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Requirements Engineering Framework for Information Utility Infrastructure for Rural e-Healthcare Service Provisioning

O. O. Olugbara, Centre for Mobile e-Services for Development, Department of Computer Science, University of Zululand, South Africa; E-mail: oluolugbara@gmail.com

S. O. Ojo, Centre for Mobile e-Services for Development, Department of Computer Science, University of Zululand, South Africa; E-mail: sundojo2000@gmail.com

M. O. Adigun, Centre for Mobile e-Services for Development, Department of Computer Science, University of Zululand, South Africa; E-mail: madigun@pan.uzulu.ac.za

ABSTRACT

The accessibility to important healthcare resources and the costs of healthcare services are serious challenges facing the rural communities of most developing countries. In order to address these problems, we are pursuing rigorous experimental investigations for the development of an information utility infrastructure, which takes advantages of emerging Utility Grid Computing (UGC) and Body Area Network (BAN) for ubiquitous e-Healthcare service provisioning. In this paper, we derive the system requirements from enterprise models and delineate the general framework guiding the development of the infrastructure.

Keywords: Healthcare Management, Body Area Network, Grid Computing, Enterprise Model

1. INTRODUCTION

Most rural communities in developing countries are facing debilitating situations regarding accessibility to quality healthcare services. There is high demand for increased accessibility to important healthcare resources, increased efficiency and quality-oriented healthcare services with limited financial resources. Rural communities are characterized by prevailing issues such as low health level, low literacy level, limited resources and professional isolation.

In a modern information society, patient care increasingly requires healthcare practitioners to access accurate and complete health information so as to effectively manage the safe and efficient delivery of complex and knowledge intensive healthcare. There is also the need to share this information within and between care teams. On the other hand, patients require access to their own health information in order to allow them play significant role in their health management. These essential requirements are becoming more urgent as focus of healthcare management shifts progressively from reactive to proactive care, which requires the involvement of patient's personal environment to provide quality healthcare services.

However, much of the fine-grained healthcare information upon which future care depends is still captured into paper archives or at best in isolated hospital databases and managed by proprietary applications. These applications are developed using different technologies and to seamlessly interoperate them is a difficult task. The problem being investigated is how to practically use Information and Communication Technology (ICT) to provide quality and cost-effective healthcare services to rural communities. A simple solution is to adopt the existing remote monitoring systems that have been used in developed countries like America and Europe. However, these technologies have not been widely used in Africa because of their (i) expensiveness and inflexibility for new services and applications, (ii) service provider dependency and (iii) possibility for communication delay during patient-healthcare practitioner interactivity.

The BAN-UGC integration has exceptional potential to improve the quality of healthcare services whilst simultaneously cutting costs by aggregating multiple heterogeneous resources. The technology will support the mobility of people and increase service availability through pervasiveness, home care support and point-of-care treatment. The rest of the paper is summarized as follows. Section 2 describes the BAN-UGC integration. Section 3 describes an Enterprise model for rural healthcare service provisioning. Section 4 gives the requirements for a healthcare utility service infrastructure and the paper is concluded in section 5.

2. INTEGRATION OF BODY AREA NETWORK AND UTILITY GRID COMPUTING

The MobiHealth [1] introduced innovative value-added mobile healthcare services based on public broadband 2.5G (GPRS) and 3G (UMTS) wireless networks for continuous monitoring and transmission of vital signals. This was achieved with the integration of smart sensors to a wireless generic BAN [2]. The BAN is a wireless health monitoring system that consists of sensors, actuators, communication and processing facilities and integrates wearable devices for connecting different sensors. The BAN sensors are responsible for data acquisition, measurement and transmission processes ensuring that a physical phenomenon, such as patient movement, muscle activity or blood flow is converted to an electrical signal. The signal is amplified and internally communicated within the BAN through intra-BAN communication process. The gateway that facilitates extra-BAN communication of vital signals to healthcare providers or brokers is the Mobile Base Unit (MBU) [3]. This way the network facilitates time and location independent monitoring of a patient's health conditions.

