of access from one network to another. Devices that harness this technology are mostly mobile phones, smart phones, and laptop computers. Since the very nature of these mobile devices is that it is lightweight and can be carried around by a person, thus mobile technology is sometimes referred to as a portable technology. Mobile technology includes WIFI, Bluetooth and 3G.

## 1.4. Motivation of the Study

Recent developments in health care have seen the shift from facility based care to home based care and/or people-centered services [21]. This is partly due to the cost of in-patient care [6] or the insufficiency of hospital beds. In 2003, the Atlas of Health in Europe [22] shows that the number of hospital beds is decreasing while the admission of inpatients in hospitals is steadily increasing. The other reason is the demand for patient mobility, which implies that the patient continue to receive the same level of health services without restraining his/her daily life activities.

Mobile technological advances are the significant enabling factors for this move from institutional services to ambulatory and people-centered services. The 'emergence of mobile communications and network technologies for healthcare' [6] paved the way for the m-health domain, which depicts an evolution from using traditional desktop systems to wireless and mobile systems [6]. It is expected that m-health will re-shape the future delivery of existing healthcare services with the utilization of these advanced mobile technologies.

An area of healthcare that is closely associated with recent developments in ICT is Telemedicine. In the m-health domain, the original definition of Telemedicine, which is 'medicine practiced at a distance' [6] is now transformed to consider the mobility aspect in the delivery of healthcare services. Indeed, recent research [23, 21] in Telemedicine focused on mobility support for both patients and health professionals. A result of these researches showed technological viability of realizing mobility support, which are demonstrated through systems that makes possible remote patient monitoring [23] as well as provision for on-demand care by health professionals [21].

In Telemedicine, the patient is usually equipped with body sensors, which collects bio-signals and other patient and environmental signals and uses mobile and wireless technologies to send these signals remotely to a data center for analysis and monitoring. The result of the analysis and monitoring determines the level of patient support to be enforced. During the chain of events, the patients stay fully mobile and continue to do their daily activities. In the preceding scenario, other actors are involved aside from the patient. Formal caregivers such as medical specialists are involved as well as informal caregivers either to interpret the vital signs, to give feedback or to give some other form of assistance. These actors are also relatively mobile and are notified when there is a need to provide aid for the patient.

In essence, the telemedicine scenarios may be viewed as a virtual community (VC) and the systems that support the realization of the scenarios may be viewed as virtual community platform. The inclusion of the mobility aspect in the scenario and thus in the virtual community correspond to a mobile virtual community (MVC) and the system that supports the MVC is referred to as MVC platform. In MVC, community members who are mobile users behave differently than non-mobile users since they are always on the move and thus also affect the roles that can be conducted in the community [12]. In a recent study of applications of MVC, mobility support is identified as a field of research that can be utilized in the health domain.

However, only few studies or projects have been identified to carry out this type of research and by far to our knowledge, none of them is purposely intended for Telemedicine.

This study aims to explore how MVC concepts can be applied in the analysis and design of an MVC platform that supports realization of Telemedicine requirements anytime and anywhere. Getting a clear picture of Telemedicine needs based on MVC concepts leads to the identification of requirements that must be met by an MVC platform to be suitable for Telemedicine. Based on these requirements, a model for the creation of a MVC for the monitoring and treatment of patients will be proposed. The underlying motive is to use these results to assess an existing platform designed by [24] to identify platform enhancements that are required.

## 1.5. Purpose of the study

The purpose of this study is to create a conceptual model that ideally represents the Telemedicine requirements based on MVC concepts, which can be used as a reference model for the analysis and design of a MVC platform for monitoring and treatment of patients. These results will be used for evaluating an existing MVC platform (integration of MSP and Dolphin) in order to suggest improvements.

### 1.5.1. Research Objective

1. To investigate relevant concepts to characterize a MVC for Telemedicine.
2. To identify requirements that must be satisfied by a MVC platform to be suitable for Telemedicine.
3. To specify a design on how to create a MVC for monitoring and treatment of patients.
4. To evaluate an existing MVC Platform to identify platform enhancements that are required to support the MVC for monitoring and treatment of patients.

### 1.5.2. Research Questions

The main research question is: *How can MVC concepts be applied in the design of an MVC platform to be suitable for Telemedicine?*

The following questions are relevant to answer the main research question:

1. What are the criteria/properties by which a MVC for Telemedicine can be characterized? What are relevant concepts from which these criteria/properties can be derived?
2. What are the minimum requirements that must be met by an MVC platform to be suitable for Telemedicine?
3. How to create a MVC for monitoring and treatment of patients?
    a. What attributes should be present based on the MVC characterization?
    b. What are the steps involved?
    c. How can the MVC platform support the creation of a MVC?
4. What are the functionalities of the existing MVC platform (MSP + Dolphin)? What improvements can be made on this platform to be suitable for Telemedicine?

### 1.5.3. Study Framework

The research includes several steps that combine both theory and practical approaches. Figure 1-2 below is the study framework that will guide in carrying out this research.

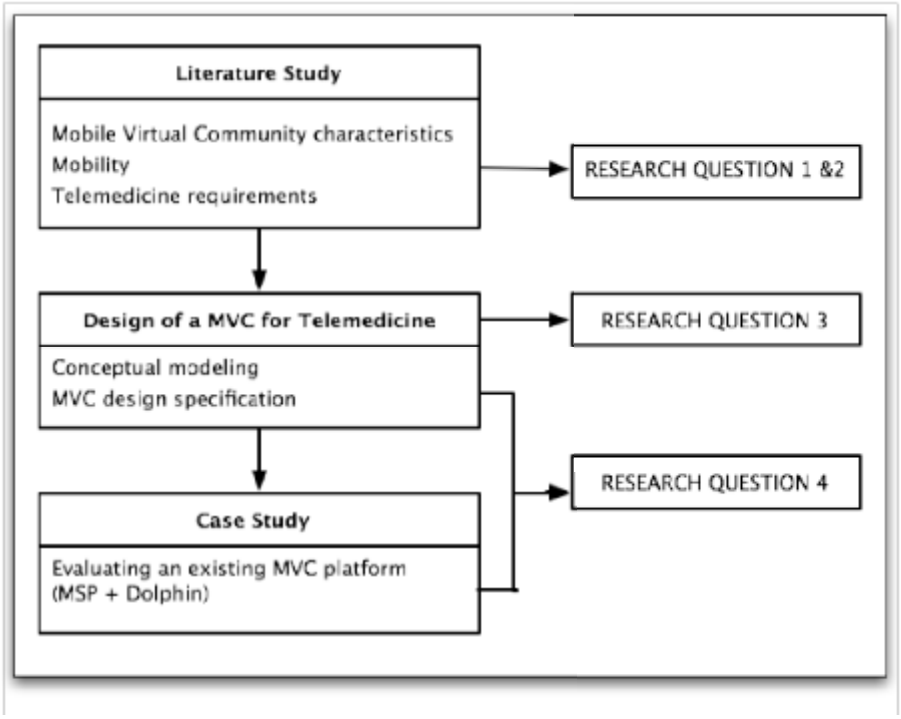



**Figure 1-2. Study Framework**

## 1.6. Thesis Structure

The remainder of this thesis is organized as follows:

*Chapter 2 – Background:* This chapter provides a background of the concepts and methods that are used in undertaking this study.

*Chapter 3 –MVC for Telemedicine Conceptual Model:* This chapter presents the design and development of a conceptual model of MVC for Telemedicine. Using the conceptual model, a scenario in the monitoring and treatment of patients is presented from which a set of requirements is derived.

*Chapter 4 – Design of a MVC platform for monitoring and treatment:* This chapter provides a specification on how the MVC platform supports the creation of a MVC for monitoring and treatment of patients.

*Chapter 5 – Case study: MSP + Dolphin:* This chapter discusses a case study of an existing MVC platform in order to validate whether it provides the necessary required functionalities.

*Chapter 6 – Conclusion and Recommendation:* This is the concluding chapter of the thesis, which provides a summary of the results of the research as well as a reflection on both the research process and the research outcome. Finally, suggestions for future work are provided.

# 2. Background

This chapter looks closely at the relevant domains in this study as introduced in the previous chapter. The Telemedicine domain (Section 2.1) discusses the basis for Telemedicine goals as well as the taxonomy in identifying efforts related to Telemedicine and finally providing related Telemedicine projects. Mobility concepts that can realize the different types or forms of mobility that is useful to support Telemedicine requirements are discussed next. (Section 2.2). Virtual community concepts help in identifying properties that can be used to characterize a certain virtual community (Section 2.3). Figure 2-1 below shows how these domains lead to the design of the MVC for Telemedicine, which is an intersection of the three domains

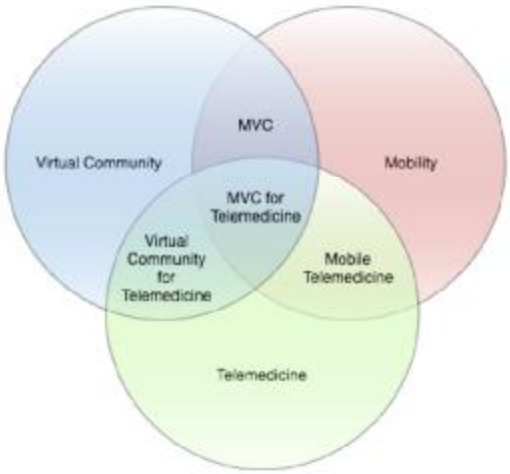



**Figure 2-1. MVC for Telemedicine building blocks**

## 2.1. Telemedicine domain

The ultimate goal of Telemedicine is to improve the well being of patients [25]. A patients' well being can be seen in the context of the International classification of functioning, disability and health (ICF) [26] model (Section 2.1.1). To fulfill the goal of improving the health status of patients, several Telemedicine efforts were undertaken but due to the broad coverage of the definition of Telemedicine, there is controversy of what is considered to be a Telemedicine effort. Tulu et al [27] proposed a Telemedicine taxonomy that provides a simple way of identifying such efforts (Section 2.1.2). Relevant recent Telemedicine efforts are given in Section 2.1.3

### 2.1.1. ICF

The ICF [26] is a revision of the International Classification of Impairments, Disabilities, and Handicaps (ICIDH), which was first published in 1980 for trial purposes. In the 1980 version, the ICF is a classification of the consequences of diseases, which focused on the impacts of diseases. The ICF has since evolved to become a component of health classification, which identifies the integral elements of health. The ICF takes a holistic view on health, which classifies health and health related domains from different perspectives: biological, individual and social. The ICF components of health are basically organized in two parts: Components of Functioning and Disability, and Components of Contextual Factors. The first component further consists of: Body component, which is divided into body systems and body structures, Activities, and Participation. The Contextual Factors are composed of Environmental Factors and Personal Factors. The relationships between these components are provided in Figure 2-2 below:

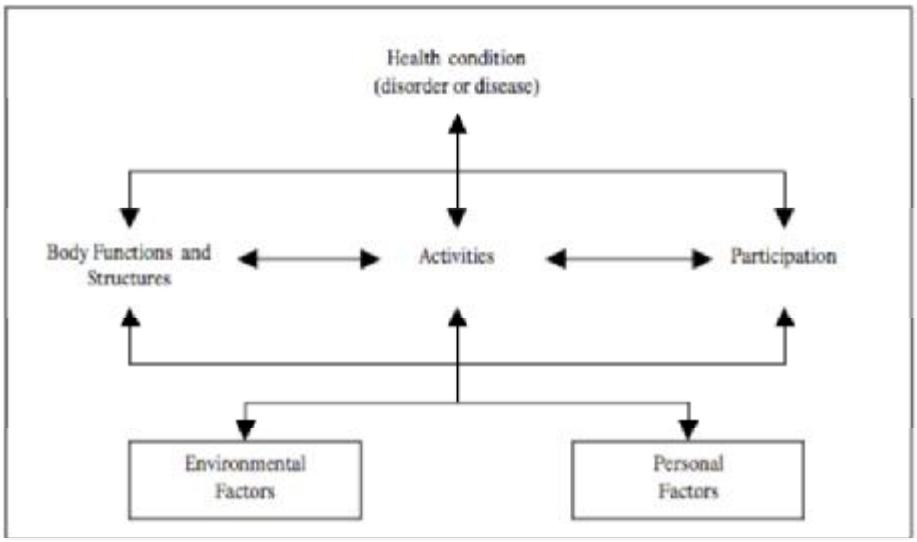



**Figure 2-2. Interactions between the components of ICF [26]**

According to this model, an individuals' health condition is determined by the state of his/her body functions & structures, and activities and participation in a life situation. This health condition is affected positively or negatively by the environmental and/or personal factors.

The ICF Model components are [26]:

1) Body function refers to the physiological functions of body systems (including psychological functions). An example is category b210, which refers to "seeing function".

   Body structures refer to anatomical parts of the body such as organs, limbs and their components. An example is category s220, which refers to "structure of eyeball"

   Body function and body structure classifications are designed to be used in parallel; a combination of both is referred to as Body Systems

2) Activity refers to the execution of a task or action by an individual in a standard environment. An example is category d410, which refers to "changing basic body position"

3) Participation refers to involvement in a life situation or execution of a task or action by an individual in the current environment. An example is category d8450, which refers to "seeking employment"

4) Environmental factors make up the physical, social and attitudinal environment in which people live and conduct their lives.

Recent studies [28, 29] show that health professionals are working on making a consensus to identify ICF Core Sets based on a certain disease. The ICF Core Sets refers to a short list of ICF components that serve as health status measures in identifying the condition of an individual in relation to a certain disease or a clinical practice. In knowing which specific components affects a certain disease, it is easier to identify which health services/treatment to be given to the patient. A study of [28], for instance showed that chronic pain, which is considered a disease, can be assessed based on Brief ICF core sets, which includes 24 ICF categories: 10 on Body Functions, 10 on Activities and Participation and 6 on environmental functions.

### 2.1.2. Telemedicine Taxonomy

The Telemedicine taxonomy proposed by [27] identified and proposed 5 dimensions, which can be used to categorize different Telemedicine efforts. These dimensions are: (1) application purpose, (2) application area, (3) environmental setting, (4) communication infrastructure, and (5) delivery option. The first two are grouped into medical dimension while the last three are part of the delivery dimension. They also included a third dimension – Organizational dimension – which takes care of HR resources, IT management, cost and legal aspects. An overview of this taxonomy is shown in Figure 2-3 below, with some examples:

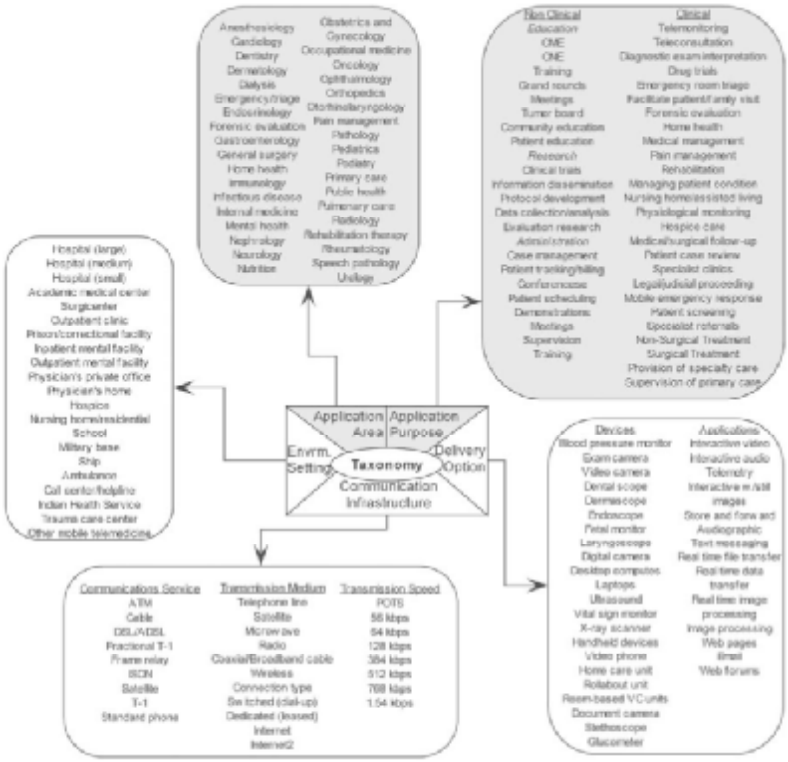



**Figure 2-3. Telemedicine taxonomy and examples [25]**

Application purpose refers to the purpose of the Telemedicine effort while the application area is the domain in the medical field. Environment setting refers to the physical environment that the patient or the physician will be using; communication infrastructure refers to the technologies for communication exchange; delivery option refers to the means or options for conducting Telemedicine. Based on their literature study, they found that all dimensions have an effect on the outcome of Telemedicine efforts but suggests that application purpose and domain requirements should be carefully taken into considerations when deciding on the delivery option [27]. They made another study [25] to check the relationship between the medical and delivery dimension; in particular, whether delivery option and communication infrastructure dimensions are dependent on the application area and application purpose dimensions. Their findings showed that there is direct and indirect effect of application areas and purposes on the use of the store-and-forward delivery option and that this technology is useful in application areas where the high quality of image is essential. On the other hand, no significant relationship was found between communication infrastructure and application area and purpose.

