

Context Aware Communication in Ubiquitous Computing Environment

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Abstract:

Healthcare is increasingly becoming a distributed service involving stakeholders and resources who may be physically far from each other. But privacy and security are potential problems. Patient's data should be available irrespective of their location, but only to authorized person. Not only that, the relationship between the person under observation and other related people, are different and the security and other characteristics concerning the data may also differ accordingly. In this paper we propose a system where an overlay network can be built in an ad hoc basis and links between different entities will be established according to the social relationship between the object person and the person at the other end and the situation of the observed person. Unlike traditional 24-hrs monitoring system, we argued that an on-demand, requirement oriented system will be beneficial for efficient resource utilization, specially in wireless communication.

1. Introduction

We are in the beginning of the era of ubiquitous computing society, where our daily lives are gradually becoming more and more dependent on various types of telecommunications. Recent progress in ubiquitous computing technologies makes it possible for anyone to access information, anytime and from anywhere. Broadband convergence with mobile and broadcasting networks has been accelerating the process of accessibility of such information.

Advancement in sensor, information and communication technology can play an important role in achieving cost reduction and efficiency improvement in health-care delivery systems, to the extent that this offers high-quality medical service anytime and anywhere, compare to conventional health-care systems utilize a central server for the look up of information.

In this paper we proposed a model for secure and personalized health-care support system where the patient is equipped with a wearable sensor device. The online data of that person is stored in a video database and also can be available real-time to the respective person if necessary in an on-demand way through live streaming.

Depending upon the type of data and the condition of the person under observation and to whom the information will be conveyed may vary accordingly.

The general health-care information along with Health-care database and training records which will be stored in a different database can be accessed by the person responsible for specialized in those specific areas, like Instructor of the training gym or Health care Advice Agent. Now, as these information are not considered as sensitive data nor an emergency information, they can be transferred through low se-

curity, medium throughput path. Whereas, personal medical record database, which only doctor has the access and if necessary can be conveyed to the family members are transferred through high-security path. And if required high quality video image also need to be transferred to the doctor in emergency situation. So depending upon the information and to whom it will be transferred we need different levels of security and bandwidth requirement of that path. So while establishing the overlay private network consisting of the concerned members of the group related to the patient as situation demands.

In this system the communication path with different QoS/Security levels can be established on demand considering following things:

- Network/Computational resource status
- Semantics of the transmitted data
- Role of the community members
- Health condition of the target person

to share necessary and sufficient information among specific members in the community, with ease and safely.

2. Remote Healthcare Support System

Conventional health-care systems, including Mobihealth [3] project, utilize a central server for the look up of information. Traditional systems only focus on organic communication and service utilization between patient and hospital, whereas they ignore the systematic communication and sharing of information between health-care workers in the hospital and the patient's family members.

There are two main concerns for developing a ubiquitous health-care system. We have to keep privacy, which is a known barrier to the acceptance of ubiquitous computing technologies [4], for the patient's personal data and at the same time maintain the quality of the services in real-time.

We can assume an overlay network consists of patient and the related people, like the doctor, his/her family members, the physio and the neighbors. This network can be built in an ad hoc mode depending on the necessity. The main difference between existing remote health-care system and our proposed system is that we are considering the level of privacy of each links according to the end-user and their relationship to the patient and the content of the data, the type of information it is carrying. We are also taking into consideration the condition of the patient, whether it is an emergency or a usual situation. The content of the information will also vary depending on that and so as the recipients. It is argued in [2] that anonymization and encryption may not provide perfect solution for privacy threats. So an overlay network has been considered here.

3. Related Works

In [7] et al. the authors' proposed an Open Healthcare Environment where multiple healthcare-related entities (such as patients, doctors, hospitals, and insurers) need to interact but do not necessarily have prior experience with each other. An open environment is "open" in the sense that there are no absolute barriers to entry: no central authority governs who can interact with whom, and environment participants are free to create, modify, and disband interactions and groups as the need arises. The usefulness of context aware services (CAS) within Personal Network (PN) is described in [10]. Where, CAS gathers context information about the user through sensor on the devices or information extraction from network/service elements. As this context describes all aspects of the owner's life, there is a fear to lose privacy. The authors argued that a PN can help in dissolving this problem, as the context is only gathered, processed, and used within the PN. The PN will handle the security and privacy needs of the user. It will react to his movements around the world, maintain the connection between his personal devices based on context information, and provide his context-aware personal services. The person himself can add new sensors as he/she wishes and install new context processing software that performs monitoring, logging and adaptation steps based on his context. For instance, he can install services that check on his health conditions, collect his movement of data, record them in a history database, and process them in order to identify situations. In somewhat similar way we can also use the concept of Overlay Network in our system. A system architecture of secure healthcare services based on Peer-to-Peer(P2) is proposed in [9]. This system consists of two regions: the Healthcare region and Hospital region. The healthcare Body Area Network (BAN) consists of sensors, wireless interface, PDA communication, and various facilities. The Hospital region composed of JXTA P2P network that supports the doctor's mobility and dynamic service management modules. In a hospital, if the healthcare workers form a peer group within the institution, they can create a secure peer group with various access rights, so as to allow the sharing of the patient's data and other kind of information under the secure environment.

