A QoS Data Management System within a Pervasive Medical Environment

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Abstract. Pervasive medical environments can produce large quantities of additional information, for example patient sensor readings. Such datasets need to be collected, correlated and presented in a context aware manner to meet the real-time needs of the mobile medical practitioners. Within this distributed environment a sophisticated middleware infrastructure is needed to manage and interpret patient and practitioner data streams. This work highlights some of the key aspects of a medical-based Data Management System (DMS). The DMS aims to effectively manage all datasets through the development of DMS protocols. The proposed architecture is designed to improve productivity levels of medical practitioners through the use of software agents. As software agents are ideally suited to deal with context rich environments, the potential improvement in accuracy of patient diagnosis at the Patient Point of Care (PPC) is increased. Within a medical environment the focus on QoS is paramount, since one should try to ensure that physicians get the “correct” data on time every time. An overview of the DMS and its QoS protocols are presented.

1 Introduction

Currently a large proportion of patient records and lab results are documented in written format, often kept in an unstructured manner. Cases frequently arise where patient medical records are unobtainable for many days and in some instances are lost. Moving from a complete paper based system to a complete electronic based environment does not guarantee a higher QoS [1]. A combination of the two may provide the optimal approach in handling patient datasets.

Access to accurate and relevant real-time patient information would greatly improve a medical practitioner’s productivity level. This may be achieved with the aid of mobile medical devices (e.g. PDA, TabletPC). Scenarios have been presented where handheld devices enhanced the QoS at the PPC [2][3]. This position paper outlines some of the key features of the Data Management System (DMS) [4]. The DMS is designed to manage context aware variables which may include patient and staff location, in conjunction with real-time patient vital sign readings. Context aware software agents provide an intelligent middleware, enabling mobile devices to provide a higher QoS at the PPC.
Three input streams are managed by the DMS, 1) Wireless patient sensors, 2) Mobile devices (e.g. PDAs and Mobile Phones) and 3) Medical information (e.g. Ontology Models, User Profiles). The objective of this research is examining and developing intelligent data collecting, data correlating and data presentation protocols which can provide a high quality of service i.e. deliver accurate and relevant data to medical practitioners.

1.1 Wireless Patient Sensor Networks

Wireless Patient Sensor Networks (WPSNs) are a growing research and product based environment. Their effectiveness will be dictated by how well they interact with general purpose computers and mobile devices. Every sensor value emanating from a WPSN needs to be defined and placed in a proper context. For example, during blood pressure analysis, systolic (contraction of the heart) and diastolic (relaxation of the heart) levels are taken. A correct analysis of a patient’s state of health is based on their context, real-time readings and profile [5]. A profile may include: the age, gender, previous medical history, current condition (e.g. pregnancy, thrombosis) of the patient. It is common for a pregnant patient to have a slightly elevated systolic and diastolic readings. If this is taken into account during diagnosis false alarms will not be raised.

New application domains are emerging as wireless sensing devices are growing in popularity and reducing in cost. Our research is based on the union between three specific domains i.e. WPSNs, Software Agents and Mobile Devices. This will enable us to investigate “how do we provide a higher QoS at the PPC?”

![Fig. 1. An exposed Tyndall-DMS-Mote working alongside the Mobile-DMS-Client (i.e. a software agent providing intelligent processing and communication behaviors) on a Nokia 9500 Communicator.](image)
2 Data Management System Protocols

DMS protocols are designed to function within a wireless medical network environment. A Tyndall-DMS-Mote (i.e. wireless patient mote) was developed (cf. figure 1) [6] to sample patient vital signs readings in real-time. It includes Blood Pressure, Pulse Rate, Body Temperature and Electrocardiogram (ECG) sensors. The Tyndall-DMS-Mote enables development of data management protocols for non-critical patients. Such protocols are designed to work in conjunction with a medical practitioner’s mobile device.

A sophisticated agent middleware is employed (i.e. Jade and Jade-Leap [7]) to handle the real-world context aware data variables e.g. medical practitioners requests, patient vital signs etc. This provides the basis of the DMS architecture [4].

All datasets within the DMS require appropriate processing and must be analysed in the context of other available medical information (e.g. patient profile). It is essential that the processing and analysis of the data is underpinned by an appropriate semantic model. An application-specific ontology which is appropriate to the needs of a cardiovascular patient has been built. This is a concise model that represents the information in the context of the application domain.

The DMS architecture enables real-world scenarios to be examined and analysed. Each DMS protocol is designed to implement certain QoS rules. DMS agents execute on general purpose computers, PDAs and mobile phones (cf. figure 2). They provide DMS protocols in four key areas:

1) User Profiles
User profiles in association with data filtering techniques may reduce information overload and return only relevant information to the end user [8]. This has the advantage of reducing the search time required at the PPC. Presented in [5] are patient and practitioner profiles in conjunction with real-time vital sign readings (e.g. blood pressure). Here real-time context aware variables are analysed based on the user’s properties, thus improving diagnosis. A practitioner's daily schedule may be used to push relevant patient datasets to their mobile device, based on their patient list and location (e.g. ward 1A) [9]. Context Real-time updates at the PPC can provide an enhanced view of the patient’s current condition. Conversely for long periods of time static datasets may reside on the mobile device. This may contain imprecise information, resulting in a poor diagnosis at the PPC.

2) Data Priority
Within an accident and emergency (AandE) department multiple patients may arrive. Each patient needs to be assigned a priority level (i.e. triage procedure). This priority is associated with the current and predicated state of that patient [10]. The DMS Data Priority protocol, examines the real-time vital sign readings of the admitted patient. Then according to various context variables the priority of the patient will dynamically change.
3) Data Validation
Sensor failures or errors may occur due to complete device malfunction or interference. Within a hard real-time medical environment such failures/errors are not acceptable as they may result in resource mismanagement (i.e. taking up staff time) or cover up a serious medical symptom. The DMS provides intelligent protocols which monitor multiple sensors of the same type (e.g. two pulse sensors) within a Body Area Network (BAN). A tolerance level is built in. However if this tolerance level is exceeded a sensor failure or error alarm is triggered.

4) Data Consistency
Multiple mobile devices may be active within a medical environment. Simultaneously one or more members of the medical staff may need to monitor a specific patient’s dataset and real-time vital sign reading. We need to ensure that all mobile devices are up to date with the necessary information. Jade agents contextually upload the medical practitioner’s PDA with the required information at the PPC.

Fig. 2. The DMS Network providing QoS Protocols.
3 Conclusion and Future Work

This position paper outlines our strategy of enabling future mobile medical devices to provide a higher QoS at the PPC. This solution motivates the use of WPSNs, context aware agent technologies and medical knowledge base systems. The synergy between these three facets result in relevant information being delivered to the medical practitioner in real-time. Four DMS protocols were outlined. Each protocol executes on top of an intelligent agent platform. This enables reactive and proactive procedure calls to be made based on all available context aware variables. Additional work is continuing with blood pressure models for non-critical outpatients within and outside their home [11]. It is envisaged that multiple real-world experimental prototypes will be deployed. The effectiveness of the DMS protocols will be analysis based on such experiments.

Acknowledgment

This work is funded by the Boole Centre for Research in Informatics and is supported by the Tyndall National Institute through the SFI-funded National Access Programme (NAP).

References