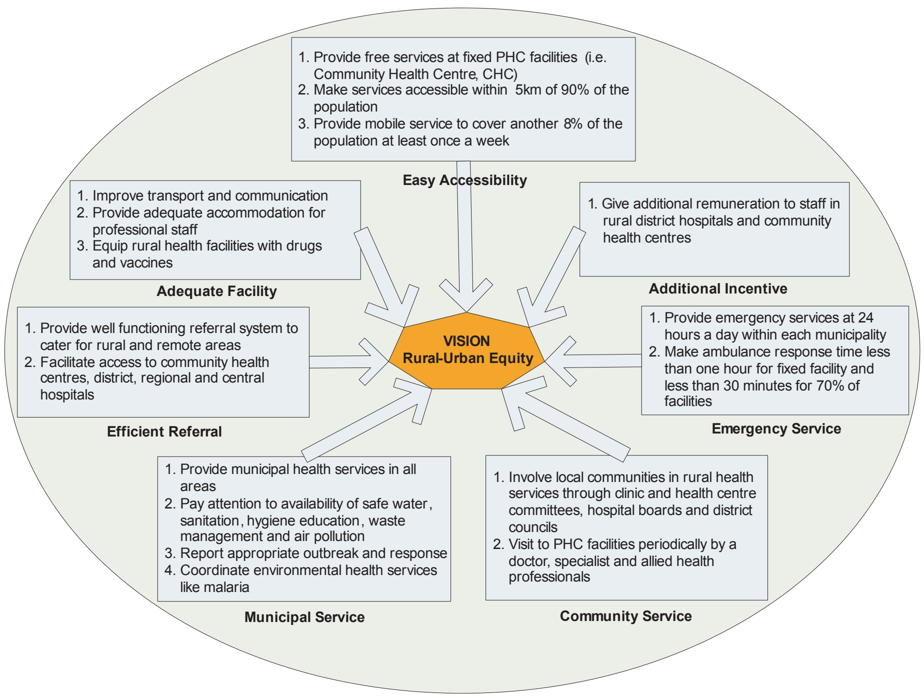
A utility grid [4] is a distributed enterprise grid that provides resources on-demand and supports a pool of computers to be assigned as needed to take-up extra demand that can defy the potential of human expertise. The BAN-UGC integration gives rise to new healthcare services and applications that can provide remote diagnosis and treatment capabilities. Using this integrated technology, healthcare practitioners and patients will have access to resources that can not be provided by BAN only. For example, a patient health records could be moved around and a healthcare practitioner would be able to collaborate with colleagues from other locations and make informed decisions anytime by sharing resources. The vital signals that are measured and transmitted to a software broker could be adequately analyzed using the discovered grid resources. The result of the analysis would be effectively delivered to the user in a real-time. Thus, enabling remote management of patient conditions and quick detection of health emergencies whilst maximizing patient mobility and minimizing healthcare costs.

3. AN ENTERPRISE MODEL FOR RURAL HEALTHCARE PROVISIONING

This section summarizes the Enterprise model for rural healthcare service provisioning in the developing country context, using the Republic of South Africa (RSA) healthcare service provisioning strategy scenario. This strategy is based on the adoption of mobile clinics, efficient referral and Primary HealthCare (PHC) systems. The healthcare service provisioning process was analyzed to align with the established ways of practice and to capture the basic invariant structure of the service provisioning tasks. The refined Enterprise model [5], which includes entities related to BAN, was extended to incorporate UGC concepts. This was used to derive the computational and engineering level requirements for the healthcare utility service infrastructure.

A rural healthcare provisioning process is a workflow of vision-driven tasks aimed at achieving rural-urban equity in healthcare service provisioning, so as to improve the health status of every citizen. From an enterprise modeling perspective, a task typically contains several subtasks, each of which represents several activities.

Figure 1. A vision-driven rural healthcare service provisioning model



A task therefore, is an embodiment of healthcare activities [6]. In this context, a task identifies the vision, goal or objective to accomplish, a subtask states what service is required and activities state how to implement the subtasks to achieve the intended vision. Figure 1 depicts the summary of the refined task activities of the rural healthcare service provisioning practice in RSA.

4. REQUIREMENTS FOR HEALTHCARE UTILITY SERVICE INFRASTRUCTURE

The Enterprise model was directly used for deriving the requirements for the infrastructure support of healthcare service provisioning processes. These can be grouped amongst others into control-plane and usage-plane requirements.

