MEPCO SCHLENK ENGG. COLLEGE

SIVAKASI

Paper Presentation on

Improving the Effectiveness of Medical Treatment with Pervasive Computing Technologies

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ABSTRACT:

Technology is moving from personal computers to handheld, intelligent and everyday devices with embedded technology and connectivity. Pervasive computing is a new dimension of personal computing that integrates mobile communication Ubiquitous embedded computer systems, consumer electronics and the power of internet. With pervasive computing, we envision a future in which computation becomes part of the environment. In this paper, we propose our idea to turn pervasive computing into a life saving tool. Our vision is that the application of pervasive computing technologies can significantly help patients manage their diseases and hence improve patient adherence to medical treatments. The scenario that we envision is one in which smart medication augmented with pervasive computing technologies – informs the patient about his blood pressure, sends reminders to take medication, informs doctors and relatives of elderly patients about their condition. If the patient's condition is critical, he is informed to be admitted to the nearby hospital. From a technological perspective, we propose the combination of smart objects (sensors), the patient's mobile phone and internet.

INTRODUCTION:

The goal of pervasive computing, which combines current network technologies with wireless technologies, voice recognition, internet capability and artificial intelligence, is to create an environment where the connectivity of devices is embedded in such a way that the connectivity is unobstructive and always available. It is a numerous, causally accessible, often invisible devices. It makes a computer so natural that we use it without even thinking about it. It provides access to relevant information and applications through a new class of ubiquitous, intelligent appliances that have the ability to easily function when and where needed. Projecting this trend into the future, we envision an explosion of interconnected small devices from watches to cars that make our lives easier and more productive. A parallel revolution lies in the network-enabling these pervasive computing devices by providing transparent, ubiquitous access to e-business services. In general, it is roughly the opposite of virtual reality.

Any time/anywhere---> any device--->any network--->any data.

Any time: 7 days X 24 hours, global, ubiquitous access

Any device: pc, PDA, cell phone and so forth.

Any network: access, notification, data synchronization, queued transactions, wireless optimization, security, content adaptation, development tools, device and user management

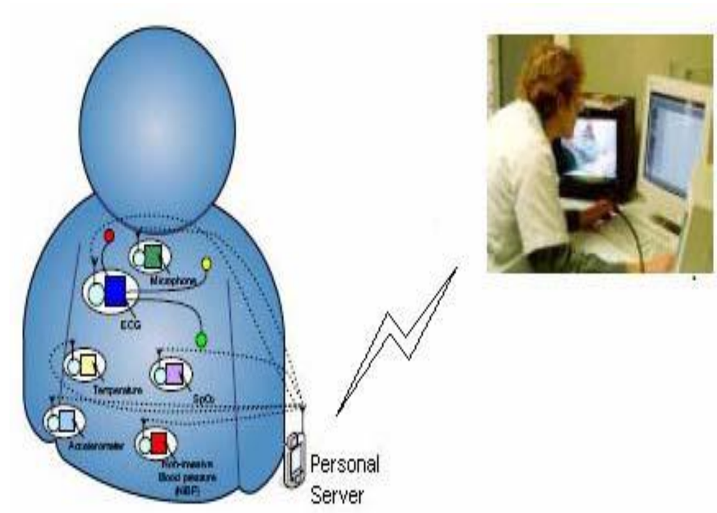
Any data: e-mail, personal information manager, inter-intranet, public services

PERVASIVE COMPUTING:

Pervasive computing is the trend towards increasingly ubiquitous (another name for the movement is *ubiquitous computing*), connected computing devices in the environment, a trend being brought about by a convergence of advanced electronic - and particularly, wireless technologies and the Internet. Pervasive computing devices are not personal computers as we tend to think of them, but very tiny - even invisible - devices, either mobile or embedded in almost any type of object imaginable, including cars, tools, appliances, clothing and various consumer goods - all communicating through increasingly interconnected networks. According to Dan Russell, director of the User Sciences and Experience Group at IBM's Almaden Research Center, by 2010 computing will have become so naturalized within the environment that people will not even realize that they are using computers. Russell and other researchers expect that in the future *smart* devices all around us will maintain current information about their locations, the contexts in which they are being used, and relevant data about the users.