### 2.1.3. Related Telemedicine Projects

Based on the above taxonomy, we are interested in telemedicine efforts under the clinical aspect of the application purpose dimension. Although Telemedicine covers a multitude of clinical application purposes, we will focus on remote patient monitoring and treatment since it is characterized by a higher degree of mobility. Some of the notable studies include:

- *MobiHealth*

The MobiHealth project [30] started in early 2002 and is funded by the European Commission. The project aimed at bringing together technologies of Body Area Network (BAN), wireless broadband communications and wearable medical devices to enable delivery of mobile healthcare services for patients and health professionals. The vision is to enhance patients' freedom to move anywhere while continuously being monitored and treated, thus improving their quality of life [31].

During the course of the project, a generic BAN for healthcare and a generic m-health service platform was developed, trialed and evaluated [31]. The MobiHealth BAN consists of sensors, actuators, communication and processing facilities connected via a wireless network. The BAN is worn on the body, which allows constant monitoring of patients' vital signals, e.g. blood pressure, heart rate and electrocardiogram (ECG). The m-health service platform, in turn, manages deployed BANs and its external communication to a remote healthcare location. The functional architecture of this platform is shown in Figure 2-4 below:

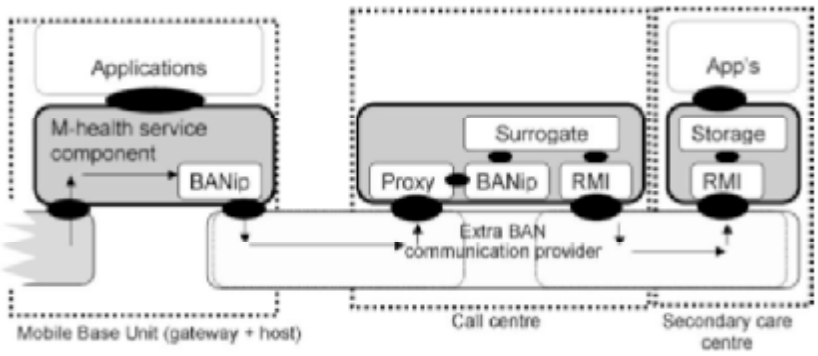



**Figure 2-4. Mobihealth mobile service platform functional architecture [31]**

- *HealthService24 (HS24)*

The HealthService24 project [32] aimed at launching an innovative mobile health care service supporting patients' and health professionals' mobility, increasing patients' quality of life and lowering health care costs. The HS24 concept allows patients and non- patients to monitor their physical condition and obtain advice and information at any place and moment. In this way, the service enables patients to be fully mobile.

To realize this aim, a user wears a BAN, which basically includes sensors and actuators that are interconnected and managed by a PDA or a mobile telephone and thus moving around with the person. This way, patients can stay mobile but monitored continuously and receive advice when needed. The sensor collects data and constantly transmits them wirelessly via UMTS or GPRS to a data centre that acts as an intermediary between patients/users and health care providers. The data centre provides three services: data repository (collecting and storage of the received data), streaming service (forwarding data to a doctor or medical centre) and alarming service (analysis of the received data and sending of a warning (event) signal to a predefined destination (using SMS or other means)). The data centre may also provide technical support and, if needed, act as the first-level medical support for the HS24 users.

The data is then forwarded to responsible healthcare professionals, who can remotely assess, diagnose and treat patients while the patient continues with his daily life activity and patients stay mobile. Vital signs that can be measured using the HS24 service include ECG, EMG, Plethysmogram, SpO2, pulse rate, respiration, and skin temperature. For cases wherein the patient is in critical condition, the data centre sends an SMS-alarm or provide the patient with a first level medical support. Figure 2-5 below provides a high-level simplified diagram of the information flow.

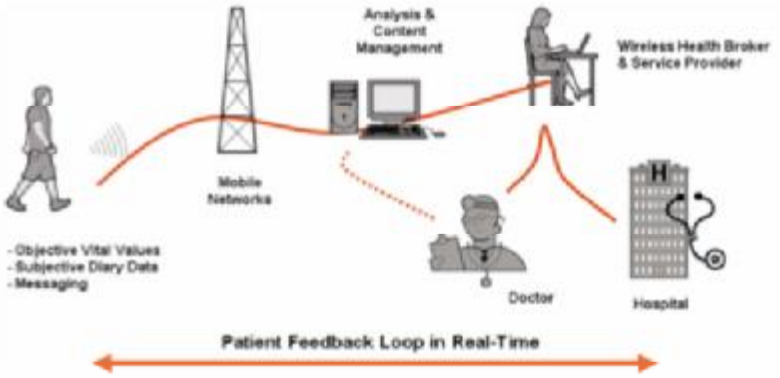



**Figure 2-5. Overview of the HealthService24 Mobile Monitoring System [32]**

- *Awareness*

In the AWARENESS [33] project vision, a human user is always and everywhere surrounded by a networking environment ('ubiquitous') that is able to determine the identity of the user and the (upcoming) context information that is (or might become) relevant to service provisioning ('attentiveness'), such that the user can have anywhere, anytime access to mobile services in a secure and privacy-sensitive manner.

- *DITIS*

DITIS [21] (ΔΙΤΗΣ in Greek, stands for: Network for Medical Collaboration) is a system that emerged as a solution to the difficulties of communication and coordination of the health care team in providing home care treatment of chronic patients. DITIS aimed to overcome these difficulties by supporting dynamic creation, management and coordination of virtual collaborative medical teams wherein the healthcare team does not need to be physically present together while providing treatment to patients.

Through DITIS, a virtual medical team composed of visiting home-care nurses, doctors and other health professionals is made available for the patient to provide a personalized and dedicated service on a timely manner. Having a virtual team of professionals made it possible to make better planning and management of patient treatment who are home-based since access to patient information is available to the virtual team based on their authorization level [21].

To make this possible, DITIS employs integration of various technologies such as Internet, Mobile Agents and GPRS connectivity.

## 2.2. Mobility

Realization of the different forms of mobility, such as terminal, personal, service, and session mobility is a technical issue. Although we will not discuss all the different approaches on how to make this happen, we will show that this is possible. We refer to a study by [9] wherein the use of Session Initiation Protocol (SIP) shows that mobility can be achieved independent of the underlying technology used by the different wireless networks.

SIP "allows two or more participants to establish a session consisting of multiple media streams" [9] such as audio, video, or other Internet-based communication mechanisms. SIP is an application-layer protocol, which means that it can be downloaded and installed in the different devices to be used, such as mobile or non-mobile host and the SIP server. For implementation details, we refer to [34].

## 2.3. Mobile Virtual Communities (MVC's)

### 2.3.1. Virtual Community Attributes

Attributes suggested by the literature [17, 19] to characterize virtual communities are the 5P: (1) purpose, (2) place, (3) platform, (4) population and (5) profit. According to [18], although there are different types of virtual communities, these attributes could still be used to describe the characteristics of virtual communities regardless of its type.

- *Purpose*

This attribute refers to the interest shared by members; it is the subject that becomes the basis of interaction in the virtual community, for instance, patient support, and golfing.

- *Place*

This attribute refers to the structural property of the virtual community where the interaction happens; whether the community members interact in a physical location or mediated by technology in order to interact whilst in different geographic location. Other scholars however suggest that interaction in virtual communities does not happen in purely virtual or physical location [Bernard, 1973; Rothaermel & Sugiyama, 2001 cited by 19]. They suggest that members interact using different modes of communication, which also includes face-to-face, and thus assert that virtual and physical communities can coexist. To settle this difference of opinion, this attribute could also be extended to refer to the degree of virtualization [Virnoche and Marx (1997) cited by 19] wherein this attribute can be either virtual or hybrid. The former refers to a meeting place that happens in virtual space and never in physical space while the latter exists in both virtual and physical space. In conclusion, this attribute could either be physical, virtual or hybrid.

- *Platform*

This attribute refers to the technical design of the system in supporting interaction in the virtual community. Interaction could be synchronous or asynchronous. Synchronous interaction requires members to be concurrently present during interaction while in asynchronous interaction, members communicate in a deferred way. A system that provides chat technology is considered to have a technical design for synchronous interaction while message boards technology is a technical design for asynchronous interaction. [18] provides detailed description of various types of technical designs. Based on the technologies present in the system, the platform attribute refers to either synchronous, asynchronous or hybrid (have both synchronous and asynchronous) design of the system. Studies [18] have shown that asynchronous technical design is most often used.

- *Population*

While platform identifies the technical design for interaction to happen, this attribute is used to determine the pattern of interaction among community members. Group structure and the type of social ties in each group structure are used as basis in identifying the pattern of interaction among community members [19]. Group structures exist in three levels: small group, network and public and in each group structure, the social ties could either be strong, weak or stressful. In small groups, strong ties are dominant since the members are normally fixed and limited. In the network structure, weak ties are prominent since the number of members is large and thus, member interaction is distributed and sometimes uneven. In public groups, membership is open to any individual with different motivations for joining and thus the social ties could be strong, weak or stressful. This is also because membership is often temporary and unstable with no expected commitment or loyalty from the members [19].

- *Profit model*

This attribute refers to whether the community is revenue generating or non-revenue generating. Three types of business models could characterize revenue-generating VC: Host, Facilitator or Owner [Krishnamurthy 2003 cited in 19]. In the Host business model, the VC enabler hosts various types of communities and revenue comes from advertisements or subscription fees. In the Facilitator business model, the VC enabler facilitates the exchange of services between and among members and thus revenue comes from transactions fees. In the Owner business model, the VC enabler and owner of the VC is the same firm and the revenue comes from all transaction that generates revenue through the use of the VC.

### 2.3.2. Mobile Community Attributes

According to [13], mobile communities differ in three aspects compared to traditional virtual communities:

(1) Mobile communities can be accessed via mobile devices, which could lead to a more spontaneous communication. Unlike traditional virtual communities wherein communication between community members is limited to the services offered by the virtual community itself, mobile communities can make use of mobile services such as short messaging service (SMS) or voice call to communicate with community members.

(2) Enhanced communication services can be made possible. With mobile technology, users can be connected to the community anytime and anyplace. They further postulate that the enhanced mobile services are characterized by:

- *Ubiquitous access*

Ubiquitous access refers to access at any time and at any place. Mobile devices allow people to readily connect to the community and make use of the mobile communication services. Thus, they benefit from real-time information and communication services (e.g SMS-Alerts).

- *Instant execution:*

With the proliferation of mobile networks such as 2.5G and 3G, it is possible to keep community members constantly connected anytime and anyplace and regardless of attachment to different kinds of wireless networks. As a result, communication between community members will be more spontaneous.

- *Personal trusted devices:*

Mobile services are accessed using personal mobile devices and these devices make use of security mechanisms such as phone numbers, SIM cards or PIN in order to clearly identify the mobile user. Thus, mobile services and mobile devices promote secure communication between community members, especially closed or private communities.

- *Location related services:*

Mobile networks make it possible to track every mobile device and therefore every user of mobile community services through the use of different positioning methods and systems. These positioning technologies make it possible to find and locate other community-members in their vicinity, thus allowing the offering of personalized services based on their location.

(3) Usage patterns will be different since mobile communities will be established around single users rather than around specific topics or interests. Results on a study by [13] shows that mobile telephony is used to communicate to close friends or relatives or people who are already known by the person who wants to communicate. They suggested that mobile communities revolve around a single mobile telephony user and thus the community will remain small since only the people known by the user is communicated with.

Mobile services are introduced in the mobile community as a means to enhance communication and facilitate activities [13]. Based on the services provided by the mobile communities, [12] suggests that MVC's can be classified using three criteria:

- *Degree of openness (private/public):*

This criterion refers to the communication between participants, which could either be exclusive to members of a certain community only (private) or open to non-members as well (public).

- *Degree of contextual information present (contextual/non-contextual):*

Context information is any information that can be used to characterize the situation of an entity or a community member. This criterion refers to whether the information present in the MVC is contextual or non-contextual.

- *Degree of interaction they permit (synchronous/asynchronous):*

This criterion refers to the design of interaction as to whether the interaction is synchronous or asynchronous. "In a synchronous interaction, the members are required to be simultaneously present when interacting. In an asynchronous interaction, the communication of members occurs in a deferred way." [12]

### 2.3.3. MVC implementation approach

The system that realizes a MVC scenario is called a MVC platform. Some of the different approaches of platform support for the MVC are:

a) Diffusion model

The study of Fremuth et. al [13] provides a diffusion model of mobile communities. The model states that mobile communities emerge from existing group of friends or peers in local vicinity and who like to communicate to each other. This mobile community makes use of various mobile community services, which leads to new types of communication spaces. Finally, established VC platforms will be enriched by these mobile community services to "mobilize" existing web-based communities. These levels are shown below:

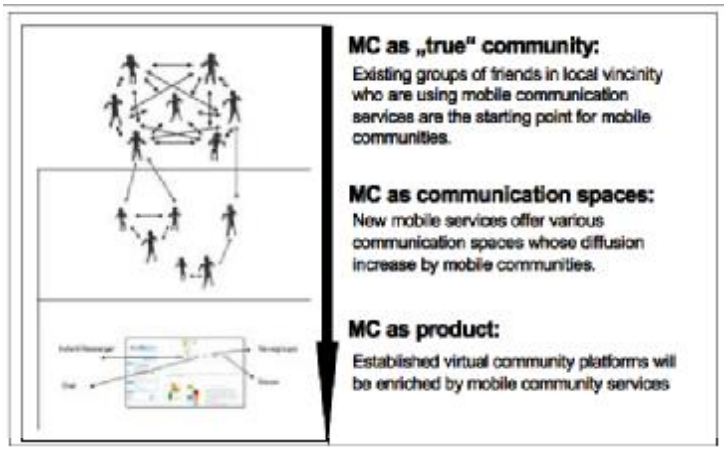



**Figure 2-6. Diffusion model of mobile communities [13]**

b) Collaboration model

In contrast to Fremuth et. al's diffusion model [13], the study of Kawash et. al. [14] state that "incorporating mobility into online communities requires more than "mobilizing" existing non-mobile communities" [14, p445]. It requires a new philosophy for the inherent nature of mobility and thus requires models and applications built from group

up intentionally for mobile applications. The authors then provide a collaboration model that forms part of this philosophy wherein they make use of the concept of spots to mark places of concern to the community (action spots) wherein community members (member spot) can be notified according to their relative position to the action spot.

In the implementation of the collaboration model, it considers the need to have an initial meeting place where members can do registration and subscription; unless users are registered, they cannot assume roles and participate in the community. For registering and subscribing to a MVC, the collaboration model introduces the use of a template service. A template service is like an empty community or a generic service with no attributes. The members fill in this template based on a particular service they offer.

With regards to member roles, although their model is based on a producer-consumer role, the producer role is at a higher rank than the consumer role. This implies that a producer is also a consumer but not vice versa. This ranking is meant to encourage active participation of members with a consumer role.

c) Context-awareness model

A recent study [24] shows that it is possible to have both producer and consumer role at any time while hiding the inverted nature of this role from the network communication. In this study, a business model is proposed that considers situations where the mobile device also acts as a content and service producer. This study further provides a high-level design of a technical platform that makes use of the context information of the community members in the delivery of community services.

## 2.4. Scenario Analysis and Modeling

Scenario analysis is the "process of understanding, analyzing, and describing system behavior in terms of particular ways the system is expected to be used."[35] Since scenarios normally represent possible ways to use a system in order to achieve certain functionality, scenario analysis is often used in identifying system requirements. Drawing use cases from the scenarios and relating requirements to the use cases allows traceability in the design process. This means that validation tests of the design decisions can be drawn from the use cases since they represent the scenario that is supposed to be supported by the system.

In systems design, models are normally used to capture the requirements that the system to be developed should fulfill. A stage that precedes systems design is requirements engineering. Requirements engineering (RE) is the "branch of software engineering concerned with the real-world goals for, functions of, and constraints on software systems. It is also concerned with the relationship of these factors to precise specifications of software behavior, and to their evolution over time and across software families." (Zave (1997) cited by [36]) In this stage, the model is used to represent a common understanding of the domain as well as the specifications of the functional requirements of the system to be developed. The models in this view are known as conceptual models. This study deals with this type of model.

In essence, "a model is a simplification of reality" [37], representing the semantics or the meaning of what is modeled. Thus, visual presentation is also a major aspect wherein different presentations depend on the appropriate level of detail needed to show the semantics. Since models are normally used for stakeholders to understand a system under development, the model is usually built with diagrams having descriptions using a natural language.

In Information Systems (IS), a conceptual model is a commitment in viewing a certain domain in a particular way with the assumption that a domain consists of objects, relationships and concepts [37]. The main purpose of conceptual modeling is to elicit the conceptual schema of the corresponding IS to be developed. The conceptual schema of the IS is the representation of the general knowledge of the domain and the functions it has to perform.