4.1 Control-Plane Requirements

These are the requirements associated to the setup of the bindings of the agent to agent communication, remote monitoring of vital signals, diagnosis and treatment. Some of the requirements include (i) addressing; the MBU needs to be addressable in the wireless environment. The devices attached to the BAN must have unique addresses to be individually addressed. The data acquisition front-end of the devices must be uniquely addressed within a centrally controlled BAN, (ii) plug-and-play; the BAN becomes unknown in the environment whenever the MBU is powered off. The MBU start-up should therefore, contain a push mechanism to enable its discovery in the augmented reality environment. Quality of Service (QoS) mechanisms should be included to enable capacity alignment within the networked and in inline with the application's QoS requirements and (iii) adaptable communication; the amount, quality and coherence of the data to be exchanged have to match with the limitations of the communication channel capability. Adaptable services are typically required in these environments to better cope with bandwidth limitations and variations in communication errors such as data loss and channel dropouts. Data buffering, data prioritization, synchronization mechanisms and data acknowledgements are important requirements. Resource control policy such as computational economy, resource prioritization and reservation are required for effective management and scheduling of resources in the highly distributed environment.

4.2 Usage-Plane Requirements

These are the requirements in respect of data transfer and they are basically the upstream push and downstream messaging mechanisms. The data transfer mechanisms should be implemented such that transfer delays do not exceed the boundaries given by human factor studies. Another important requirement is the communication costs, continuous monitoring of signals and resource consumption must be regulated for effective management purpose. A different cost model for continuous transmission applications such as flat rate charge for unlimited data and usage is desirable.

4.3 e-Healthcare utility-Service Broker

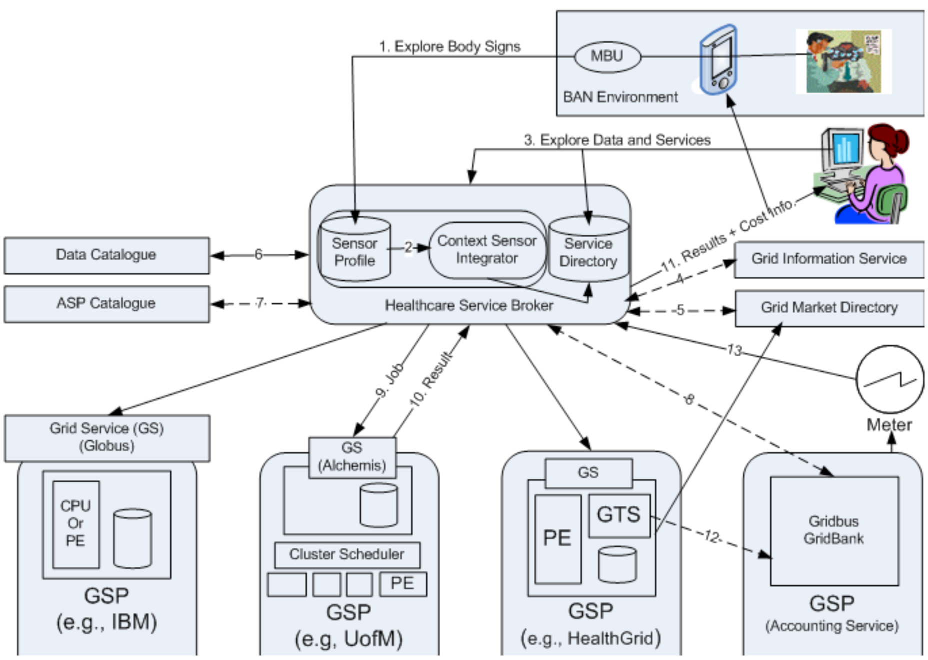
The BAN-UGC integration raises some entirely new requirements for service infrastructures. These requirements can be met by a new type of Grid Resource Broker (GRB), a Healthcare utility-Service Broker (HSB). The HSB acts as a mediator between the user and the network resources to perform various tasks such as patient's health status monitoring, diagnosis and treatment, using sensors and grid services. Figure 2 depicts the on-demand assemblage of healthcare services using the HSB technology.

The BAN collects and transmits vital signs to the sensor profile (Step 1). Context Sensor Integrator (CSI) converts sensor data to a service request specification and store in the service directory (Step 2). User requests can in two forms (i) a service retailer registers services to offer to end-consumers as free social services or on charge basis and (ii) a user subscribes for a service using proximate selection (Step 3). The broker performs service discovery based on request using web services-based Grid Information Service (GIS) and Grid Market Directory (GMD) (Steps 4 and 5). The broker identifies the list of data sources or replicas and selects the optimal ones (Step 6). The broker also identifies the list of computational resources that provides the required services using Application Service Provider (ASP) catalogue (Step 7). The broker ensures that the user has the necessary credit or authorized share to utilize resources (Step 8). The broker scheduler assigns and deploys jobs to grid services that meet QoS requirement (Step 9). The broker agent on the grid resource at the Grid Service Provider (GSP) then executes the job and returns the result (Step 10). The broker collects the results plus cost information and passes them to the user (Step 11). The metering system charges the user by passing the resource usage information to the accounting service (Step 12). The accounting service reports the remaining resource share allocation and credit available to the user via the broker's Local Billing System (LBS) (Step 13).