Imagine a world filled with all sorts of electronic devices - traditional desktop computers, wireless laptops, small PDAS, smart cell phones, tiny wristwatch pagers, clever little coffee pots. Imagine all these devices talking easily to one another to bring you the news you need when you need it, regardless of where you are. You have just imagined the future of Pervasive Computing (PvC).

Mainframe Computing era → Personal Computing era → Pervasie Computing era



APPLICATIONS:

Pervasive computing will have strong impact on our society with new technical possibilities, entirely new kind of applications and services arise, bringing benefits for individuals and business. Some of the important applications are

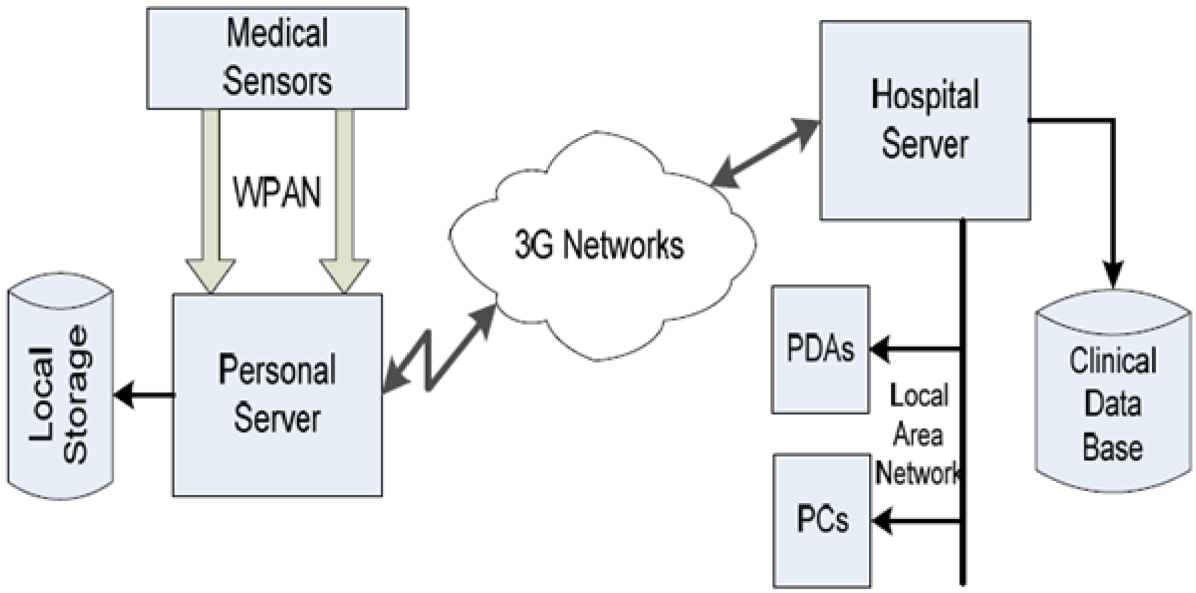
- Airline check-in and booking
- Sales force automation
- Health care
- Car information systems

- Email access via WAP and voice
- Entertainment industry
- Manufacturing industries and logistics

PROPOSAL:

Mass produced patient vital sign measuring devices provide a low cost approach for monitoring at the home. They are particularly suited in remote areas where access to medical assistance is not readily available. They also provide a convenient approach in the self diagnosis of non-critical patients at the home. Wireless mobile sensing devices open up new possibilities within the healthcare environment . They provide valuable real-time information enabling physicians to monitor and analyse a patient's current and previous state of health. Wireless patient monitoring devices offer an efficient approach in sampling a patient's physiological state. They "provide the opportunity to obtain multiple readings which enable a more accurate estimate of the patient’s true blood pressure.” . Through the assistance of telecommunications patient vital signs may be taken and transmitted over large geographical areas. Presented in this paper is a low cost patient sensing device the Tyndall-DMS-Mote.