The UML [38] will be used as a modeling tool for visual representation of the semantics of what is modeled. UML diagrams can be used to capture different levels of modeling from requirements to systems design.

## 2.5. Database Reverse Engineering

In systems development, reverse engineering is an approach of "going backwards through the development cycle" [39] wherein the output of the implementation is reversed back to the analysis part. DataBase Reverse Engineering (DBRE) is the process of analyzing the complexity of a system by reverse engineering the database [40]. Motivations for DBRE mentioned in [40] include eliciting requirements and enhancing the functional goals of a system. Analysis of existing systems through its database can provide useful information during the requirements phase of systems development [40]. The results of the analysis help in identifying system extensions.

Figure 2-7 shows a general architecture of the DBRE methodology provided by [40].

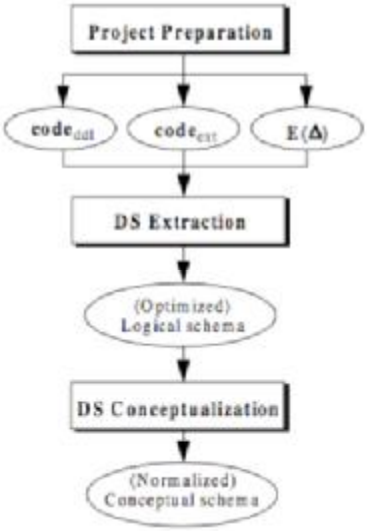



**Figure 2-7. DBRE methodology architecture [40]**

The DBRE phases include:

A. The preliminary step is the Project preparation, which aims at identifying the resources needed for the rest of the phases. This phase deals with project management and is not be necessary to discuss in detail for this project because only a fraction of the database will be analyzed.

B. The data structure extraction phase aims at creating a logical schema. The source inputs for this phase comes from:

   a. Data Definition Language (DDL) statements to identify explicit structures such as tables, columns, views and constraints such as primary key, foreign key, unique key, indexes and check constraints.

   b. Program code analysis, forms/screens analysis, program execution, and documentation to identify implicit structures.

   The logical schema resulting from this phase needs to be optimized by disregard technical details that are no longer necessary, like indexes.

C) The data structure conceptualization phase aims at extracting the relevant semantic concepts underlying the logical schema and normalizing it to show proper relationships, hierarchies, etc.

## 2.6. Summary

The goal for doing Telemedicine is to improve a patient's health status and the ICF provides a starting point to assess a patient's health condition. Due to a number of categories in the ICF, health professionals are working on a consensus to identify the ICF Core Sets, which provides a short list of ICF components that will serve as health status measures in identifying the condition of an individual in relation to a certain disease or a clinical practice.

Current developments in healthcare show a shift from institutional services to ambulatory and community-based services [21]. This implies participation of multiple actors, which could be part of different institutions or communities, in providing care to the patient. With this scenario, mobility support is necessary. Related studies provided in Section 2.1.3 shows that realization of this scenario could be achieved anytime and anywhere. However, these studies [30, 32] showed support for terminal and personal mobility. SIP as proposed by [9] allows realization of other forms of mobility, such as session and service mobility.

However, in the design of these existing systems [30, 32, 33], it is difficult to evaluate the effectiveness of the systems in supporting community participation. In essence, this scenario can be viewed as a mobile virtual community (MVC) and similar scenarios can be realized using a MVC platform. Since MVC is an emerging field of research [12], its application is limited to few domains such as leisure, tourism and gaming. Since the requirements of Telemedicine are very different from these domains, there is a need to identify the characteristics of a MVC for Telemedicine.

Due to the broad coverage of the definition of Telemedicine, there is controversy of what is considered to be a Telemedicine effort. Thus, [27] presents a taxonomy to identify such efforts. This taxonomy provided a medical dimension consisting of application area and application purpose wherein the former refers to the medical domain while the latter refers to the purpose of the effort. From this taxonomy, we limit the focus of this study on remote patient monitoring and treatment since it is characterized by a higher degree of mobility.

Conceptual modeling is used to characterize a MVC for Telemedicine. The purpose of the characterization is to first get a clear picture of the properties that a MVC has in order to identify it as a Telemedicine effort. UML diagrams will be used as a complement for the representation of the conceptual model as well as in the eventual design of the MVC platform. A scenario analysis approach is used to elicit requirements specific for the creation of a MVC for monitoring and treatment of patients.

In order to reuse existing resources available, the results of the scenario analysis and platform design will be used to assess an existing platform proposed by [24], which is an integration of MSP and Dolphin community platform. However, since no comprehensive documentation about Dolphin is available, we use DBRE approach [40] to uncover the semantics from the design of the Dolphin platform in order to have it at an abstraction that can be evaluated.

# 3. MVC for Telemedicine Conceptual Model

This chapter aims at specifying the conceptual model that ideally represents the Telemedicine requirements based on MVC concepts. Based on the literature discussed in chapter 2, a list of criteria is identified to make the characterization (Section 3.1). The characterization, which provides a representation of a MVC for Telemedicine, is used to define a scenario that can be used to identify the requirements to be supported by the MVC platform (Section 3.2). From the analysis of the scenario, required functionalities of the MVC Platform are specified (Section 3.3).

## 3.1. Characterizing MVC for Telemedicine

To make the characterization, a conceptual model is initially presented to show a high level visualization as a result of the characterization made (Section 3.1.1). The process of arriving at this model is explained next wherein the selected criterion is first defined then motivation for its inclusion in the criteria is discussed (Section 3.1.2). Based on the literature, a description on how to specify each criterion is provided (Section 3.1.3).

### 3.1.1. Conceptual Model

Figure 3-1 displays a conceptual model of the MVC for Telemedicine, which shows the entities and their relationships. In the model, the MVC refers to the sub-community. In essence, the MVC is realized using an MVC platform and from the perspective of the MVC platform, *Community* refers to the aggregation of all *Sub-communities*. The next sub-section makes a detailed explanation of the model as well as discussion of concerns that is not captured by the conceptual model.

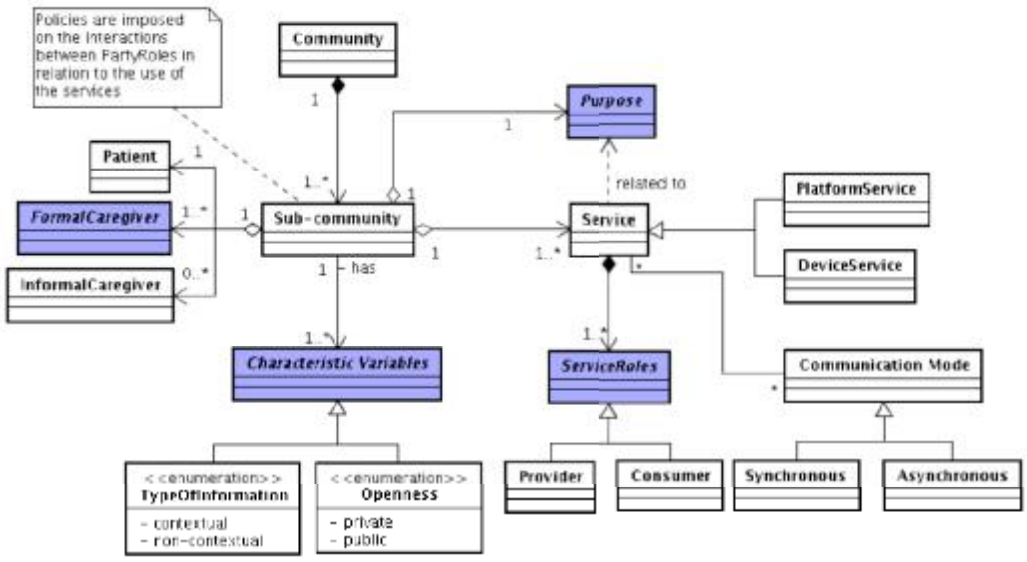



**Figure 3-1. MVC for Telemedicine conceptual model**

### 3.1.2. Characterization

For discussion of the characterization, the terminology *community* refers to the sub-community in the conceptual model.

- *Purpose*

This criterion refers to the reason behind the existence of the community or the shared goal of the community. In principle, the main purpose of the MVC is to do Telemedicine. However, since MVC for Telemedicine is to support a Telemedicine conduct then it is considered a Telemedicine effort, thus the purpose for its conduct can be specialized in the context of the

taxonomy of Tulu et. al [27]. Nevertheless, the main aim is to improve the health status of the patient. In this context, this criterion also aims to identify which health condition to be supported by the community. The ICF model [26] guides the specification of the purpose by providing a classification of health components to be supported by the MVC. Figure 3-2 below shows how the Telemedicine goal is specified.

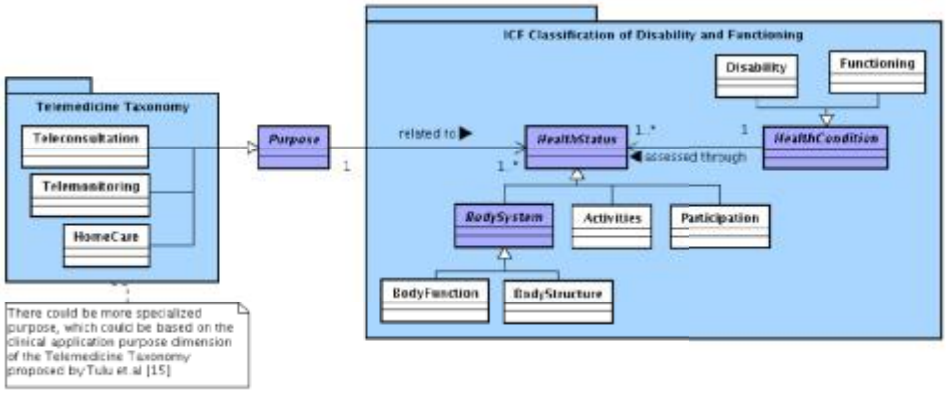



**Figure 3-2. Goal of Telemedicine based on ICF [26] and Telemedicine Taxonomy [25]**

Goals related to Body Functions/Structures are characterized by the need to reduce impairments or problems in Body Functions/Structures. Goals related to Activity are those that allow an individual to overcome difficulties in executing activities. This may include using assistive devices. Goals related to Participation are those that enhance the individuals' experience in involvement in life situations. Problems related to participation may not always be related to impairments but can result from the social environment.

The purpose criterion serves as a starting point for determining how the other criterion can be specified.

- *Roles*

This criterion refers to a role played by a party. A party represents a person, an organization or an organization unit. The role defines a set of behavior of a party playing the role. Unlike in traditional VC where members directly interact with the community services, the notion of roles is that a party takes on a role wherein permissions on the use of the community services are associated with the roles.

From previous Telemedicine projects [30, 32, 33], we can draw the roles. These roles and their responsibilities are:

a. Patient – a person whose health status is being monitored and analyzed in order to maintain or improve his health status.

b. Caregiver – a person who provides care to a patient. A caregiver could be either formal (paid professional caregiver) or informal (provide voluntary aid). An informal caregiver can be a patients' family member, friend, or neighbor, or could also be a volunteer. These informal caregivers can be warned in case of an emergency regarding the patient and can be summoned to attend to the patient.

   A formal caregiver could either be a medical practitioner or an allied health professional. The former refers to qualified practitioners of medicine concerned with maintaining or enhancing a patients' health status. They could either be general practitioners or medical specialists. A medical specialist is highly trained in a specific branch of medicine while a general practitioner is trained to provide primary health care to patients. Thus, a medical specialist is authorized to analyze a patient's health status. Allied health professionals,

such as nurses and paramedics, are people who are trained to do medical work in assistance to the medical practitioners.

c. Healthcare center – an organization that provides healthcare services. Such a center could be, for instance, a hospital.

A model of the role hierarchy as well as the role relationships is shown in Figure 3-3 below:

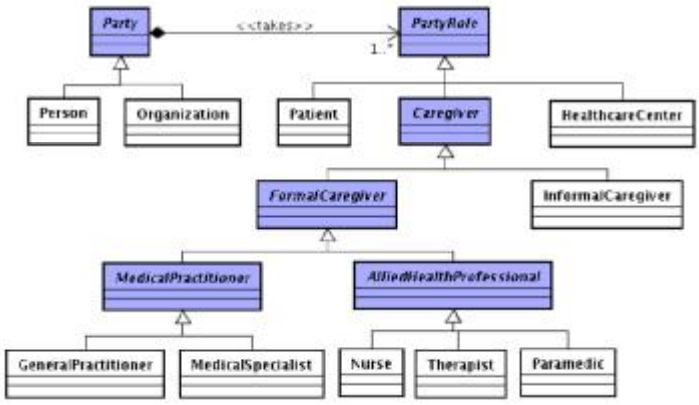



**Figure 3-3. Party-Role relationship in MVC for Telemedicine**

- *Services*

A service refers to a "unit of work which can be done by a service provider to achieve desired end results, for a service consumer" [41]. This criterion then identifies which type of services should be present in the MVC. This criterion is used to make a distinction between traditional VCs and MVCs. In traditional VCs, services would refer to web-based (interaction) services. However, the impact of mobile technologies makes available different mobile services, which are basically produced/consumed using mobile devices. Due to this fact, [24] identified two groups of services: mobile device services and platform service. Device services are those running in the mobile device and platform services are those that are running in the VC platform.

This criterion is also used to identify which services are required by the MVC. The services that will be utilized by the community are related to the purpose of the MVC. Based on typical scenarios [23, 33], the set of services that could be present are:

a. Vital sign delivery service – service that allows the acquisition and sending of bio-signals. This service should support both store and forward and real-time method of delivery. In store and forward method, vital signs (or bio-signals) are acquired and stored locally and later forwarded to medical specialists. In real-time method, vital signs are transmitted at the same time as it is being acquired. This service is necessary in order to monitor the health status of the patient.

b. Location service – service that allows the identification of an individuals' location. Knowing the locations of the party involved could aid in deciding who will be involved in effectuating the treatment.

c. Availability service – service that allows the identification of an individuals' availability. For instance, unless an informal caregiver is available, an informal caregivers' location may not be enough in making a sound decision on whom to send to the patient.

d. Viewing service – service that allows the medical specialist to view and/or monitor and analyze patients' bio-signals

e. Interaction services – service that supports synchronous and asynchronous mode of communication. Video conferencing is a typical synchronous method used in

monitoring and analysis of a patients' condition during emergencies. Short message service (SMS) is a known protocol used for notifications purposes.

f. Matchmaking service – service that allows the selection of the appropriate results based on some criteria/parameters; for instance, selecting the nearest caregiver to attend to a patient during an emergency based on both patient and caregiver locations.

g. Alarm service – a service that allows the detection of an emergency situation

h. Activity service – a service that allows detection of an individuals' activity by, for instance, motion sensing and processing.

i. Other context-aware services – service that allows the identification of other relevant patient and environment signals, like, the weather.

The individual services do not exist in isolation of the other services; usually a combination of results from other services may be needed in order to deliver the appropriate service. For instance, in making a match, the location service and availability service is necessary to make a match while the SMS is used for notifying the appropriate party to attend to the patient.

In using services, we can draw a new type of role, which we will refer to as service roles, which could either be producer or consumer. The producer role allows a party to produce and publish information in the MVC while a consumer role allows a party to consume the published information. A party could take a role of both consumer and producer in using MVC services.

- *Policy*

This criterion refers to the rules or constraints imposed on either the composition of roles in the MVC or in the interaction with the services. In terms of composition, policy rules could be used to define cardinality constraints or separation of duties (SoD) constraints. Cardinality constraint refers to the minimum and maximum number roles that a party can take up in the MVC. SoD constraint refers to the assignment of conflicting roles to a single party. In terms of interactions between a role and a service, rules could be related to permission constraints and prohibition constraints. Permission constraints refer to the prescription that a certain interaction is allowed to occur. Prohibition constraint is more of the opposite of a permission wherein the interaction must not occur at all.

Specifying policies will be based on analysis of scenarios since the policy will depend on the purpose of the MVC as well as the roles and services that are present in the MVC. However, based on previous studies [23, 32, 33] and our definition of Telemedicine, we can already specify some known policies:

- There should be at least one patient role. Since the main aim of Telemedicine is to improve the health status of a patient then it follows that the MVC activities or interaction revolve around the patient, thus a patient role is required.
- There should be at least one caregiver role. To complete one loop of Telemedicine, a caregiver role is required to provide care for the patient.
- There should be a producer and consumer role. Due to the mobility aspect introduced through the use of mobile services, a patient should be able to produce at least vital sign information in order to be monitored while moving. For the vital sign information to be analyzed, a caregiver should be able to at least play the role of a consumer.
- These services should at least be present: vital sign delivery service, viewing service and interaction service.

These constraints imply that an MVC must have at least all these elements to satisfy a certain purpose related to Telemedicine, regardless whether it is related to either of the ICF components.

