Pervasive Communications for Care professionals in Hospitals

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***Abstract*—It has been demonstrated that effective communications among specialists is essential in the delivery of high quality of patient care. A location-enabled VoWLAN service may further bring seamless connections for medical professionals to communicate and collaborate with each other efficiently. It greatly assists the locating relative professionals in hospital urgencies and delivering critical information to specific professionals. In this article, we proposed an enhanced Hospital Patient Care Call System (EHPC2S), which converges the voice and context information for the purpose of reducing medical errors and providing better hospital quality of service.**

Keywords- location-awareness; VoWLAN

I. INTRODUCTION

In hospital environments, medical professionals are essentially require higher mobility and coordination due to the complexity of the task performed. Rapid access to information and collaboration with specialists are highly dependent on their locations and other contextual conditions. Recently, the ubiquitous computing has provided the technology needed for the location-awareness medical applications [1]. Since hospitals may require in-time information about the location of their patients, doctors, and medical staffs when medical emergencies arise, and what is more, medical related assets tracking and management are useful location-awareness applications in hospital.

It has been demonstrated that effective communication among professionals is essential in the delivery of high quality of patient care [2]. VoIP over WLAN (VoWLAN) is the novel telephony service in hospital. Since the prevalence of wireless LANs(WLANs), VoWLAN has been quickly accepted by many health care administrators and care delivery staffs since it is cost effective, easily deployed and interference free [3]. Several well-known SIP based VoWLAN services include powerful features for medical workers, such as One-Number service, Follow-me service and Three-way conference call [4].

Pervasive communication enables anytime, anywhere communication of anything with anyone else [5]. Therefore, a location-enabled VoWLAN system may bring seamless connections for medical professionals to communicate with colleagues without the waiting time on hold to find someone and the traveling time to and from the nurse stations back and forth. It will dramatically reduce unnecessary time and the waste of medical resources. The integration of location awareness and VoWLAN fulfills the requirements of reducing medical errors and providing better hospital quality of service. For example, it is convenient to find the nearest caregiver to form the medical care team when emergency happened. Voice and context information convergence will facilitate pervasive computing technology in medical care. The rest of this article is organized as follows. Section 2 introduces the actual state and challenges of the communication system in the hospital environment. The proposed location awareness VoWLAN system is addressed in Section 3. Section 4 concludes the work.

II. OVERVIEW

The context awareness technology plays an important role to improve a quality of medical care. In vast medical care scenarios, the information needed by the caregivers typically depends on their current location. The information includes documents/devices tracking, and professionals locating. Since documents are often misplaced in the emergency situation or hectic environment, such as patient's records and laboratory results. Medical equipments and hospital assets are often moved within the hospital as needed. Medical professionals can easily find the patient's records, rolling out wheelchair or IV pump by using the documents/device-tracking information. Moreover, the patient tracking had been developed for the case of psychotic and SARS. On the other hand, the medical professionals tracking can reduce the time for finding, deliver urgent information to the right place, and further facilitate the patient care.

In hospital, Radio Frequency identification (RFID) is mostly used in instruments tracing, patient identification, and the entrance guard of restricted area. However, the cost of RFID instrument is still too high so far, especially the readers are the major expenditure of RFID systems. Today, Internet and WLAN have grown remarkably and spread rapidly in hospital settings, IEEE 802.11 WLAN hotspots can be easily deployed in most medical areas without interference. The costs of WLAN infrastructures such as access points (APs) are much lower than RFID system, Bluetooth, and other related location

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awareness instruments. What is more, WLAN gets much wider coverage area than that of other technologies.

Communication is essential and critical in emergency situation. A tragedy often happened by the time delay in seconds. An effective communication system among the surgical teams may avoid adverse events that can compromise patient safety. The actual hospital communication systems are public switched telephone network (PSTN), pager, mobile phone, and personal handy-phone system (PHS). However, they cannot fulfill the requirements of delivering critical information to relative professions. The PSTN and pager systems cause the waiting times on hold and the traveling back and forth to a phone [1]. Mobile phone and PHS system cannot rapidly deploy new service model and can not be used in some area, like MRI unit and operating room. The hospital cost will increase due to monthly fee. Besides, there are still some challenges of traditional communication system in hospital:

A. Nurses in the ward usually can not reach doctors on duty through one call if patients are in danger.

B. Broadcast system may result in noise for other medical members and patients in the wards. Also such disruption can affect the quality of medical and patient care.

C. Communication system in hospital can not provide an effective connection when medical professionals need to call for the patient physiological report immediately or conducts a three-way conference.