It can monitor a patient’s blood pressure, pulse rate, body temperature and electrocardiogram (ECG). To enable remote non-intrusive patient monitoring the Mobile-DMS-Client (i.e. a software agent client executing on a Nokia 9500 Communicator) is introduced. The monitored patient now has the freedom to function as normal within and outside their home, as the Mobile-DMS-Client can transmit over Wi-Fi, Bluetooth (i.e. indoor hotspots) and SMS (Short Message Service) (i.e. wireless outdoor telecommunication services). Multiple wireless patient monitoring devices exist with the capability to wirelessly communicate with mobile devices (e.g. laptops, mobile phones). Presented in this paper is the Mobile-DMS-Client which is built on a Jade-Leap agent middleware. This provides sufficient intelligence to effectively monitor the patient’s vital signs without having to interact with the DMS-Server on a continual basis. The Mobile-DMS-Client has the added advantage of executing complex tasks locally. This enables ECG processing and data compression algorithms to be processed promptly at the patient point of care without having to wait for a response from an external clinical unit. A larger knowledge base (i.e. DMS Ontology, DMS rules) may now reside at the patient point of care as the Mobile-DMS-Client’s memory and processing capabilities supplement those of the Tyndall-DMS-Mote.



1.1. Non-intrusively Monitoring a Patient's Blood Pressure at the Home

Consider a scenario where an individual, Andrew Smith, suffers from faint dizzy spells and light chest pains. He is admitted to hospital for analysis. It is discovered that Andrew's blood pressure levels are extremely high. After a period of medical treatment his blood pressure returns to normal. Andrew's blood pressure needs to be monitored on a daily basis. However as his local doctor is 12 hours away by car, daily checkups are unmanageable. To overcome this issue he is given a Tyndall-DMS-Mote and its accompanying Mobile-DMS-Client (i.e. Nokia 9500 mobile phone) The Mobile-DMS-Client is configured to read Andrew's blood pressure every 30 minutes. Localised analysis algorithms can execute in search of potential warnings. A daily report is transmitted to the DMS-Server enabling physicians to keep a watchful eye during his recovery phase.

1.2. DMS Architecture

The DMS (Data Management System) architecture functions within ubiquitous medical environments. Its objective is the timely delivery of accurate data. Accuracy is defined as “ensuring physicians get the correct data on time every time”. To achieve this goal software agents are employed to intelligently interpret all context

situation, real-time patient and environment data variables. The interaction between software agents and DMS datasets needs to be well defined. An explicit classification of each variable within the DMS dataset and its associated relationships ensure a higherquality of service (i.e. correctness).

The Tyndall-DMS-Mote’s core functional processing and I/O interfaces are derived from the Tyndall25. The Tyndall-DMS-Mote is capable of processing (atmel128 processor) and sensing (blood pressure, pulse rate, body temperature, and ECG) in a non-intrusive non-invasive manner. The Tyndall-DMS-Mote in association with the Mobile-DMS-Client is capable of monitoring non-critical outpatients over large geographical areas. A large majority of patient sensing devices are confined to specific areas (hospital ward, outpatient’s home) due to the limitations placed on its communication range (e.g. Wi-Fi, Maximum range 100 meters). With the Mobile- DMS-Client higher levels of patient monitoring is achieved with its built in SMS (Short Message Service) capabilities.