The patient and caregiver role are necessary since there should be one role (patient) in need and another role (caregiver) that satisfies the need. The services are the means for the need to be satisfied and relative to these services, these acts as a producer or consumer role. For instance, there is a need to monitor a heart rate; the patient is the one in need of the monitoring and the caregiver does the monitoring. Using the vital sign delivery service, the patient acts as a producer of the heart rate while the caregiver is the consumer.

- *Degree of Openness*

This criterion refers to whether the communication within the MVC is private or public. This criterion is related to the purpose of the MVC since a certain level of privacy may be necessary based on the purpose. Looking at the ICF classifications [26], we can specify that communications in MVCs with goals related to Body functions/structures are exclusive to the parties involved whereas MVC's with goals related to Activities and Participation could either have communications exclusive to members (private) or open to other non-members (public).

- *Degree of Contextual Information Present*

This criterion is related to the services used in the MVC. This is to indicate that if the service is context-aware then information present in the MVC is contextual. With context-awareness, we mean the ability of the service to identify the context of the party; context here refers to any information that can identify the situation where a party is. Context information may include where the party is and the other parties or resources that are nearby.

- *Degree of interaction permitted*

This criterion is again related to the services used in the MVC. This is to indicate that a MVC could allow synchronous or asynchronous mode of interaction depending on the interaction mode that is allowed by the service.

## 3.2. Scenario Analysis

The characterization provides the boundaries from which a MVC for Telemedicine could be identified. To demonstrate the use of this model, a scenario analysis is made to identify specific requirements to be supported by the MVC platform relative to the monitoring and treatment of patients. The scenario is based on a Tele-monitoring scenario used in the Awareness project [33] but some changes are made in order to also depict relevant activities that require support from the MVC platform. In this section, the term *Community* refers to the MVC platform community while sub-community refers to the MVC.

### 3.2.1. Scenario Description

*This scenario is about an epilepsy patient (Mr. Janssen) who has to be constantly monitored, since he suffers from seizure despite taking his medications regularly. Mr. Janssen wears a 24-hour seizure-monitoring system. Based on variability in heart frequency and physical activity, this system can predict future seizures and is able to contact relatives or health care professionals automatically. The aim of using this system is to provide Mr. Janssen higher levels of safety and independency in order to function more normally in society despite his seizures. To make this possible, we consider the use of a MVC platform.*

*Using the MVC platform, Mr. Janssen's medical specialist creates a sub-community for monitoring Mr. Janssen and invites him to join the sub-community and take the patient role. The medical specialist also identifies which roles and services are necessary based on Mr. Janssen's condition as well as the required policies on access of information and interaction with services. Mr. Janssen accepts the invitation and joins the sub-community by taking the patient role. Mr. Janssen has permission by the medical specialist to invite family members, friends, neighbors or a volunteer to join the sub-community and take on an informal caregiver role. This role allows the sub-community to contact the preferred invited informal caregiver to assist Mr. Janssen during seizure attacks. Mr. Janssen uses email or SMS to invite his preferred informal caregivers. The invited informal caregivers need to register first to the MVC platform to create a log-in account and a profile prior to joining the sub-community.*

*Suppose Mr. Janssen is at home and couple of minutes before the onset of his seizure, the 24-hour monitoring-system already detects the signs of a seizure. The medical specialist, who is currently in the car approaching the healthcare center, is notified immediately by a system alarm. As Mr. Janssen is currently at home, a broadband network is available and the medical specialist, using his mobile device, has the possibility of receiving and examining real time vital signs and location information from Mr. Janssen. However, for better viewing of the vital signs for analysis, the medical specialist transfers the session of viewing the vital signs from his mobile device into his computer. Based on the vital signs, the medical specialist decides to warn Mr. Janssen of a possible imminent seizure.*

*The medical specialist also contacts one of his informal caregivers. A context-aware matchmaking service provided by the MVC platform is used to find the informal caregiver based on preferences defined in the sub-community as well as their location and availability. Informal caregivers can make their availability known by means of mobile presence and instance messaging. The medical specialist at the healthcare center sees on his screen that Mr. Janssen's first informal caregiver, his wife, is in a work meeting a long way away from the house. She cannot be contacted at the moment. But the second informal caregiver, a neighbor and good friend, is at home. By means of instant messaging, he is approached by the medical specialist. After sending a receive-confirmation to the platform, the neighbor hurries to Mr. Janssen's home. Meanwhile, Mr. Janssen indeed suffers from a tonic-clonic seizure. The informal caregiver helps Mr. Janssen and makes sure he does not hurt himself.*

### 3.2.2. Use Cases

Based on the scenario, use cases will be derived. The use cases do not only show possible uses of the platform but also identifies who are involved and their tasks in fulfilling the use case. The characterization in Section 3.1 provides the basic tasks of the roles involved. Figure 3-4 shows the use cases that can be identified from the scenario.

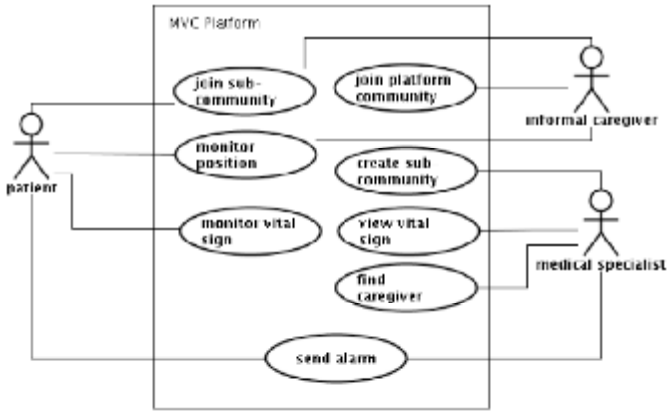



**Figure 3-4. Use cases for Telemonitoring scenario**

Below, the use cases are defined and the requirements are identified.

- ***Create sub-community use case***

In this use case, the medical specialist creates a sub-community and defines the roles, services and policies within the sub-community. The detailed description of the use case is given below:

| • **Use Case 1: Create sub-community** | |
|---|---|
| Goal | To create a sub-community for monitoring of epilepsy patient |
| Scope & Level | MVC platform<br>Summary |
| Precondition | Medical specialist creating the sub-community is known to the MVC |

| | | |
|---|---|---|
| | | platform |
| Success End-condition | | Medical specialist creates the sub-community with specific criteria |
| Failed End-condition | | Medical specialist is not able to create the sub-community |
| Roles | | Medical specialist |
| Description | | |
| | 1 | The medical specialist logs in to the MVC platform using his/her username and password |
| | 2 | The medical specialist makes use of a module in the MVC platform that allows him/her to create a sub-community |
| | 3 | The medical specialist identifies and/or selects appropriate conditions for the sub-community to be created. Such conditions include which roles and services should be present; what policies govern the interactions between roles; and whether the sub-community is private/public. |
| | 4 | The medical specialist saves information and creates the sub-community |

#### *3.2.2.1. Join sub-community use case*

In this use case, the patient receives an invitation from his medical specialist to join the sub-community. The detailed description of the use case is given below:

| | | |
|---|---|---|
| • **Use Case 2:** | | **Join sub-community** |
| Goal | | To register patient to the sub-community |
| Scope & Level | | MVC platform<br>Summary |
| Precondition | | Patient is known to the platform; patient received an invitation from the medical specialist to join the sub-community. |
| Success End-condition | | Patient is a registered member of the sub-community |
| Failed End-condition | | Patient is not registered to the sub-community |
| Roles | | Patient |
| Description | | |
| | 1 | Patient accepts the invitation by logging on to the VC platform and updates their profile to add required information specific to the sub-community |

A second use case flow is defined to show an informal caregiver joining the sub-community:

| | |
|---|---|
| Goal | To register informal caregiver to the sub-community |
| Scope & Level | MVC platform<br>Summary |

| | | |
|---|---|---|
| Precondition | | Use case 3 is fulfilled |
| Success End-condition | | Informal caregiver is a registered member of the sub-community |
| Failed End-condition | | Informal caregiver is not registered to the sub-community |
| Roles | | Informal caregiver |
| Description | | |
| | 1 | Informal caregiver updates their profile to add required information specific to the sub-community |

### 3.2.2.2. *Join platform community use case*

In this use case, the informal caregiver receives an invitation to join the sub-community. Prior to joining the sub-community, the informal caregiver should be known first to the MVC platform. The detailed description of the use case is given below:

| | | |
|---|---|---|
| • **Use Case 3:** | | **Join the Platform Community** |
| Goal | | To admit informal caregiver in the MVC platform community |
| Scope & Level | | MVC platform<br>Summary |
| Precondition | | Informal caregiver is not an existing member of the main community; Informal caregiver can access the MVC platform |
| Success End-condition | | Informal caregiver creates a profile and gets a username and password, which he can use to access the MVC platform |
| Failed End-condition | | Informal caregiver is not able to register and join the MVC platform community |
| Primary Role | | Informal caregiver |
| Secondary Role | | Patient |
| Description | | |
| | 1 | Patient invites informal caregiver to join the sub-community |
| | 2 | Informal caregiver joins the main community |
| | 3 | Informal caregiver provides the basic information such as name, address, gender, email, and address, which are necessary to create a profile; Informal caregiver also creates a username and password to use for logging to the MVC platform |
| | 4 | Informal caregiver is informed of a successful admission to the MVC platform |

### 3.2.2.3. *Send alarm use case*

In this use case, a caregiver gets an alarm notification that an emergency situation regarding the patient is detected. The authorized caregiver receives information about the emergency situation, such as the seizure, the location of the patient, and instructions on what should be done by the caregiver. The detailed description of the use case is given below:

| • **Use Case 4:** | **Send alarm** |
|---|---|
| Goal | To notify caregiver of an emergency situation |
| Scope & Level | MVC platform<br>Summary |
| Precondition | The alarm service has detected an emergency situation (seizure) |
| Success End-condition | The authorized caregiver is notified. |
| Failed End-condition | |
| Roles | Patient,<br>Caregiver |
| Description | |
| 1 | Patient suffers from a sudden epileptic seizure. The alarm service notifies the sub-community regarding the emergency situation. |
| 2 | The MVC platform makes use of the sub-community details to identify the authorized caregiver to be notified |
| 3 | The authorized caregiver receives information from the MVC platform about the emergency situation, such as the seizure, the location of the patient, and instructions on what should be done by the caregiver. |

#### *3.2.2.4. Monitor vital signs use case*

In this use case, a patient's vital signs are constantly monitored. The vital signs to be monitored should be registered in the sub-community. The detailed description of the use case is given below:

| • **Use Case 5:** | **Monitor vital signs** |
|---|---|
| Goal | To continuously monitor patient's vital signs |
| Scope & Level | MVC platform<br>Summary |
| Precondition | Patient is enrolled in the vital sign delivery service of the sub-community; |
| Success End-condition | Patient's vital signs can be monitored |
| Failed End-condition | |
| Roles | Patient |
| Description | |
| 1 | The MVC platform continuously collects vital signs of the patient |

#### *3.2.2.5. View vital sign use case*

In this use case, an authorized medical specialist views a patient's vital signs. The medical specialist can view the vital signs on any of his preferred device and has the option to transfer

the viewing session to any of his registered devices. The detailed description of the use case is given below:

| • **Use Case 6:** | **View vital signs** |
|---|---|
| Goal | To view patient's vital signs |
| Scope & Level | MVC platform<br>Summary |
| Precondition | Use case 5 is successful; Medical specialist is authorized to view the patient's vital sign |
| Success End-condition | Patient's vital signs can be viewed without interruption |
| Failed End-condition | Viewing of vital signs may be interrupted when session is transferred from different devices |
| Roles | Patient, Medical specialist |
| Description | |
| 1 | The Medical specialist can view the vital signs in his mobile device. |
| 2 | The Medical specialist can transfer session of the viewing of the vital signs to another preferred device. |

#### 3.2.2.6. *Monitor position use case*

In this use case, the position of the patient and the caregiver is constantly monitored. This is in line with the SendAlarm use case in order to know the location of the emergency situation. This use case is also necessary to find a caregiver to assist the patient during the emergency. The detailed description of the use case is given below:

| • **Use Case 7:** | **Monitor position** |
|---|---|
| Goal | To monitor patient's and caregiver's location |
| Scope & Level | MVC platform<br>Summary |
| Precondition | Patient and caregiver is known to the MVC platform |
| Success End-condition | A patient and caregiver's location are known |
| Failed End-condition | |
| Roles | Patient, caregiver |
| Description | |
| 1 | The platform keeps track of the patient and caregiver's location |

#### 3.2.2.7. *Find caregiver use case*

In this use case, the appropriate caregiver is identified. The caregiver is selected based on preferences of the sub-community where patient and caregiver are members. The detailed description of the use case is given below:

| • **Use Case 8:** | **Find caregiver** |
|---|---|
| Goal | To select appropriate caregiver to aid the patient |
| Scope & Level | MVC platform<br>Summary |
| Precondition | Patient and caregiver is known to the MVC platform |
| Success End-condition | A patient and caregiver's location, availability and other context information are known |
| Failed End-condition | |
| Roles | Patient, Medical specialist, caregiver |
| Description | |
| 1 | The Medical specialist requests the platform to find the appropriate caregiver. |
| 2 | The platform either informs the medical specialist about the options or the system chooses the appropriate caregiver based on preferences defined in the sub-community. |
| 3 | If the preferences are not defined, the medical specialist selects the caregiver based on the options provided by the platform |

## 3.3. Requirements

Using the characterization and analysis of use cases, we define a list of high-level requirements that must be fulfilled by the MVC platform in order to support the use cases.

| No. | Description | Source |
|---|---|---|
| 1 | The platform should allow creation of a sub-community. | Use case 1 |
| 2 | The platform should allow configuration of sub-community such that preferences and constraints can be made regarding roles and services. | Use case 1 |
| 3 | The platform should be able to store the preferences and constraints imposed on the created sub-community | Use case 1 |
| 4 | The platform should provide synchronous or asynchronous communication service such as chat service and instant message for inviting community members to join sub-community. | Use case 2 |
| 5 | The platform should allow creation and management of profiles. | Use case 2 |
| 6 | The platform should provide asynchronous communication service such as email for inviting non-community members to join the main community. | Use case 3 |
| 7 | The platform should be capable of analyzing the vital signs in order to detect an emergency situation. | Use case 4, [33] |
| 8 | The platform should be able to identify who should be alarmed in case of an emergency | Use case 4, 8, [33] |
| 9 | The platform should be able to have information about the patient's location | Use case 4, 7, 8, [33] |
| 10 | The platform should be able to collect the vital signs of the patient | Use case 5 |
| 11 | The platform should be able to store the vital signs of the patient | Use case 5 |
| 12 | The platform should be able to stream vital signs of the patient | Use case 6 |
| 13 | The platform should be able to transfer viewing session without interruption | Use case 6 |
| 14 | The platform should be able to support multiple devices associated with one role | Use case 6 |

| | | |
|---|---|---|
| 15 | The platform should be able to detect the caregiver's location. | Use case 7, 8 |
| 16 | The platform should be able to support role-based access | Roles characterization |
| 17 | There should be at least one patient role in the sub-community | Policy characterization |
| 18 | There should be at least one caregiver role in the sub-community | Policy characterization |
| 19 | There should be at least one producer role in the sub-community | Policy characterization |
| 20 | There should be at least one consumer role in the sub-community | Policy characterization |
| 21 | These services should at least be present: vital sign delivery service, viewing service and interaction service. | Policy characterization |
| 22 | It should be possible to restrict access to the sub-community | Degree of openness characterization |

**Table 3-1. High-level requirements**

## 3.4. Summary and Remarks

In identifying the requirements to be fulfilled by the MVC platform, it is necessary to first characterize what an MVC for Telemedicine is. A set of criteria is drawn from the literature and motivations for its selection is provided. The purpose is the starting point in specifying the results/values for the other criteria. The roles and services that are present in the community are dependent on the purpose to be achieved by the community. Based on the services, additional service roles are identified, that is, producer and consumer roles. Also, the degree of openness, degree of contextual information present and degree of interaction permitted criteria depends on the services that are provided in the community.

After identifying what an MVC for Telemedicine is, a scenario is selected from a previous study [33] and revised to depict and adapt terminologies used in the characterization. The scenario is also adjusted to highlight the requirements that are supposed to be supported by the MVC platform. Based on the scenario, a use case diagram showing the possible interactions between the platform and the roles is presented. Each use case is discussed in detail to provide event flows.

A list of high-level requirements is identified based on the use cases as well as specification choices already made in the characterization. These requirements should be supported by the MVC platform in order to fulfill the use cases. The next chapter will make use of these requirements in formulating a design of a MVC platform for creating this MVC.