5. CONCLUSION

This paper gives the infrastructure requirements for BAN-UGC integration that incorporates smart sensors and grid services to support and improve distributed

Figure 2. On-demand service provisioning in utility grid



healthcare service provisioning. These requirements were derived from Enterprise models capturing the community invariants of the healthcare service provisioning processes. The proposed approach has the benefit of making ubiquitous quality healthcare services available and helps in addressing the rural-urban healthcare service provisioning inequality.

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Community-Based Performance Management in Local Government

Peter Demediuk, Victoria Graduate School of Business, Victoria University, Australia; E-mail: peter.demediuk@vu.edu.au

NOTES:

I have finished all progam coursework and am enrolled part-time in the doctoral program. I am in the process of constructing the proposal. I would expect to have the proposal ready in May for comment and discussion, and plan to have the thesis completed in 18-24 months after that.

SUMMARY

Performance management occurs where performance measurement intersects with organizational action - and the ambit of accounting has extended to cover significant parts of this cycle. The best value reforms to local government in the UK and Australia valorize performance measurement and community engagement as necessities for effective governance, and so we must now cope with the interaction of action, performance measurement and community engagement. This research will investigate current practice in community engagement within service delivery areas of Australian local governments. In particular the research will explore the gap in the literature about how the engagement impacts on decision-making.

COMMUNITY ENGAGEMENT AND PERFORMANCE MANAGEMENT

"Citizen participation in the decisions that affect their lives is an imperative of contemporary society", and since the latter part of the twentieth century we are witnessing a shift away from reliance on public officials and administrators to frame objectives and action (Roberts 2004, p. 369). The trend towards public involvement in decision-making should "… grow as democratic societies become more decentralised, interdependent, networked, linked with new information technologies, and challenged by wicked problems" (Roberts 2004, p. 316).

Kathi and Cooper (2005, p. 559) categorise the central arguments for citizen participation in governance under moral and instrumental normative grounds. The moral normative argument is that citizen participation in the work of government is a basic right in a democracy. The three instrumental normative arguments hold that community participation: promotes efficiency and effectiveness; is a vehicle for community empowerment and change; and bolsters political stability.

The 'Best Value' performance management framework in Victoria requires local governments to provide, and continuously improve, 'value for money' services that are relevant to community needs. This requirement has three important implications for performance management in government. Firstly it calls for rational decision-making by local government politicians and managers, where action must be driven by good performance information. Secondly, it calls for robust accountability mechanisms, where good performance information needs to capture the results of action. Thirdly, because the nature and impact of services must reflect community needs, the performance information which drives action and captures results must be the subject of community input. So Best Value in Victoria, and similar reforms in Sweden, the UK and New Zealand have challenged traditional practice by requiring a three-way linkage between institutional action, performance measurement, and community engagement. In the midst of such initiatives by governments to increase the level of community engagement, there is a gap in our understanding about the impact of community engagement on decision-making (Kathi & Cooper 2005) (Department of Justice Canada 2001).

AIM AND OBJECTIVES OF THE THESIS

The aim of this study is to investigate the nature of community engagement in local government and its impact on performance measurement and organizational learning. This study seeks to identify: the forces that shape community engagement; the levels and mechanisms of engagement; and how engagement drives changes in performance measurement and management. From the research results, we should gain a better understanding about the effect of community engagement on decision-making and specify critical success factors for sustainable and effective community-centered corporate governance in local government.

OBJECTIVES

- identify: the forces that shape community engagement; the levels and mechanisms of engagement; and how engagement drives changes in performance measurement and management
- gain a better understanding about the effect of community engagement on decision-making and specify community informatics success factors and other CSFs for sustainable and effective community-centered corporate governance in local government

Note: community informatics is the design & application of information and communication technologies to enable community processes and the achievement of community development objectives (Denison et al. 2003).

This study will examine and contrast the perceptions of local government managers and politicians in Victoria and Sweden about the interaction between community

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