An agent middleware provides the necessary intelligent behaviours to manage and coordinate multiple streams of input (e.g. patient sensors) and output (DMS-Clients, DMS-Servers). To assist in its decision making process a rule-based system (i.e. DMS Rules) is employed. Predefined context triggers are continually examined against specific datasets. If a DMS rule is activated, the relevant agent behaviour is initiated. The DMS-Server processes large mounts of patient and environmental data. As patient datasets are based on multiple context elements it is critical that such information is correlated and accurate. A user profile (e.g.

medical staff, patient) and its associated software agent merges the relevant data sets (i.e. sensor data, patient history and medical knowledge) to increase the quality of service (i.e. level of correctness). A user profile not only points to real-time data input steams but contains patient medical history (such as allergies and other specific health related information) and combines this information with the relevant medical knowledge base. Presented in section two is the Mobile-DMS-Client and how it integrates with the DMS architecture. Section three gives an overview of the DMS blood pressure ontology and DMS rules.

2. Mobile-DMS-Client

Presented in figure 1 is the temporal interaction between the Mobile-DMS-Client and the DMS-Server. The Mobile-DMS-Client and the Tyndall-DMS-Mote provide the observed patient with two monitoring approaches:

1) Monitoring in the home

• Tyndall-DMS-Mote (patient sensor) to DMS-Client (Home Computer). Here raw sensor data sets are sent directly (via Nordic 2401 radio) to the DMSClient for analysis.

• Mobile-DMS-Client (i.e. Nokia 9500) to DMS-Client (Home Computer). Data may be sent to the DMS-Client (via Wi-Fi or Bluetooth) for storage, further analysis or as a means to communicate with the DMS-Server. Data may also be processed locally if sufficient medical knowledge resides on the device.

2) Monitoring outside the home

• Mobile-DMS-Client to SMS service. If a critical DMS rule is activated, medical practitioners or caregivers need to be informed immediately. With SMS capabilities the Mobile-DMS-Client may alert assigned individuals. Short term communication failure does not result in data loss. Sensor readings may be stored and processed locally on the Tyndall-DMS-Mote (i.e. 3KB) or the Mobile-DMSClient (i.e. 2GB). Data compression and filtering techniques may also be applied to save on communication and storage costs. Built-in audio alarms (i.e. warnings) may be activated to inform the patient to seek immediate medical attention.

Communication between the Mobile-DMS-Client and the DMS-Server is achieved by deploying a software agent platform to handle dynamic real-world requirements. Outlined are the primary features of the Mobile-DMS-Client and its interaction with

DMS components:

- Mobile-DMS-Client

The Mobile-DMS-Client with its communication, storage and processing capabilities complements the Tyndall-DMS-Mote. With a direct I/O interface (serial connection) between the two devices the Mobile-DMS-Client may execute complex tasks locally rather then communicating with the DMS-Client.

Mobile-DMS-Client elements:

- Mobile Phone: Nokia 9500 Communicator
- Operating System (OS): Symbian
- Agent platform: Jade-Leap

This combines the capabilities of a PC based operating system with a software agent middleware.