# 4. Design of a MVC platform for monitoring and treatment

This chapter makes use of the MVC characterization and high-level requirements identified in chapter 3 in order design a MVC platform that meets these requirements. A design of the external view of the MVC platform is first presented to specify how the requirements are achieved by the MVC platform from a users perspective (Section 4.1). To realize the external design, the internal architecture of the MVC platform is designed (Section 4.2). The result of these designs is used to identify VC platform support services that are needed to ensure that the designs will be realized (Section 4.3)

## 4.1. External Design

To illustrate how the MVC platform supports the scenario, a design of how to specify the requirements related to the use cases is presented. The design will show an external view of the MVC platform, which will show a user interface (UI) design. Within the scope of this study, the focus is on the process of creating a sub-community. In creating a sub-community, specifications are made which aims at ensuring that the sub-community will function in a certain manner.

- *General information*

In creating a sub-community, a medical specialist specifies the appropriate parameters to define the characteristics of the community. At this point, the medical specialist has knowledge of who the patient is. Figure 4-9 shows a module for creating a sub-community wherein the purpose is related to a patient's body function. The *description field* allows the medical specialist to provide detailed information about the purpose of the community. The ICF [26] is used to identify the health context in which the purpose for the sub-community is related. A sub-community can only be related to one health context since different policies may apply to certain services used in the other health context.

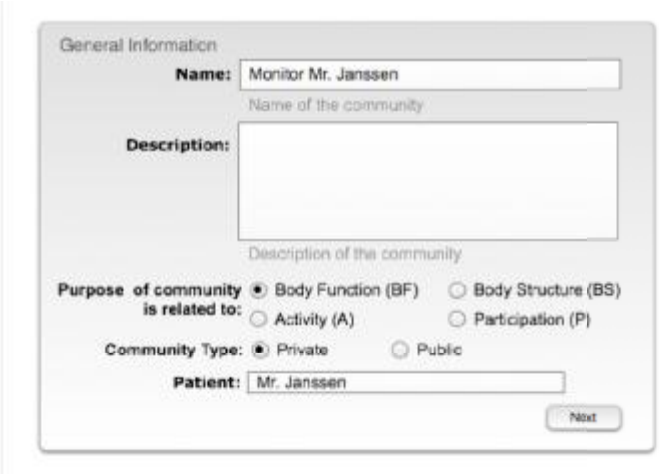



**Figure 4-1. Specifying the purpose of the sub-community**

- *Specifying roles*

After defining the purpose, the medical specialist specifies the roles and the number of roles that will participate in the sub-community. Figure 4-2 shows how this is achieved.


**Figure 4-2. Specifying roles**

The *min* and *max* parameter refers to the minimum and maximum number of parties that can take up the role at a certain time within the lifecycle of the sub-community. Specifying the roles in this manner makes it possible to dynamically allocate roles to parties. For parties to take up the roles, policies apply as to who can invite whom. In this design, a party in a medical specialist role is authorized to invite a party to take up a nurse role while the patient is authorized to invite a party to take up an informal caregiver role.

- *Specifying services*

After specifying the roles, the services that will be needed in order to fulfill the purpose of the sub-community are selected. In Figure 4-3, the medical specialist selects the service from a drop-down list of all services provided by the MVC platform.


**Figure 4-3. Specifying services**

Once the services are selected, policies can be described for each service as to which roles can provide the content and the roles that will consume the content.

- *Specifying policy for the alarm service*

The purpose of the alarm service is to identify whom to notify during an emergency situation. Medical protocols may be used to identify severity level of an emergency situation. Figure 4-4 below shows how a medical specialist can specify the policies related to an alarm service.

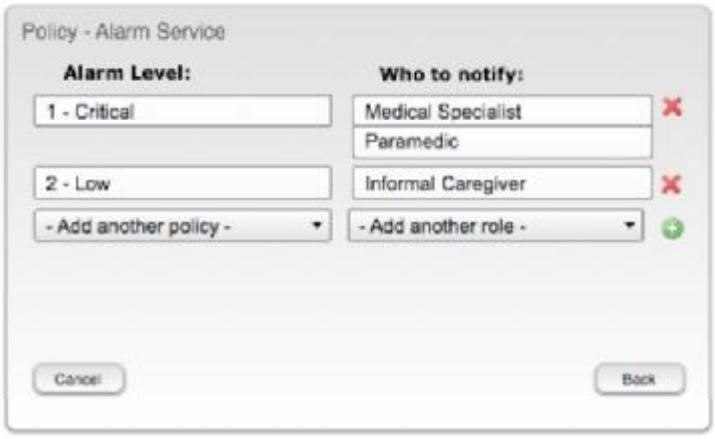



**Figure 4-4. Specify policy for Alarm service**

In this design, we identified two alarm levels to show that on critical situations, a medical specialist is notified first before a paramedic while in cases where the alarm level is low an informal caregiver is notified. This service could have dependency on the vital sign monitoring service in order to identify which parameter goes beyond the acceptable margin and thus automatically initiating the alarm service.

- *Specifying policies for Chat service*

In a chat service or other similar services, policies exist as to who initiates contact to whom. These policies are related to the purpose of the chat session. Figure 4-5 shows how this can be specified.


**Figure 4-5. Specifying policies for Chat service**

The purpose for chatting is first selected then the roles as to who initiates to whom is identified. In identifying the purpose for chatting, these can be based on the name of the chat rooms where the chat session will be done. The policies in this design shows that for consultation, a patient can initiate contact to a nurse or a medical specialist while for the purpose of socializing, there is a bidirectional relationship between a patient and an informal caregiver.

- *Specifying policies for Location service*

With a location service, not all roles have access to view the location of other roles. For instance, an informal caregiver does not need to know the location of a medical specialist. This specifications identifies who is the provider of the location information as well as who are the consumers of this information. Figure 4-6 shows how this can be specified.


**Figure 4-6. Specify policy for location service**

- *Specifying policies for Vital sign delivery service*

In a vital sign delivery service, the patient is the provider of the vital sign while there could be multiple roles that could consume the vital sign information. Figure 4-7 shows how this can be specified.

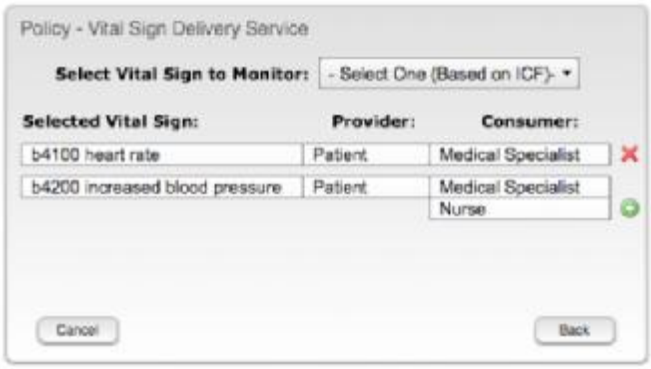



**Figure 4-7. Specifying policies for Vital sign delivery service**

A design decision is made to link a certain vital sign delivery service to an ICF classification [26]. For instance, ECG monitoring is related to monitoring the heart rate. Using the ICF [26] to identify which vital signs to monitor makes it consistent with the purpose of the sub-community. In this case, the purpose of the sub-community is related to a patient's body function and the ICF [26] provides a list of categories for measuring the health status of a patient's body function.

- *Specifying policies for Viewing service*

This service is intended to allow a consumer to view a certain content or information. What can be supported by this service is to specify multiple devices that can be used in viewing the content or information to be consumed. Figure 4-8 shows how this can be specified.

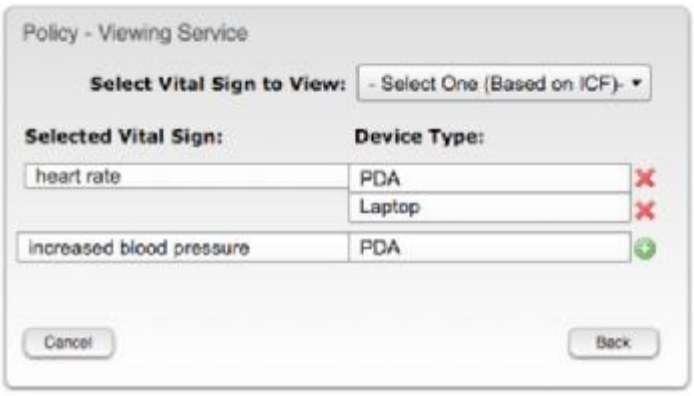



**Figure 4-8. Specify policy for Viewing service**

In this design, a heart rate can be viewed using two devices wherein the PDA is the preferred device while the laptop is an alternative device. In order to make use of these devices, it should be registered and known by the platform. There could be different technical implementations as to how registration of these devices is made possible. However, these concerns are out of the scope of this study and can be addressed in future research.

## 4.2. Internal Design

This section does not intend to make a design of the entire MVC platform nor does it intend to provide a design of each of the service. Rather, the focus is only on how the VC component supports the creation of the MVC. To make this explicit, a high-level architecture of the MVC platform will be presented to identify the starting point of the design (Section 4.2.1). A UML class diagram will be used to design the structure of the VC (Section 4.2.2). UML sequence diagrams are then used to show sequence of steps in realizing a scenario based on interactions and flow of information between objects (Section 4.2.3).

### 4.2.1. MVC Platform high-level architecture

In the design of an MVC platform, several technical layers are involved. Pawar et. al [21] provides a high-level architecture of a MVC based on a Mobile Service Platform (MSP) infrastructure. The MSP is integrated via Web service to a community platform, which was an extension of a community builder software called Delphin [12].

For the design of the MVC Platform, the design focus is on the VC platform and the mobile infrastructure and integration layer as defined by [21] is assumed to apply in the MVC for Telemedicine. Figure 4-9 shows a high-level architecture of the MVC platform wherein the VC platform is highlighted to show the design focus.


**Figure 4-9. MVC Platform high-level architecture**

### 4.2.2. Community Platform Components

In creating a sub-community, different components of the VC platform are used. These are:

1. *Member Manager*

This component provides the functionality for the initial admission of parties to the MVC platform as well as the creation of roles that each party will take up when joining sub-communities. Prior to the creation of a sub-community, a party should be known by the VC platform. Upon registration, the party needs to fill up minimum information in order to give him/her access to the VC platform. This set of information about a party is called a profile. When a party joins a sub-community, it takes up certain roles in order to participate in the sub-community. The member manager knows all information related to a party's profile.

The member manager provides the functionality of the creation of the roles. For this design component, support for role-based access is essential in order to define obligations and/or responsibilities for tasks that can be performed within a group. Roles are also used to access services and without proper assignment of roles to group members the expected results required from these services will not be fulfilled.

2. *Service Manager*

This component provides functionality for the provision of a list of all services that are published in the MVC platform and which can be utilized by the sub-communities. Before a certain service can be offered to the sub-communities for utilization, it should already be known by the VC platform. The service manager provides this functionality of allowing different parties to enlist their products and/or services to the VC platform so that the VC platform can offer it to the sub-communities. Eventually the service manager then holds a registry of all the services in the VC platform.

Other functionalities of the service manager that may not be visible during the registration of sub-communities are discussed below.

- *Single sign-on (SSO)*

The Open Group defines SSO as the "mechanism whereby a single action of user authentication and authorization can permit a user to access all computers and systems where that user has access permission, without the need to enter multiple passwords." [43] Basically, SSO allows a user to log in once and gain access to multiple resources without being prompted to log-on again.

In monitoring vital signs, a medical specialist may be a member of different sub-communities involving different patients using different services. The platform should be able to support the monitoring process without the medical specialist having to register to the different services involved. In the case where a person is a patient in one sub-community and an informal caregiver in another sub-community, it should be possible for the person to use both services in each sub-community without the need to register or deregister the services.

- *Service provisioning*

Service provisioning refers to the act of associating a certain consumer with the use of a service [44]. In Service Oriented Architecture, this requires service registration and service discovery before a service session between a service consumer and a service provider can be activated. Service registration is the registration of services by service providers to potential consumers. Service discovery is the process of discovering these registered services and obtaining a reference to use the service. Once an appropriate service is selected, a service session can then be established.

However, it is usually the case that there are a lot of loosely coupled services involved in delivering a certain service that meets the service consumer needs. There should be a way to pull together a set of loosely coupled service operation based on consumer needs. At the same time, there should be a way to describe the valid ordering of messages exchanged between these services. The former technique is called orchestration while the latter is called choreography.

In supporting a certain goal of the MVC, interaction between multiple services maybe required. Example is selecting the proper informal caregiver for the patient wherein invoking different services such as location and availability services are required to make a match on selecting whom to send to the patient.

*3. Community Manager*

This component provides the necessary functionalities in order to configure and register a sub-community to the MVC platform. When a request for creating a sub-community is received, the community manager provides a module from which preferences on the sub-community can be specified. Preferences that can be specified in the community are the roles and services that should be present and the allowed interactions between them. The roles are created using the *member manager* while the services are registered using the *service manager*. For this reason, the community manager requires both components.

In configuring a sub-community, a medical specialist usually goes through a series of steps before finally creating the sub-community. The community manager has a functionality of creating a template service, which allows pre-defining the parameters that could be set when creating a sub-community. For instance, based on previous works such as in [23, 31, 32, 33], common roles and services are known to exist in a sub-community for tele-monitoring. Based on these commonalities, a template can be created to already reflect these preferences so that when creating a sub-community using this template, the medical specialist can just confirm the preferences or maybe make minor adjustments. In relation to the external design in chapter 4.1, this implies that the medical specialist may take a shorter step in making the specifications.

In Telemedicine, parties take on specific roles when joining a sub-community. For each role, there are certain responsibilities and obligations to be fulfilled as well as some prohibitions. These roles define and constrain the behavior of a party taking up the roles. It is possible that a certain party takes up different party roles in different sub-communities. Example would be a patient in one sub-community and an informal caregiver in another sub-community and both roles are active at the same time. It should be possible for the MVC platform to support multiple roles belonging to the same person. In the same manner, it should be able to determine restrictions on activation of both roles at the same time. An example is that a patient who is in a state of emergency should not be selected as an informal caregiver to another patient even though s/he has the nearest location. In conclusion, since membership to the community is done through roles, a role-based access is required.

*4. Data Access*

This component provides the functionality to create, read, update and delete information in the database.

### 4.2.3. Class diagram

A class diagram showing the structure of the system in support for creating a sub-community is shown in Figure 4-10. The class diagram is not intended to show completeness of model elements but is used as a sketch to highlight significant model elements in relation to realizing the external design. The classes refer to domain specific representation of the information on which the VC platform operates.

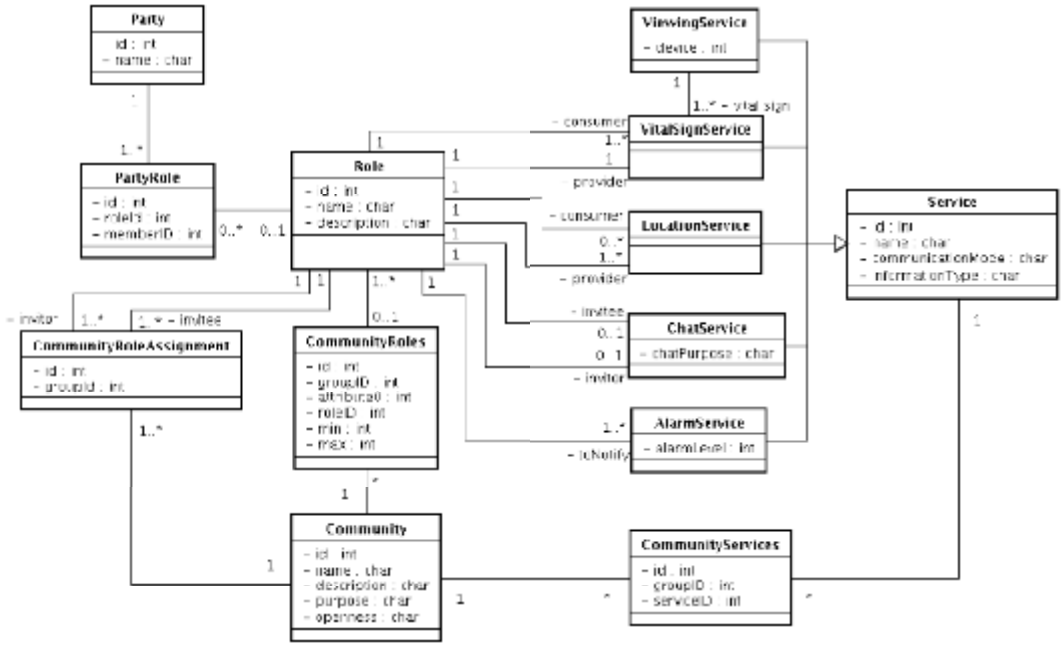



**Figure 4-10. Class diagram for creating a sub-community**

The classes and relationships are discussed in Table 4-1 below:

| Class Name | Description |
|---|---|
| Party | The party class refers to the parties of the MVC platform. |
| PartyRole | This model element shows the association type between a party and a role. The relationship shows that a party can take up multiple roles and that this is a requirement before a party takes up a role defined in a certain sub-community. |
| Role | The list of roles and its description are represented in this class |
| CommunityRoles | This model element identifies the distinct roles that can only participate in the sub-community. These roles can be filled up by party roles |
| Community | This model element refers to the sub-communities that are created in the MVC platform and which uses the services of the MVC platform. A sub-community may use multiple services in order to fulfill its goals. This class knows the name, description and purpose of the sub-community as well as the attribute related to the degree of openness of the sub-community. |
| CommunityRoleAssignment | The class contains the policy on role assignments in the sub-community |
| CommunityServices | This model element refers to the services that are to support the goal of the sub-community. |
| Service | This model element refers to the related Telemedicine services that can be utilized by certain sub-communities. |
| AlarmService | This class contains the policy on who to notify depending on the alarm level |
| ChatService | This class contains the purpose of the chat as well as the policy on who initiates the chat and to whom it was initiated. |
| LocationService | This class contains the policy on who provides location information and who can consume the provided information. |
| VitalSignService | This class identifies the vital sign that will be collected from the provider as well as the policy on who consumes the vital sign |

| | |
|---|---|
| | information. |
| ViewingService | This class contains the device that will be used for viewing the vital sign information. This service is used in conjunction with the VitalSignService, wherein the consumer role makes use of the device preference defined in this ViewingService in order to view the vital sign. |

**Table 4-1. Description of Classes**

A design decision is made to show that parties have no direct access on the services. The services are linked to the sub-communities since the motivation for using these services should be to support the purpose of why the sub-community was created in the first place. In the same manner, not all roles have access to the sub-community services. Only authorized roles and parties as set in the policy for using the services are allowed to utilize the service

### 4.2.4. Sequence Diagram

A Sequence Diagram is an Interaction Diagram, which is a "graphical representation to show how a set of classes describes a pattern interaction between objects in the real world" [36] Figure 4-11 shows a sequence diagram for creating a sub-community.

