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A pervasive assistant for nursing and doctoral staff

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Abstract. The goal of health-care institutions is to provide patient-centric health care services. Unfortunately, this goal is frequently undermined due to human-related aspects. The PervasIve Nursing And docToral Assistant (PINATA) provides a patient-centric system powered with Ambience Intelligence techniques and Semantic Web technologies. Through PINATA, the movement of patients and medical staff is tracked via RFID sensors while an automated camera system monitors the interaction of people within their environment. The system reacts to particular situations autonomously by directing medical staff towards emergencies in a timely manner and providing them with just the information they require on their handheld devices. This ensures that patients are given the best care possible on a 24/7 basis especially when the medical staff is not around.

1 INTRODUCTION

One of the main challenges faced by healthcare institutions is to maximize the available time that doctors and nurses spend with patients and to decrease mundane tasks such as form filling, which though important, inhibits the health worker's efficiency and effectiveness. Ambient Assisted Living (AAL) systems which make use of Ambient Intelligence (AmI) technologies can help to solve these problems and to provide personalized solutions such as in [2] and [4]. These systems can be used for various tasks such as monitoring the patient's permanence in a hospital, track down medical records, monitor diet, track movement and detect incidents (such as falls). Back-end intelligent systems are required to analyse the feedback obtained through the different sensors located around the hospital and recommend a plausible course of action for the medical staff.

2 STATE OF THE ART

Ambient Intelligence (AmI) builds on three key technologies: ubiquitous computing, ubiquitous communication and intelligent user interfaces [2]. Ubiquitous computing means integration of microprocessors into everyday objects like furniture, clothing, white goods, toys and even paint. Ubiquitous communication enables these objects to communicate with each other and with the user by means of ad-hoc wireless networking. Intelligent user-interfaces enable people in the AmI environment to control and interact with the environment in a natural (voice, gestures) and personalised way (preferences, context) [1]. In AmI, people are empowered through a context aware environment that is sensitive, adaptive and responsive to their needs, habits, gestures and emotions. It is expected that by providing intelligent environments, quality and cost control can be improved and innovative intelligent personal health services can be developed.

The five rights of patient care are often given as right patient, right drug, right dose, right route and right time [8]. Through technologies such as RFID or Radio-Frequency Identification, it is possible to further integrate the digital and healthcare worlds to maintain those five rights and to join-up care and processes. In [2] this technology was used to provide personalised visualisation of patients' information (including also images) to doctors during a clinical session. In [4] there is an outline of an RFID model for designing a real-time hospital-patient management system. A pilot implementation was done in [3] which consisted in monitoring of person and patient logistics in operating theatres, tracking and tracing of operating theatre materials and tracking and tracing of blood products. In [9] it was being predicted that the RFID technology was to play a very important role in the healthcare sector.

3 METHODOLOGY

PINATA is based upon a Service Oriented Architecture (SOA) similarly to [7] and is composed of two main components (as can be seen in Figure 1); a Knowledge Brokering module (KBr) and a Device Manager (DM).

The KBr consists of two main components, a KnowledgeBase (KB) and an AmI module. The role of the AmI is to integrate the patients' information obtained through various sensors (after storing it inside the KB), analyse it and recommend a way forward. This module makes use of a number of domain specific ontologies which have been crafted in consultation with various medical entities. The Patient Ontology is one such ontology. It is an electronic representation of the patients' records and describes patients' profiles in terms of various health-related information. The Medical Ontology, is based on [5] and [6] and represents conceptual knowledge about clinical situations from three perspectives; clinical problems, investigations and recommendations. A set of rules are used to represent the decision-making logic of PINATA. The SOA approach was adopted to facilitate the integration of the patient-related data which typically resides in different hospitals or clinics. This approach allows the system to query the different organizations, get the data and collate it together thus providing a unified view of the information for the KBr. Once all the information is inside the KB, the AmI infers new knowledge from the available information and sends it to the medical staff for immediate action.