• Tyndall-DMS-Mote

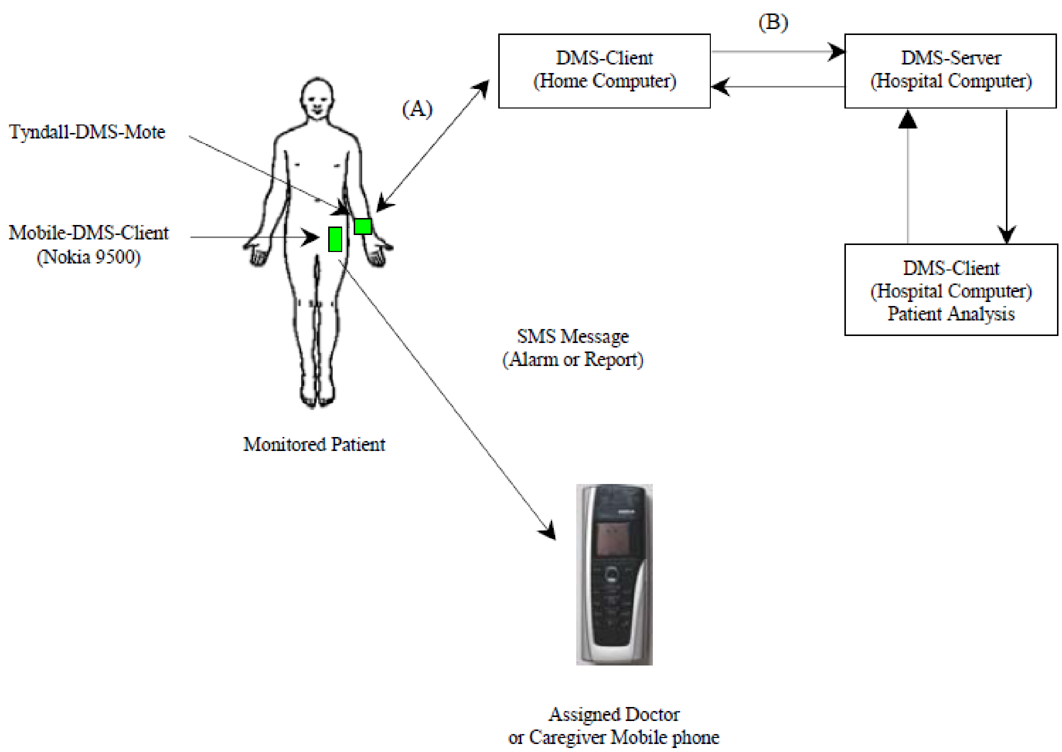
A Wireless Patient Sensor Network (WPSN) is comprised of autonomous devices with computational, sensing and communication capabilities. The Tyndall-DMS-Mote is a highly modular and miniaturised medical patient sensing device Tyndall-DMS-Mote elements:

• Sensors: blood pressure, pulse rate, body temperature and ECG

• Operating System: TinyOS

• Agent platform: Agilla

• DMS-Client and DMS-Server



Both the DMS-Client and DMS-Server operate through Jade, a FIPA compliant software agent architecture. It can dynamically manage and organise incoming and outgoing medical data in a context and situation aware manner. Protégé helps create an ontology which defines the data and the explicit relationships between the different data sets (i.e. static (archived) and dynamic (sensor)) as used in the DMS. Jess is a rule based system that enables developers to define a set of context and situation aware rules based on the DMS's ontology.

2.1. Monitoring and Interacting with the Blood Pressure Sensor

Outlined are three approaches in which the Mobile-DMS-Client may interact with the Tyndall-DMS-Mote in relation to blood pressure analysis:

• Periodically

A patient's profile contains information on their blood pressure history (i.e. high or low). This dictates the rate sensor readings are taken (e.g. once every 20, 80, 120 minutes). The Tyndall-DMS-Mote may then store these sensor values locally. Patient sensor readings may then be transferred onto the Mobile-DMS-Client on a daily bases if required.

• Contextually

A patient's medical condition (e.g. recovering cardiovascular patient, pregnancy) and current state (active, not active) affect blood pressure regulation. For example during pregnancy a patient's blood pressure may become elevated(often referred to as gestational hypertension). If the rule base and ontology systems did not account for this phenomenon, false alarms would be sent out to assigned monitors, resulting in a poor quality of service (i.e. incorrectness). Therefore the context of the patient (i.e. current activity) and the situation (e.g. pregnant, thrombosis) play an important role in delivering an efficient service.

• Custom run time calls

Custom run-time calls are required for 1) Sporadic adjustment of patient monitoring parameters (e.g. periodic sampling rate) 2) Integration of specialised functions onto the Mobile-DMS-Client through a Jade agent injection and 3) retrieving of patient sensor values.