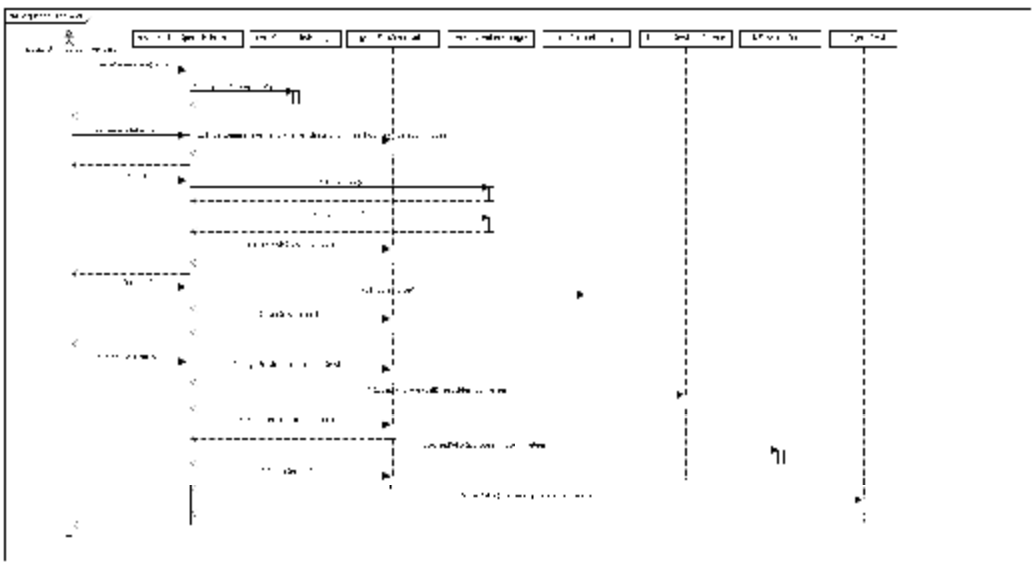


**Figure 4-11. Sequence diagram for creating a sub-community**

Figure 4-11 shows that a medical specialist uses an interface to initiate the creation of the sub-community. The interface could be a wired or wireless device that is connected to the Internet. Using the interface, it requests the MVC platform that it will create a sub-community. The *Community Manager* component handles this request and provides a module used for the creation process. Using this module, the medical specialist specifies the general information about the sub-community to be created.

The next step is to identify the roles that will participate in the sub-community. The *Member Manager* component provides the list of roles in the MVC and from this list the medical specialist selects the roles. After selecting the roles, the policies are specified as to the number of roles that could participate as well as who can invite whom. After the roles, the services to be utilized by the sub-community are identified. The *Service Manager* component handles this request and provides a list of services that are known to the MVC platform. The medical specialist selects the services from this list.

For each service selected, policies are specified. In this sequence diagram, specification of policies is shown for the location service, chat service and vital sign service.

## 4.3. Traceability Matrix

The traceability matrix in Table 4-2 shows which external and internal designs fulfill the requirements identified in Table 3-1. As shown in the matrix, all the requirements are dealt with to some extent. Some of the requirements are not directly fulfilled by the design elements; instead these design elements makes it possible that these requirements will be achieved later on. For instance, requirement 10, which refers to the ability of the platform to collect the vital sign of the patient, is not directly related to the design elements for creating a sub-community. However, since this requirement needs to be fulfilled, the design considered the provision of these services by providing a design element to specify the use of services when creating a sub-community.

| Requirements | External Design | Internal Design |
|---|---|---|
| 1 | General information | Community Platform Components> 3. Community Manager |
| 2 | Specifying roles / Specifying services | Community Manager |
| 3 | | Class diagram for creating a sub-community |
| 4 | | Community Platform Components> 1. Service Manager |
| 5 | | Community Platform Components> 1. Member Manager |
| 6 | | Community Platform Components> 1. Member Manager |
| 7 | Specifying policies for Vital sign delivery service | Vital Sign Service |
| 8 | Specifying policy for the alarm service | Class diagram for creating a sub-community>AlarmService |
| 9 | Specifying policies for Location service | Location Service |
| 10 | Specifying policies for Vital sign delivery service | Vital Sign Service |
| 11 | Specifying policies for Vital sign delivery service | Vital Sign Service |
| 12 | Specifying policies for Vital sign delivery service / Specifying policies for Viewing service | Vital Sign Service |
| 13 | Specifying policies for Viewing service | Viewing Service |
| 14 | Specifying policies for Viewing service | Viewing Service |
| 15 | Specifying policies for Location service | Location Service |
| 16 | Specifying roles | Class diagram for creating a sub-community |
| 17 | Specifying the purpose of the sub-community | |
| 18 | Specifying roles | |
| 19 | Specifying policies for Vital sign delivery service | |
| 20 | Specifying policies for Vital sign delivery service | |
| 21 | Specifying services | Community Platform Components> 1. Service Manager |
| 22 | Specifying the purpose of the sub- | |

| | | |
|---|---|---|
| | community | |

**Table 4-2. Traceability Matrix**

## 4.4. Summary and Remarks

This chapter has detailed how to realize the requirements identified in chapter 3. An external view of how a medical specialist can specify and register a sub-community is initially provided. From this external view, a design of the internal architecture of the VC platform is provided. A class diagram is designed to show a structure of the system and followed by a sequence diagram showing possible interactions between different model elements. At the outset, the components that support these interactions are discussed as well as key support services that must be provided by the VC platform to realize the creation of a sub-community.

# 5. Case Study: MSP + Dolphin

This section makes use of the preceding design specification to assess an existing MVC platform, which could be used to support the MVC for remote monitoring and treatment of patients. An introduction of the MVC platform is first given to get a view of its components and basic functionalities (Section 5.1). The Dolphin community platform, which is intended to support the MVC, is analyzed in detail to find the extent of support it can give to the MVC (Section 5.2). Based on the analysis, platform enhancements are suggested (Section 5.3). A summary and remarks (Section 5.4) concludes this chapter.

## 5.1. Introduction

The MVC Platform is an integration of a web-based community platform and a Mobile Service Platform (MSP). The community platform is an extension of an open source community builder called Dolphin [42]. MSP is a proxy-based middleware based on the Jini surrogate architecture specification and developed in Java [24]. Figure 5.1 below shows the high-level overview of the platform.

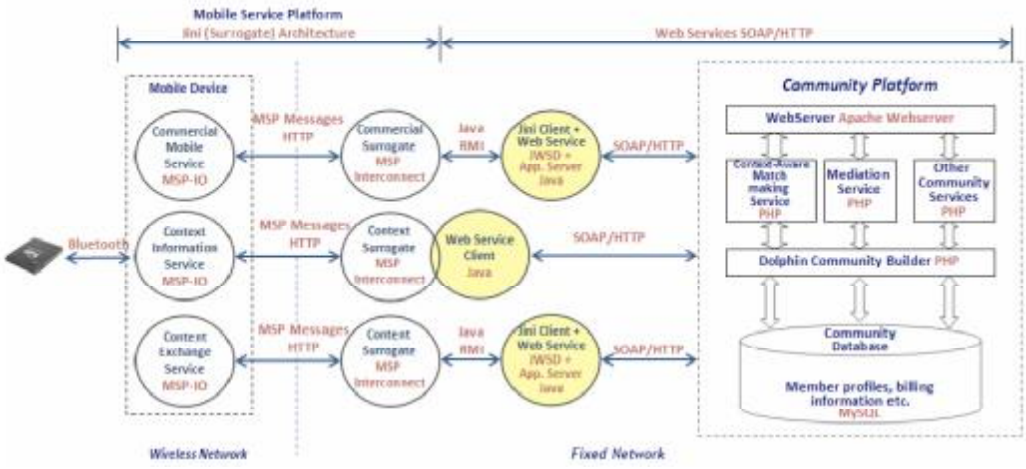



**Figure 5-1. High-level overview of the technical platform [24]**

In this figure, services are implemented at the community platform using PHP. For the MSP and the community platform to communicate, Web Services middleware is used for integration. An initial service tested for implementation at the community platform is the location service, which makes it possible to locate members of the community. The community platform referred to is an extension of Dolphin wherein new PHP scripts were developed and deployed so that web services can be implemented in the platform. For the remainder of this document, the term Dolphin platform will include the extensions made using the Dolphin community builder.

For the remainder of this chapter, the Dolphin platform is assessed. The mobile service platform is taken as a design step and for its implementation we refer to [24]. The purpose of the assessment of the Dolphin platform in this study is on how it can support the creation of a sub-community for remote monitoring and treatment of patients. In Dolphin platform terminologies, a sub-community is the same as a group and member is the same as a party. The external view of the Dolphin platform is first evaluated followed by its internal view.

### 5.1.1. External View

An external view of the functionalities that a user can do in the Dolphin platform is shown in Appendix A. However, the focus is only on the process of the creation of a group and other

processes that are required to make this possible. We use the same criteria as defined in chapter 4.1 to identify what Dolphin offers.

- *General Information*

In this module, general information about the group is known. Figure 5-2 shows the parameters to be set in creating a group by using Dolphin.


**Figure 5-2. Creating a group in Dolphin**

In this figure, *category* refers to which classification the group will belong; within a category, there could be several groups. *Open join* is a constraint as to whether approval is needed before a Dolphin user can join the group. *Hidden group* is a constraint that identifies whether the group details is hidden from non-members of the group. *Members can post image* gives permission to group members to post images that can be used by other group members. *Members can invite* gives permission to any group member to invite Dolphin users to join the group; if set to No, only the group creator can invite. The other parameters are self-explanatory.

- *Specifying Roles*

Looking at Figure 5-2 and the parameters that are available, only creator and member roles can be identified. Since only one Dolphin user can take the creator role, all other group members take up the member role. In an open-group type, inviting other Dolphin users to join the group means that all existing members can invite.

- *Specifying Services*

Dolphin provides different services that are available for use by Dolphin users such as chat service, instant message service, blogs, photo/music/video sharing, and others. However, only the group forum and group gallery services are available that is exclusive for use in the group. In the group forum, all members within a group can participate while in the group gallery all members can post images.

- *Specifying Policies*

In the use of services, it is not possible to set policies as to who can participate. Only registered user of the Dolphin platform can use all services in Dolphin. Policies are only specified with regards to access to the group details as well as in inviting members to the group.

### 5.1.2. Internal View

To realize the proposed internal view of an MVC platform as described in chapter 4.2, the internal structure of the Dolphin platform is also evaluated. Using database reverse engineering method, the Dolphin platform system structure is inversed in a state that it can be analyzed and from this, a conceptual schema is derived. Only a sub-set of the Dolphin database is analyzed based on its relation to the creation of a group. Dolphin functionalities of interest include profiles, groups, chat, instant messenger and services. Figure 5-3 shows a UML class diagram of this conceptual schema.

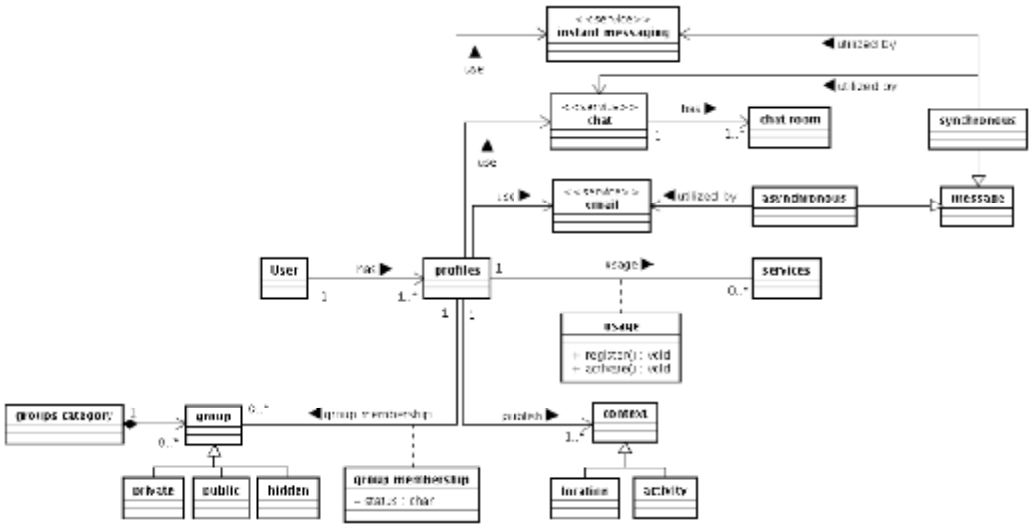



**Figure 5-3. Conceptual schema**

The conceptual schema originates from the DB structure as well as program code analysis of the PHP scripts and program execution of the Dolphin platform through the user interface. Table 5-1 shows the table and their description from which the classes in Figure 5-3 are derived.

| List of tables | Description |
|---|---|
| context | An additional table created to accommodate context information related to context services; for this implementation, it was used to store information related to the location service |
| groups | Contains the available groups and their properties and the group category they belong to |
| groupscateg | Contains group categories, (group categories are created by Dolphin admin) |
| groupsgallery | Contains images shared within a certain group; any group member can upload and delete entries in the gallery |
| groupsmembers | Shows user membership in the groups |
| messages | Stores inbox information; this includes the sender, receiver & message |
| profiles | Stores user profiles, important fields include ID (userID), nickname (username), and password |
| raychatcurrentusers | Stores users using the chat service and the status of their usage. When users are successfully logged out, the data is deleted. |
| raychatmessages | Store current chat messages sent by user but is deleted at a certain time interval, thus no permanent data is actually stored. |

| | |
|---|---|
| raychatrooms | Stores all available chat rooms created by community members in addition to the two default chat rooms |
| rayimcontacts | Stores the sender and recipient of the instant message and when it was sent |
| rayimmessages | Stores current instant messages sent by user but is deleted at a certain time interval, thus no permanent data is actually stored. |
| rayimpendings | Stores pending instant message from sender to receiver and when it was sent. Once the receiver accepts the message, the data is deleted from the database. |
| services | An additional table created to show the active services that are utilized by the community users; these services are provided by 3rd party applications in the sense that they are not initially provided by the Dolphin community builder. |
| userservice | Stores relationships between a service and its users, showing the registered services by the users. |

**Table 5-1. Dolphin database tables**

## 5.2. Analysis

Dolphin is analyzed based on the requirements that are realized by the design components identified in chapter 4.2.4.