The DM handles the various devices connected to the system. It also serves as a communication gateway between the AmI and the medical staff. In the present hospital scenario, the patient has an

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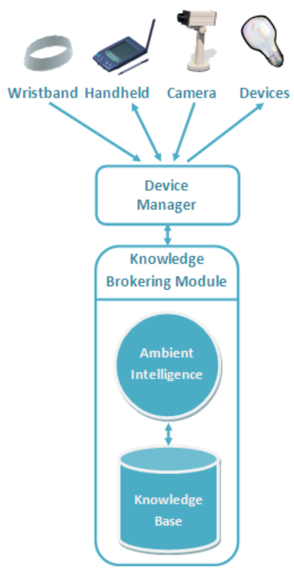

Figure 1. The PINATA Architecture

RFID tag embedded inside the wrist band. The various RFID readers around the hospital detect the movement of the patient and send the information to the DM and eventually to KBr. This ensures that the patient's whereabouts are continuously known by the medical staff. Handheld devices are used to provide the staff with various types of information including alerts (related to patients' medication schedule). These alerts are described in the Medical Ontology and the web service responsible of keeping track of the patient's medications makes use of this knowledge when sending out the alert to the nurse's device. When a nurse is in the proximity of a patient, the handheld device reads the RFID tag and can automatically display the patient's information, again via the appropriate set of web services.

PINATA makes use of a camera-based monitoring system similar to [10], which tracks the movement of patients, through image processing and in case of an emergency alerts the nurse. To ensure that this system in no way presents a threat to the patient's privacy, images are not recorded by the cameras. A typical situation in which this system becomes important is that in which a patient faints and falls in his room. Information captured through the camera is collated and analysed by the KBr which triggers an alert via the DM that is sent to the nurse. The RFID system is used to track the nurse which is in the closest vicinity to the patient in distress. The system also uploads automatically on the nurse's handheld device, all the information required for that particular context. In a typical situation such as that in which the patient is suffering from anaphylactic shock due to some allergic reaction, the system is able to recommend to the nurse the best course of action. If the situation is deemed critical by the system (based upon various cues extracted from the environment and based upon knowledge accumulated during past events), it will automatically escalate the problem and request for reinforcements.

Through the DM, PINATA can also interact with the surrounding environment and influence it. The KBr module is constantly collating the various inputs from the sensors (obtained through the DM) and managing the status of the environment. This involves switching on/off electrical equipment autonomously or alerting the person about possible dangerous situations. A typical situation is that in which a patient wakes up in the middle of the night to go to the bathroom. The KBr can distinguish between a movement in the bed (while the person is sleeping) and the actual action of going out of the bed. In the latter case, the system can switch on the lights of the bathroom automatically and switches them off once the person returns back to his/her own bed.

When patients return back to their homes, a basic version of PINATA can be installed in their homes. This is feasible due to the fact that PINATA is based around a SOA architecture. Thus it is possible to have cameras and sensors installed in the households while the processing and interpretation of the captured data is sent to the main hospital servers for continual monitoring. By doing so, the care provided by the hospitals can be extended to the community, thus making it possible for more patients to spend less time in hospitals and more time recovering in their homes. Once in homes, PINATA can be further extended to handle other aspects of health-care and safety in order to improve on the quality of life.

4 CONCLUSION

Even though PINATA is still a prototypical system and more work needs to be done, the results obtained from the system are encouraging. Patients quickly got used to it and the medical staff understood its potential and are now exploring new possibilities with our help. The beauty of the whole system is that it makes use of rather cheap technology which is readily available but which is controlled by a powerful brain. The KBr module is capable of integrating information obtained from various sources, reasoning things out and deciding on the best strategy. This has showed us that the time is reap to fuse intelligent systems with the real world and this fusion is unleashing new possibilities never thought of before in the field of personal health care and safety.

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