3. DMS Blood Pressure Classification

High blood pressure levels provide no obvious external symptoms and may go undetected for large periods of time. This may result in damage to the kidneys and other organs. Therefore it is necessary to monitor high risk patients on a continual basis. To react in an effective and controlled manner, agents observe the ontology model presented in table 1. It contains a list of blood pressure classifications ranging from N**ormal** ((Systolic) 120 mmHg over 80 mmHg (Diastolic)) to **Very Severe** (230 over 140). Each classification has an associated set of agent procedures. A **Normal** level implies that blood pressure regulation is within the optimal range. A **Moderate** classification requires medical attention and blood samples need to be taken for further analysis. **Severe** indicates that a patient is at very serious risk of developing stroke or heart failure and requires emergency medical care.

Through the development of a blood pressure ontology model, semantic regions are defined which outline a patient's particular blood pressure state. Movement between these states results in appropriate checks being made and, if required, alarms or reports being sent. Presented in a DMS rule. It compares the patient’s current blood pressure level against the patient’s profile (i.e. **NORMAL** expected range). If a normal classification is not found the next level above and below normal are examined (i.e. hypertension and hypotension)

	Systolic Regions		Diastolic Regions	
Classification	Min Level mmHg	Max Level mmHg	Min Level mmHg	Max Level mmHg
Very Severe stage 4	211	230	121	140
Severe stage 3	181	210	111	120
Moderate stage 2	161	180	101	110
Mild stage 1	141	160	91	100
Normal	120	140	80	90

ALGORITHM:

```
;;Checking Patient Blood Pressure (BP), Classification NORMAL (defrule
NormalBP (PatientProfile (MinNormalSystolicBP
?MinNormalSystolicBP)) (PatientProfile
(MinNormalDiastolicBP ?MinNormalDiastolicBP))
(PatientProfile (MaxNormalSystolicBP ?MaxNormalSystolicBP))
(PatientProfile (MaxNormalDiastolicBP ?MaxNormalDiastolicBP))
(PatientProfile (currentSystolicBP ?currentSystolicBP))
(PatientProfile (currentDiastolicBP ?currentDiastolicBP))
(test (<= ?currentSystolicBP ?MaxNormalSystolicBP))
(test (>= ?currentSystolicBP ?MinNormalSystolicBP))
(test (<= ?currentDiastolicBP ?MaxNormalDiastolicBP))
(test (>= ?currentDiastolicBP ?MinNormalDiastolicBP))
=>
```

```
(printout t "
NORMAL_BLOOD_PRESSURE_FOUND
In Rule Base:
Current Systolic Blood Pressure is: " ?currentSystolicBP "
Current Diastolic Blood Pressure is: " ?currentDiastolicBP "
" crlf)
(store NORMAL_BLOOD_PRESSURE_FOUND))
```

FUTURE ENHANCEMENTS:

Presented is the Mobile-DMS-Client and how it monitors an outpatient's blood pressure level in a non-intrusive non-invasive manner. Localised processing and sensing at the patient point of care provides a higher degree of monitoring as it reduces the need to interact with external information servers. An intelligent agent middleware (Jade) provides the context capabilities to function within a pervasive medical environment. Working alongside the agent platform is a rule-based system which triggers predefined actions based on a set of DMS rules. An outline was given of the

DMS blood pressure ontology model which enables semantic regions to be defined. Such regions may then be modified (i.e. based on a patient's situation e.g. pregnancy, thrombosis) with respect to that patient's profile. This approach effectively correlates multiple data sources thus improving the quality of service (i.e. delivery of "correct" data). Further investigation into pulse rate and ECG ontologies and how they interact with the DMS architecture is required. DMS protocols need to be developed to improve on data consistency, priority and validation to improve the quality of service

delivered to the mobile user.

CONCLUSION:

Pervasive computing is quite a bit different, because it assumes a distributed environment model. It has the potential to dramatically alter how people use devices to connect and communicate in everyday life. In this paper, we have described the implementation of pervasive computing in medicine – as a life saving tool. Thus, we stand at the beginning of yet another era in computers – pervasive era.

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