| Design component | Requirement | Dolphin |
|---|---|---|
| Member Manager | The platform should allow creation and management of profiles. | Dolphin supports this; a profile refers to a users set of information, which is provided when joining the Dolphin community. The required information includes username, email, password, date of birth, city, tags, headline, and description. |
| | The platform should be able to support role-based access. Role-based access in this sense refers to assignment of roles and responsibilities attached to the role when joining a group. | Within a group, only two roles exist: creator and member. There is no way to create a new role explicitly nor is there a way to set responsibilities for each member of the group. Thus, this requirement is supported in a very limited way. With this limitation, it can still support a group where only two roles are necessary such as a patient, which can take the member role and a medical specialist as the creator. In addition, this limitation also implies that a person is always tied to its task in the group. For instance, if Alice is the group creator (medical specialist) and Bob is a member (or the patient). When Bob needs treatment and Alice is not available; it is not possible to assign the group creator (medical specialist) role. Thus this limitation is insufficient in providing treatment that is independent of time and location since the mobility support is undermined. |
| Group Manager | The platform should allow creation of a sub-community. | In Dolphin, a sub-community refers to a group. Dolphin supports this requirement. |
| | The platform should allow configuration of sub-community such that preferences and constraints can be made regarding roles and services. | In creating a group in Dolphin, it is possible to configure parameters depending on the preference of the group creator. The limitation is that there are only two roles that can exist in the group: a creator and member role. With respect to assignment of roles to members, this is not supported. |

| | | |
|---|---|---|
| | There should be at least one patient role in the sub-community | This is not supported since creation of new roles is not possible. |
| | There should be at least one caregiver role in the sub-community | This is not supported since creation of new roles is not possible. |
| | There should be at least one producer role in the sub-community | This is not supported since creation of new roles is not possible. |
| | There should be at least one consumer role in the sub-community | This is not supported since creation of new roles is not possible. |
| | It should be possible to restrict access to the sub-community | This is supported through the parameters *open join, hidden group, and member can invite.* |
| Service Manager | The platform should provide asynchronous communication service such as email for inviting non-community members to join the main community. | Dolphin supports this. |
| | These services should at least be present: vital sign delivery service, viewing service and interaction service. | Dolphin does not provide these services at the moment. However, looking at the implementation of the location service, making extensions through PHP scripts may also allow provision of these services in Dolphin. Suppose these services are provided, Dolphin should be able to store and manage the information related to these services. |
| | The platform should be capable of analyzing the vital signs in order to detect an emergency situation. | This requirement is a concern of the MVC platform and the responsibility of Dolphin in this context is to store the information about the vital signs and the alarm level. |
| | The platform should be able to identify who should be alarmed in case of an emergency | These requirements are related to policies that could be imposed on the services that will be used in the group. However, these services are not currently provided by Dolphin and thus are not supported by the platform. |
| | The platform should be able to collect the vital signs of the patient | |
| | The platform should be able to stream vital signs of the patient | |
| | The platform should be able to transfer viewing session without interruption | |
| | The platform should be able to support multiple devices associated with one role | |
| Data access | The platform should be able to store the preferences and constraints imposed on the created sub-community | Dolphin supports this. |
| | The platform should be able to store the vital signs of the patient | The vital sign is information that is associated to a certain service, which is not provided by the platform at the moment, thus Dolphin does not also store the data. |
| | The platform should be able to detect the caregiver's location. | Dolphin provides a location service through an extension by means of creating new PHP scripts and integrating it to Dolphin through web services. This service makes it possible to store the location information of Dolphin users. However, for Dolphin to support this requirement, it should be possible first to create a caregiver role. |
| | The platform should be able to have information about the patient's location | |

**Table 5-2. Dolphin analysis**

### 5.2.1. Summary of Findings

The summary of the findings is structured based on required support services for each design component.

- *Member Manager*

At the moment, only two roles exist in the group, a creator and a member role; creation of new roles is not possible. Dynamic assignment of roles for group membership is also not supported but is necessary in order to provide flexibility for taking responsibility of tasks related to the purpose of a group.

- *Group Manager*

Although Dolphin provides a module for configuring a group, the parameters that can be set are very limited. Comparing the external view of Dolphin with the design proposition in chapter 4.1, a lot of information is missing at the moment. This limitation extends to the database of Dolphin, which needs to store the information.

- *Service Manager*

At the moment, only group forum and group gallery are the services that are predetermined to be used in the group. Other services, such as chat and instant message, are available but are designed for usage by all Dolphin members regardless of their group memberships. Required services for the purpose of remote monitoring and treatment are not provided by the platform except for the location service.

## 5.3. Platform enhancements

*1. Support for role-based access in group management*

Based on the findings, providing a role-based access per group is a critical functionality that needs to be available yet it has very limited support by the Dolphin platform. Options on how to deal with this limitation are provided.

- *Option 1:* Work around procedure for creating and managing roles by introducing new functionalities but without much change to the existing business logic of Dolphin. In this option, the following algorithm can be followed.

    1) The Dolphin platform provides and Admin panel wherein pre-defined options are available to change properties of the Dolphin community. These options include changing the interface layout or specifying which modules should be there and which information is shown. Using Profiles Field Manager of the Admin panel, create a new field name *role*. Set properties of this field such as:

        a. Make *field_type* as drop down list and enter the possible type of roles such as patient, informal caregiver, medical specialist, nurse, etc.

        b. Set *visible to* property to member and admin so that only the owner of the profile and the administrator can view.

        c. Set *show on page* in join page and edit page so that information can only be viewed in these pages, which means that only the person owning the profile can see these information.

    2) After this step, the *Profile* can now be taken as a role. When users join the Dolphin community, they have the option to select the role that they will portray in the Dolphin community.

    3) When creating a group, a *policy* and *rolepolicymanager* classes are introduced. The *policy* class contains information on the permissions about a role while *rolepolicymanager* provides rules and functionality on assignment of policies to a role. The *policy* can be implemented as a table while *rolepolicymanager* can be implemented as a PHP class.

Change to the *groupmanager* is needed to make use of the *rolepolicymanager* when making invitations to join a group. A class diagram of these changes is shown below:

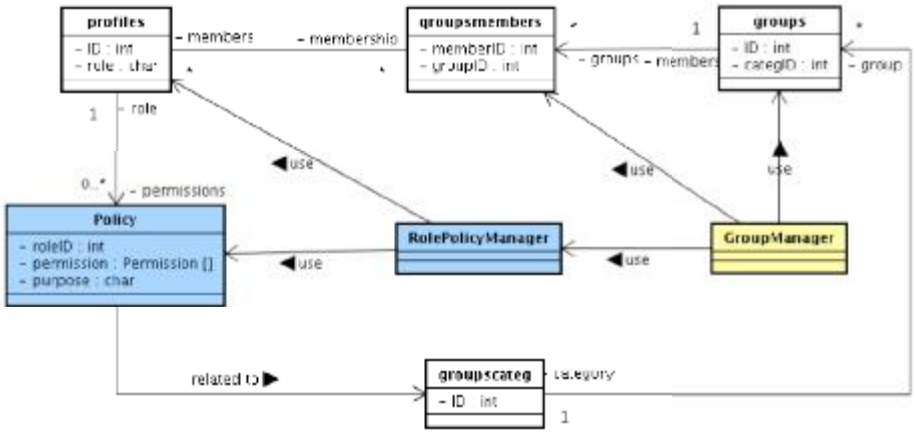



**Figure 5-4. Proposed enhancement with policy**

With these changes, it is now possible to create new roles and assign permissions to this role. It also makes it possible to have group members with different roles instead of only a group creator and member role. The policies however are attached to a specific role but there is a need for the role to fulfill different functions depending on the purpose where it will be carried out. Since groups are created under a specific group category, the group category can be taken as the generic purpose of the groups. Multiple policies can then be specified for a certain role but not all policies will be exercised when using the role; only the policies related to a purpose is used.

The limitation of this enhancement is that multiple roles at the same time per Dolphin user are not supported. This means that if a person named Alice takes up the nurse role, she cannot take an informal caregiver role in parallel; thus Alice can only perform a certain set of functionalities at a time.

*Option 2:* Extension on DB structure to accommodate roles per group

This enhancement involves making drastic changes to the business logic related to group management of Dolphin. In the first option, the role is attached to a member while in this option the role is relative to the group. This allows flexibility on assignment of roles to group members wherein the role could be filled up through direct invitation to Dolphin users or could dynamically be filled up by another group. A class diagram of these changes is given below wherein the new classes that are required are highlighted.

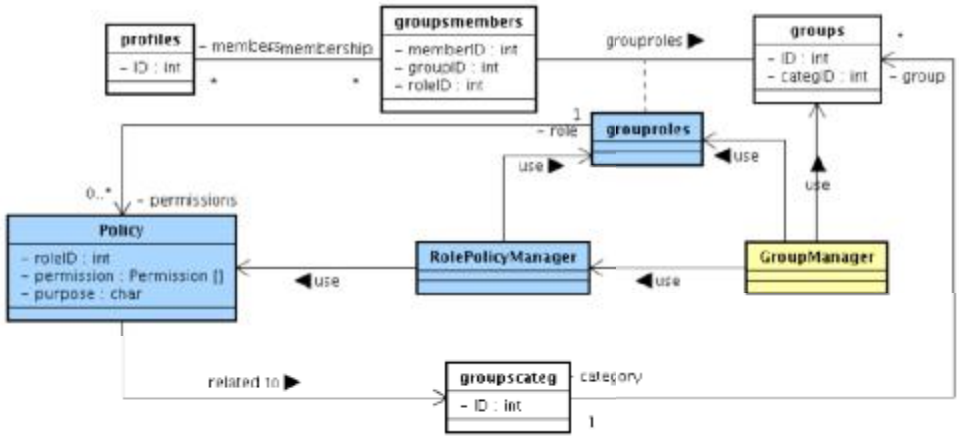


**Figure 5-5. Enhancement for role based access per group**

The figure shows that group members take up *grouproles* when joining a group and that policies are related to the group roles and not on member roles.

2. *Support for service management*

On the provision of required services for remote monitoring and treatment such as vital sign delivery and viewing service, the Dolphin platform do not need to develop an application from the ground up to provide these services. Rather, it should be able to provide a service registry from which providers of these services can publish them.

## 5.4. Summary

This chapter evaluates an existing MVC platform, which is an integration of MSP and a community platform developed by extending Dolphin. The MSP is taken as a design step and for its implementation, the study of [24] is provided for reference. The Dolphin community platform is then analyzed from its external view and later its internal view. Analysis is made as to how it can realize the design for MVC for monitoring and treatment as proposed in chapter 4. The result of the analysis shows that the Dolphin community platform is very limited in realizing the design. With these limitations, platform enhancements are proposed.

# 6. Conclusion and Recommendation

This final chapter presents the conclusions and recommendations of the study as well as areas for future work. A summary of the entire research to highlight notable findings will be first presented (Section 6.1). A conclusion on the outcome of the case study as well as the general conclusion of the study follows next (Section 6.2). Finally, a recommendation for the case study as well as for future research concludes this chapter (Section 6.3).

## 6.1. Project Summary

In this thesis, we identified different domain groups from which we can characterize a MVC for Telemedicine; these domains are virtual community, mobility and Telemedicine (Chapter 2). From the intersection of these domains, we identified different criteria for characterization, which resulted in a conceptual model of a MVC for Telemedicine. From this model, initial requirements can already be identified. To demonstrate how this model can be used, a scenario is used to derive specific requirements related to the creation of a MVC for monitoring and treatment of patients (Chapter 3). These requirements served as a basis for the design of an MVC platform wherein a design of the external and internal view of the MVC platform is presented. The MVC consists of two major components – MSP and community platform – but the focus of this study is on the VC platform. In order to realize the design, required VC platform support services are identified (Chapter 4). The design and the required VC platform support services were used as baseline parameters to investigate an existing MVC platform to analyze the extent of how it can satisfy these necessary functionalities (Chapter 5).

## 6.2. Conclusion

### 6.2.1. Conclusion on findings from the case study

In this thesis we have presented the details of the Dolphin community platform and how it can support the creation of MVC for monitoring and treatment of patients. The current features of Dolphin show that it has very limited support for role-based access and policy specifications, which are critical functionalities required for creating a MVC. With this limitation, platform enhancement options are provided which can fulfill this requirement. These options however, not only require changes in the user interface design but additional PHP classes are also needed to provide required functionalities.

On the other hand, the case study also reveals that although the Dolphin platform has various functionalities for building communities, it is still not readily applicable or configurable to be used for Telemedicine.

### 6.2.2. General conclusions of the study

The main research question for this study is: *How can MVC concepts be applied in the design of an MVC platform to be suitable for Telemedicine?* Several domains have been identified from which different criteria are derived in order to develop a conceptual model that depicts a MVC for Telemedicine. The guiding criterion to identify a MVC for Telemedicine is the purpose.

The usage of the ICF [26] as a starting point for identifying the purpose that should be supported by the MVC for Telemedicine proved to be useful since current developments in the healthcare domain [28, 29] showed that, relative to a certain disease, a person can be assessed based on ICF core sets. In knowing which specific components could be supported regarding a certain disease, it is easier to identify which health services/treatment to be given to the patient. From this purpose, specification for other criteria for characterizing a MVC for Telemedicine is derived. And from hereon, requirements are identified that leads to a design of an MVC platform that is suitable for creating a MVC for monitoring and treatment of patients.

Below is a tabular view of the answers for each research questions in line with the objectives of this study.

| Objective | Research Questions | Conclusion |
|---|---|---|
| To investigate relevant concepts to characterize a MVC for Telemedicine. | What are the criteria/properties by which a MVC for Telemedicine can be characterized? What are relevant MVC concepts from which these criteria/properties can be derived? | There are seven criteria from which a MVC for Telemedicine can be characterized. They are:<br>1. Purpose<br>2. Roles<br>3. Services<br>4. Policies<br>5. Degree of Openness<br>6. Degree of Information present<br>7. Degree of Interaction permitted<br>These criteria are based on the intersection of the three different domains, which are Telemedicine, Virtual Community and Mobility. |
| To identify requirements that must be satisfied by a MVC platform to be suitable for Telemedicine | What are the minimum requirements that must be met by an MVC platform to be suitable for Telemedicine? | The characterization of a MVC for Telemedicine serves as a starting point for identifying the requirements that should be supported by the MVC platform. The minimum requirements identified are:<br>• It should support a role based access in the MVC<br>• It should provide a template service for configuring a MVC<br>• It should provide a directory service from which service providers can publish their services to the MVC Platform so that it can be promoted to the MVC's.<br>• The following Telemedicine domain services should be provided: vital sign delivery service, viewing service and interaction service. |
| To specify a design on how to create a MVC for monitoring and treatment of patients. | How to create an MVC for monitoring and treatment of patients?<br>• What attributes should be present based on the MVC characterization?<br>• What are the steps involved?<br>• How can the MVC platform support the creation of a MVC? | To create a MVC for monitoring and treatment of patients, the roles, services and policies are specified. This specification provides constraints in such a way that the MVC will function based on its purpose. The MVC platform should be able to support the creation of roles and provision of services that will be needed in making the specification. In the same manner, the MVC platform can provide a template that represents common specifications regarding typical purposes. Having a template reduces the time for the medical specialist in specifying the properties of each MVC to be created. |

| | | |
|---|---|---|
| To evaluate an existing MVC Platform to identify platform enhancements that are required to support the MVC for monitoring and treatment of patients. | What are the functionalities of the existing MVC platform (MSP + Dolphin)? What improvements can be made on this platform to be suitable for Telemedicine? | The MVC platform architecture as proposed in [21] makes it possible for mobile services to be exposed as web services to the Dolphin community platform. However, the functionalities of interest for this study are that of the Dolphin community platform or Dolphin in short. Dolphin provides membership management, group management and several interaction services such as chat, instant messaging, blogs, forums and photo/video/music sharing among others. On top of this, an online administration panel is provided for configuration of the community.<br><br>On the internal part of Dolphin, extensions were made by [21] to provide service management functionality that allows registration and de-registration of services to the Dolphin platform. An example implementation showed that a location service is registered to the Dolphin platform and can now be utilized by community members.<br><br>However, despite these functionalities, it lacks or has very limited support for group management, role-based access and policy management. In creating a group, the platform should allow participation based on roles as well as specification of policies on the interaction of roles with the services. In this way, it can constrain the group to function in a manner that is desired based on its purpose.<br><br>At the moment, only location service is provided by the Dolphin platform. Services that are required in order to support monitoring and treatment of patients are not provided but must be provided by the platform. Such services include vital sign delivery service, viewing service and interaction service. In relation to these services, the Dolphin DB should store information to support this, extensions on the DB schema is necessary. |

**Table 6-1. Conclusion for each research question of the study**

## 6.3. Recommendation

This study is exploratory in nature since there are no previous studies of applying MVC in Telemedicine. This is partly due to the fact that MVC is an emerging field of research [12]. Thus, several issues are identified as recommendations for further research.

1) The purpose that is supported by the MVC is drawn from the ICF as to understand the tasks that should be supported. It could be the case that if the medical specialist is not familiar with this standard then it might be difficult to identify which classification to use when specifying the purpose of the MVC. For this reason, further study can be done to identify other concepts from which the purpose could be derived.

2) The design specifications for the MVC for monitoring and treatment are based on requirements derived from a single scenario. It is recommended that further tests on the design specification be applied in other scenarios to check the viability of the design.

3) Instead of using scenario analysis in eliciting requirements, other methods such as interviews or surveys can be employed. Interviews and surveys on medical specialists or patients can be beneficial to identify further usability requirements of the MVC platform since these actors are the eventual users of the platform.

4) In the course of enhancing a patient's health status, inter-community interaction may be necessary wherein each the services in each MVC maybe provided by different parties. For instance, a patient with back pain is part of a telemonitoring community but could also be part of a community for physical therapy. There could be parameters in the first community that could be referred to by the second community. To identify these issues, further study is required.