4. System Description

The object in our system is the person under observation, that is the patient or an elderly person who is needed to be monitored. The object will be equipped with a wearable computer. They have been applied to areas such as behavioral monitoring, health monitoring system, information technologies and media development. Wearable computing facilitates a new form of human-computer interaction comprising a small body-worn computer (e.g. user-programmable device) that is always on and always ready and accessible. The always ready capability leads to a new form of synergy between human and computer, characterized by long-term adaptation through constancy of user-interface.

With a bluetooth device the patient will be connected to the ad hoc network. The other participants in the network will be

the doctor, physio, family member(s) and the neighbors and they will have their own devices, like PCs or PDAs to monitor the related data including video images of the patient.

The general information of the patient can be broadcasted to all the person connected through the overlay network build on ad hoc basis. But there are sensitive data regarding patient's health (physical or mental) which should be handled with required care and the distribution of these data should reach only to the appropriate person(s). In order to transfer sensitive data between two entities data should be transferred through highly secure links and in high quality, as it may provide the required security [1].

4.1 System Scenario

Here we explain the scenario illustrated in the Fig. 1.

1. We have four community members to manage health conditions of the *Healthcare Target Person*, say Mr.X. They are his daughter, doctor, health-care adviser and instructor of the training gym.
2. The doctor, adviser and instructor make healthcare advice to Mr.X based on the profile, information and record of him stored in their local DBs.
3. His daughter has a laptop PC connected by wireless access link.
4. Mr.X puts on a wrist-watch or any such wearable device sensor device connected to the PDA by Bluetooth. The PDA is also connected to the Internet with wireless access link.
5. His daughter supervises the situation of the Mr.X.
6. The vital data of Mr.X is transmitted to the Medical Record DB. In this case, high security communication path with encryption is automatically established between PDA and the DB as its content private and sensitive data.
7. If some abnormal symptoms are recognized on the vital data, the situation is informed to the health-care advice agent in the PDA. The agent collects useful information from health-care Web page. The agent subsequently provides the information to Mr.X.
8. The adviser agent also requests to the Web camera to capture video image of Mr.X, because his condition may deteriorate. The live video is sent to both his family member and video DB. In this case a multicast path with high throughput and medium-level security is established to deliver the video streaming.

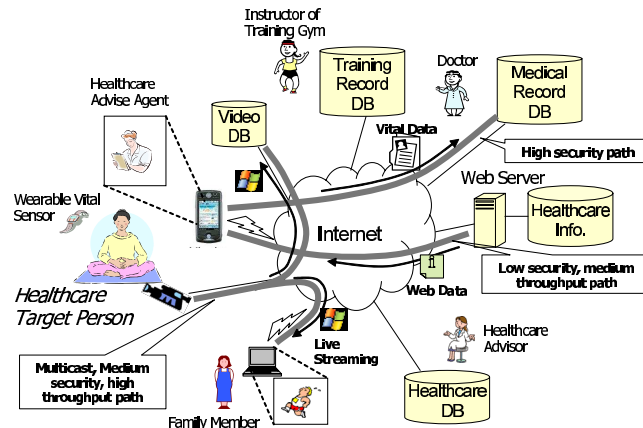
This kind of context-aware video delivery can greatly reduce network/computational resources, compared to 24-hours supervising, similar to our previous work [5].

5. System Architecture and Functional Details

People involved: Target person, Doctor, Trainer, Health-care adviser agent, Family member(s), Friends/neighbors

Main features:

1. Construction of an on-demand overlay network in ad hoc basis, including some or all of the members, depending on the situation or with user's choice.
2. The parameter needs to be considered:



Context-aware, on-demand, private overlay network for health-care support community.