## References


1 TM Alliance. Telemedicine 2010: Vision for a Personal Medical Network, *Final Reports, Project no. IST-2001-35026 of the lnformation Society Technologies* (ISTI Programme of the European Commission (July 2002 - December 2003); 2003; p. 55-57.

2 Ried J., A Telemedicine Primer: Understanding the Issues. Billings, *MT: Innovative Medical Communication*, 1996; 3 4.

3 Roine R., Ohinmaa A., Hailey D., Assessing telemedicine: a systematic review of the literature. *Canadian Medical Association Journal* 2001;165:765–71.

4 Grigsby J., Sanders JH., Telemedicine: where it is and where it's going. *Ann Intern Med.* 1998; 129:123–127.

5 Linkous, J., Business Briefing: Global Healthcare – Advanced Medical Techonologies, 2004, www.touchbriefings.com, last accessed on 12 June 08

6 Istepanian, R., Laxminarayan, S., Pattichis, C (2006). M-Health: Emerging Mobile Health Systems, USA: Springer.

7 Taylor, M., Waung, W., Banan, M. Internetwork Mobility: The CDPD Approach. Prentice Hall Professional Technical Reference ISBN 0-13-209693-5; September 2006

8 Akyildiz, I.F. et al., Mobility management for next generation wireless systems, *Proc. IEEE*, 87(8), 1347-1385, 1999.

9 Schulzrinne, H. and Wedlund, E., "Application-Layer Mobility Using SIP", *Mobile Computing and Communications Review*, Volume 4, Number 3, pp. 47--57, July 2000.

10 Popescu, I., Supporting Multimedia Session Mobility using SIP, *CNSR 2003 Conference*, May 15-16, 2003, Moncton, New Brunswick, Canada.

11 Wang, Q., and Abu-Rgheff, M. Towards complete solution to mobility management for next-generation wireless system, *London Communications Symposium*, 2002.

12 El Morr C., Kawash J., Mobile Virtual Communities: Current Trends and Future Perspectives, *International Journal of Web Based Communities*, Vol. 3, No 4, pp. 386-403, 2007.

13 Fremuth, N., Tasch, A., Fränkle, M., Mobile Communities - new business opportunities for mobile network operators?, In: *Proceedings of the International Workshop on Mobile Multimedia Communications*, Munich, 2003.

14 Kawash, J., El Morr, C. and Itani, M., A novel collaboration model for mobile virtual communities. *International Journal Web Based Communications*, Vol. 3, No.4, 2007.

15 Rakotonirainy, A., Loke, S.W., and Zaslavsky, A., Towards Multi-Agent Support for Open Mobile Virtual Communities, In: *Proceedings of the International Conference on Artificial Intelligence* (IC-AI 2000), pages 127–133, Las Vegas, EUA, 2000. CSREA Press.

16 Leimeister, J.M., Daum, M., and Krcmar, H. "Mobile Virtual Healthcare Communities: An Approach To Community Engineering For Cancer Patients," *Proceedings of the Xth European Conference on Information Systems (ECIS)*, Gdansk / Danzig, 2002, pp. 1626-1637.

17 Hampe, J. F., Schubert, P., Schneider, F., Mobile Community Support: A Mobile Reservation System for the Leisure Industry, In: *Proceedings of the 17th International Bled Electronic Commerce Conference*, Bled, Slovenia, June 21-23, 2004.

18 Preece, J. (2000). Online Communities: Designing Usability, Supporting Sociability. Chichester, England: John Wiley & Sons.

19 Porter, C.E., A Typology of Virtual Communities: A Multi-Disciplinary Foundation for Future Research, *Journal of Computer-Mediated Communication*, Vol. 10 (1), November 2004.

20 Maloney-Krichmar, D. and Preece, J., A multilevel analysis of sociability, usability, and community dynamics in an online health community, *ACM Trans. Computer-Human Interaction*, 12(2), 201-232.

21 Pitsillides, A., Pitsillides, B., Samaras, G., Nicolau, M., Andreou, P., Avgousti, R., Enhanced Home-Care through DITIS's dynamic creation management of Virtual Health-care Teams, www.ditis.ucy.ac.cy/publications/bookchapters/DITISIndianBookChapter.pdf, last accessed 20 July 2008.

22 Atlas of Health in Europe (2003). World Health Organization Library, ISBN 92 890 1370 2.

23 Van Halteren, A., Bults, R., Wac, K., Konstantas, D. and Widya, I., "Mobile Patient Monitoring: The MobiHealth System," *The Journal of Information Technology in Healthcare*, 2004; 2(5): 365–373

24 Pawar, P., Subercaze, J., Maret, P., van Beijnum, B., Konstantas, D., Towards Business Model and Technical Platform for the Service Oriented Context-Aware Mobile Virtual Communities, http://liris.cnrs.fr/Documents/Liris-3377.pdf (last accessed 27-Aug-2008).

25 Tulu, B., Chatterjee, S., and Maheshwari, M., Telemedicine Taxonomy: A Classification Tool. *Telemedicine and E-Health Journal*, Vol.13, No.3, 2007, pp.349-358.

26 WHO: ICF: International classification of functioning, disability and health. World Health Organization Geneva, Switzerland; 2001.

27 Tulu, B., Chatterjee, S., and Laxminarayan, S., A Taxonomy of Telemedicine Efforts with respect to Applications, Infrastructure, Delivery Tools, Type of Setting and Purpose, *Proc. 38th Hawaii International Conference on System Sciences*, 2005.

28 Cieza, A., Stucki, G., Weigl, M., Kullmann, L., Stoll,T., Kamen, L., Kostanjsek, N., and Walsh, N., ICF Core Sets for chronic widespread pain, *Journal of Rehabilitation Medicine*, Volume 36, Issue S44 August 2004 , pages 63 – 68

29 Stucki G., Cieza A., Ewert T., Kostanjsek N., Chatterij S., Bediran Ustunn, T., Application of the International classification of functioning, disability and health (ICF) in clinical practice, *Disability and Rehabilitation*, 2002, Volume 24, pp. 281 – 282.

30 Mobihealth – Putting Care in Motion, http://www.mobihealth.org/, last accessed on 13 November 2008.

31 Jones, V., Halteren, A., Widya, I. et. al. "Mobihealth: Mobihealth Services Based on Body Networks," M-Health Emerging Mobile Health Systems. Springer-Verlag, Berlin, pp. 219-236., 2006, ISBN 0-387-26558-9.

32 Mobile Healthcare Solution - A Life Less Limited, www.healthservice24.com, last accessed on 10 November 2008

33 Awareness: Context AWARE mobile NEtworks and ServiceS, http://awareness.freeband.nl/, last accessed on 10 November 2008.

34 Wedlundand, E. and Schulzrinne, H., "Mobility support using SIP," In: *Second ACM/IEEE International Conference on Wireless and Mobile Multimedia* (WoWMoM'99), (Seattle, Washington), Aug.1999.

35 Hsia, P. et al., "Formal Approach to Scenario Analysis," *IEEE Software*, Vol. 11, No. 2, Mar. 1994, pp. 33-41.0

36 Booch, G., Rumbaugh, J. and Jacobson, I. (1997). The Unified Modeling Language user guide: Addison-Wesley.

37 Olive, A. (2007). Conceptual Modeling of Information Systems, Springer.

38 Unified Modeling Language, http://www.uml.org/, last accessed date: 10 November 2008

39 Warden, R. (1992). Software Reuse and Reverse Engineering in Practice. London, England: Chapman & Hall, 283–305.

40 Hainaut, J. Introduction to Database Reverse Engineering, Technical report, University of Namur (2002). http://www.info.fundp.ac.be/~dbm/publication/2002/DBRE-2002.pdf last accessed on 22 October 2008.

41 Subarcaze, J., Maret, P., Calmet, J., and Pawar, P. A Service Oriented Framework For Mobile Business Virtual Communities, liris.cnrs.fr/Documents/Liris-3422.pdf, last accessed on 20 October 2008.

42 Dolphin – Smart Community Builder – Free Software, www.boonex.com/products/dolphin/, last accessed date: 10 November 2008

43 Single Sign-on, http://www.opengroup.org/security/sso/, last accessed date: 10 November 2008

44 Studer, R., Grimm, S., Abecker, A. (2007) Semantic Web Services: concepts, technologies and applications. Springer.

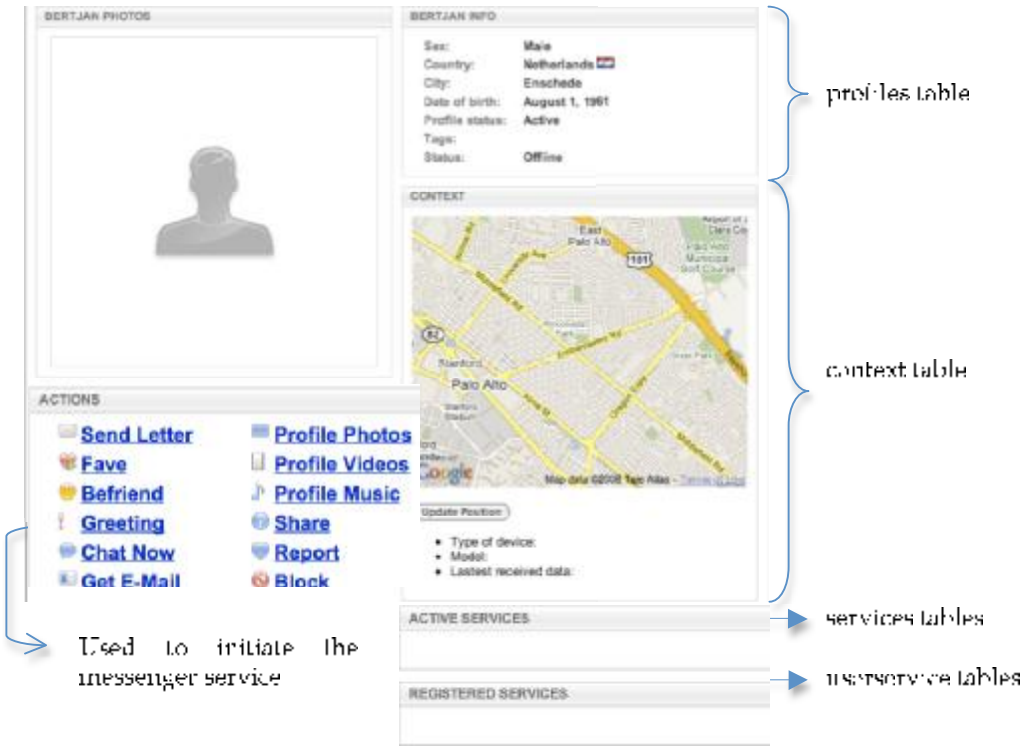
# Appendix

## A. Mapping of Dolphin interface to the database tables

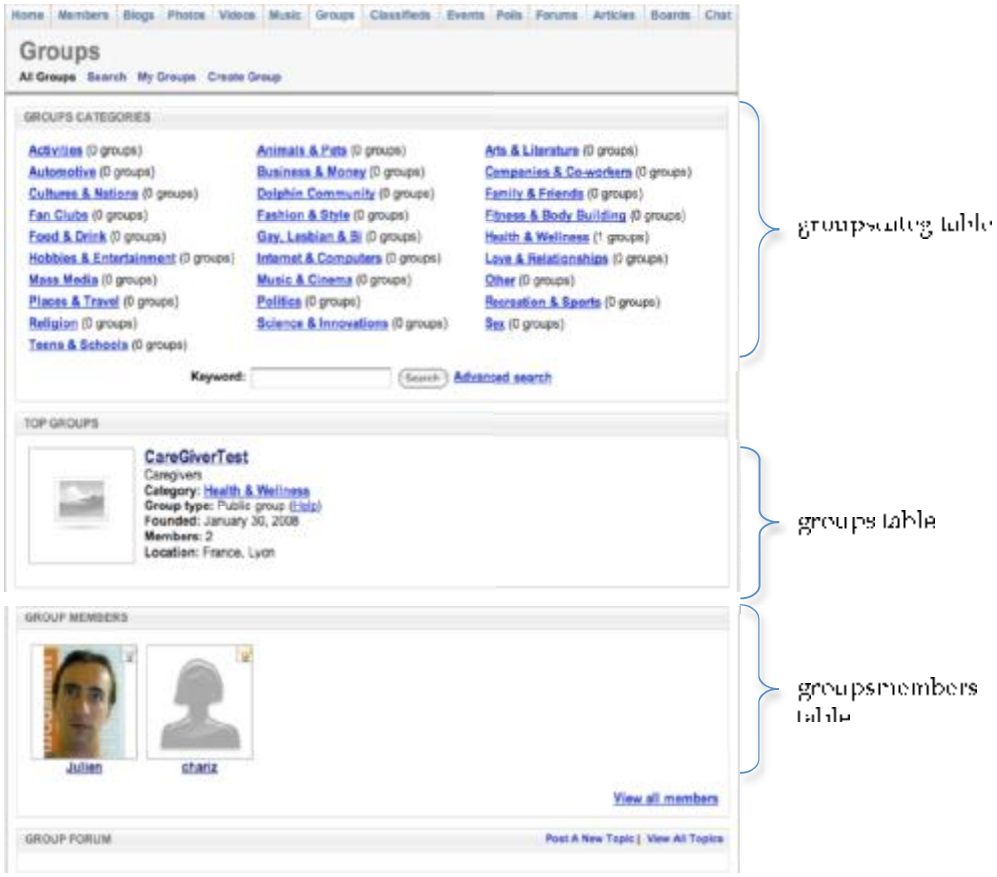
- Dolphin Menu


| Menu | Main Tables |
|---|---|
| Members | profiles |
| Blogs | blogs |
| Photos | profiles |
| Videos | raymoviefiles |
| Music | raymusicfiles |
| Groups | groups |
| Classifieds | classifieds |
| Events | sdatingevents |
| Polls | profilesxolls |
| Forums | pw forum |
| Articles | articles |
| Boards | rayboardboards |
| Chat | raychatcurrentusers |

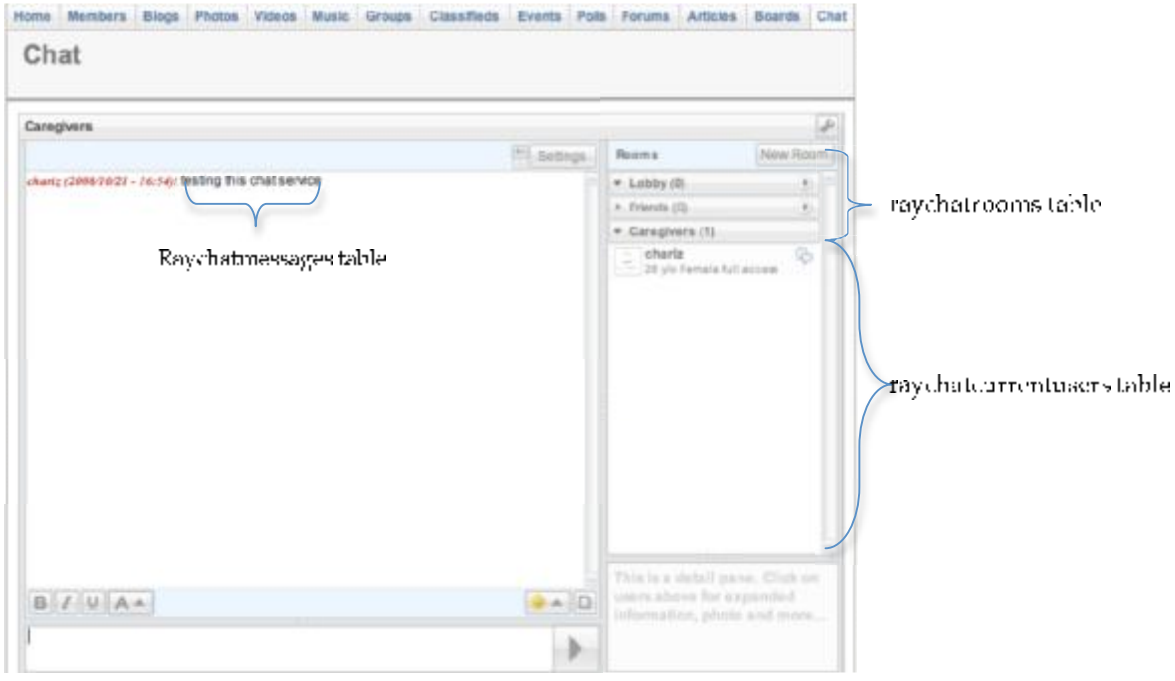
- User Profile



- Groups and group membership




- Chat service



- Instant Messaging (IM) service

  The sender can only invoke the IM service when the receiver is logged on to the community platform. A separate screen pop up when the IM is used by the sender. If the receiver is not using the pop up screen, a notification shows up in the community platform showing the pending message from the receiver. When the receiver accepts the message, a private communication can then be made.