Figure 1. Scenario of Health-care Support System

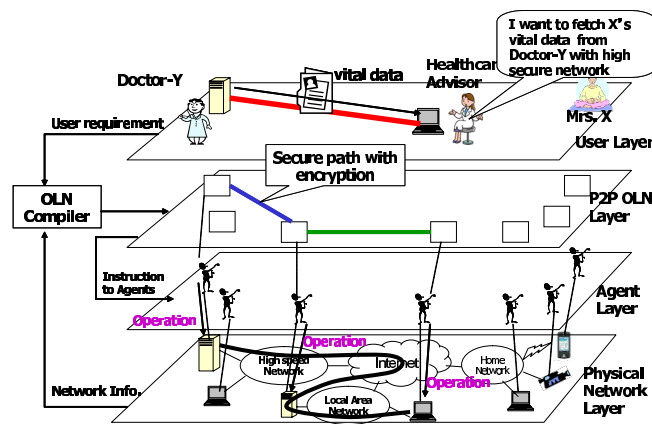


Figure 2. Transferring vital data with high security network

- Security of the links. For example - when vital personal data will be transferred security is of highest concern.
 - Reliability - while transferring vital data reliability of (100% loss free) is very important. As incorrect data will incur inaccurate diagnosis.
 - High performance - for the family members, who may prefer to watch the object person, who is under observation with video streaming. In this case, the quality of resolution is more important than security or loss free data transfer.
 - Delay (jitter) - depending on the content of the information, such as, pulse rate or heart-beat, where the influence of jitter can play a vital role and give a wrong picture of the actual situation.
3. Another important feature of this system is the establishment the overlay network in an ad hoc basis. Depending on the situation and necessity related members will be connected with each other with respective link-criteria (high QoS, high security, high reliability, low jitter etc.). We consider this ad hoc mode instead of 24-hrs monitoring and constant transferring of data, as it will be

a sheer wastage of resource unless the situation is emergency.

The whole system can be divided in four layers according to the functionality as shown in Fig. 2:

(1) **User layer** - where all the members of this system exists, including the Target person, his/her health care support team, family members and friends/neighbor. In their respective display, whether it is a PC or PDA or any other devices, they can observe the image (or icon) of other entities. According to the situation or necessity they may want to connect to one or many members in that local community (consisting of the members). User can also mention the criteria of the connecting paths.

(2) **P2P Overlay Network Layer** - This layer situated under the User Layer and receive the user requirement. The instruction will be conveyed to the next layer, i.e. Agent Layer.

(3) **Agent Layer** - Consists of agents with their respective role to serve their particular responsibilities to handle the devices in the actual network layer. This is a multi-agent platform, where negotiation among each other (agents) as well as with the network layer will play an important role to create

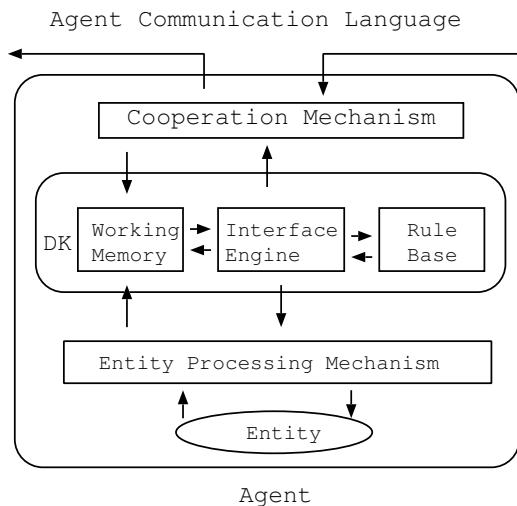


Figure 3. Basic Agent Architecture

the network to the satisfaction of user requirement.

(4) Network Layer - In this layer the servers and all the other hardware devices exists. The upper layer's Agents will be responsible for these devices to establish a path as close as possible to the user requirement. This is a tricky task as it needs a fine balancing between user requirement and availability of resources.

5.1 Agent Architecture

The basic architecture of agent is shown in Fig.3. Here Cooperation Mechanism (CM) is a mechanism for exchanging messages among agents. Domain Knowledge (DK) is a knowledge-base system to store and activate various domain knowledge concerning the target entity. Based on the knowledge, agent monitors and controls the target entity, and makes actions to other agents. Entity Processing Mechanism (EPM) is an interface between DK and target entity. It passes events from entity to DK such as exceptions, and directs control instruction from DK to entity.

DK consists of three subsystems, i.e., Working Memory, Inference Engine and Rule Base. In Working Memory and Rule Base, set of Facts and Rules are stored respectively. Inference Engine refers to the Rules and Facts, and works as production system. By employing this inference mechanism, agent performs interaction with other agents and controls the target entity.

6. Conclusion

In this paper we describe the concept of a secure and personalized health-care support system model, comprised of various level of QoS and security in an on-line and on-demand fashion, considering the available computational power and bandwidth of the link, semantics of the transmitted data, relationship between the observed person and the recipient of the data, and the health condition of the concerned person.

Acknowledgement

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