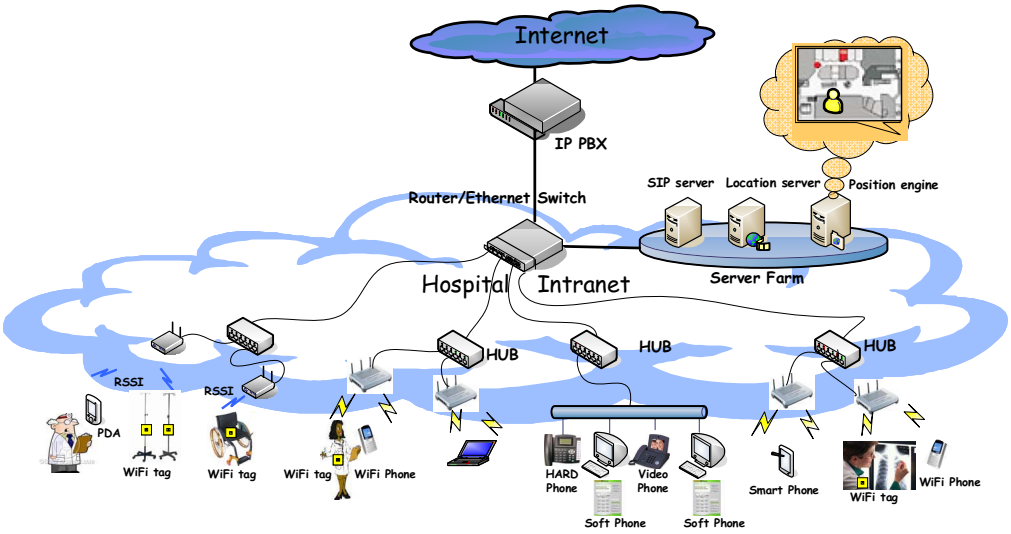

Figure 1. Location-aware VoWLAN system infrastructure

Due to the rapidly availability, cost effectiveness and popular deployment, an innovative VoWLAN service is an alternative solution that provides flexible abilities to develop diverse applications. Additionally, it can dramatically reduce the hospital management cost. The whole infrastructure of the system is illustrated in Fig. 1. Position Engine extracts the received signal strength intensity (RSSI) from the wireless device or WiFi tags attached on specific personnel and certain assets. It recognizes each device or tag through its unique MAC address, and then transmits the location information to the location server to resolve the corresponding URL (Uniform Resource Locator). Therefore, the location awareness VoWLAN system can accomplish the pervasive communications for the specialists in hospitals.

III. Location Awareness Patient Care Communication

According to the hospital communication requirements, we propose an intelligent and cost effective communication system to improve the quality of patient care and hospital service. Two main components of our system are VoIP (Voice over IP) over WLAN (VoWLAN) and WiFi location-awareness. VoWLAN is the delivery of voice traffic over Internet.

VoIP involves sending voice information in digital packets rather than by using the traditional PSTN. The packets are transmitted using Real Time Protocol (RTP) over User Datagram Protocol (UDP) over Internet Protocol (IP). RTP is commonly used in Internet telephony applications. RTP combines the data transport with a Real Time Control Protocol (RTCP) to monitor data delivery [6].

Standards like Session Initiated Protocol (SIP) and H.323 are maturing to support convergence services in next-generation networks. H.323 was designed for multimedia communication over IP networks, including audio, video conferencing. SIP was design to be a part of the overall Internet Engineering Task Force (IETF) multimedia data and control architecture. However, many consider the SIP a powerful alternative to H.323 because of its flexible deployment, easy maintenance, and simple format for commands, et al. As a result, a VoIP communication system based on SIP can develop diverse services correspond to different requirements.

In a SIP-based VoIP system, a user is allowed to register at several different locations. When the server receives a request to initiate a call (i.e. INVITE message), it will fork the request and transmit the branched requests to all the registered destinations, such as office SIP phones, PC-based soft phones, and WiFi phones. Anyone in these destinations picks up the phone then server will terminate the other pending requests by sending CANCEL message. This scenario is known as "one number service.

In location tracking part, the system can be divided into ***"site survey"*** and ***"position locate"*** two stages. The system process flow is shown in Fig.2. As for the first stage, collecting RSSI to obtain the most uniform WiFi coverage is the first step of ***site survey***. In order to make the ***site survey*** more realistic, we define the environmental factors like concrete walls, wooden doors, open space onto the RSSI radio map.

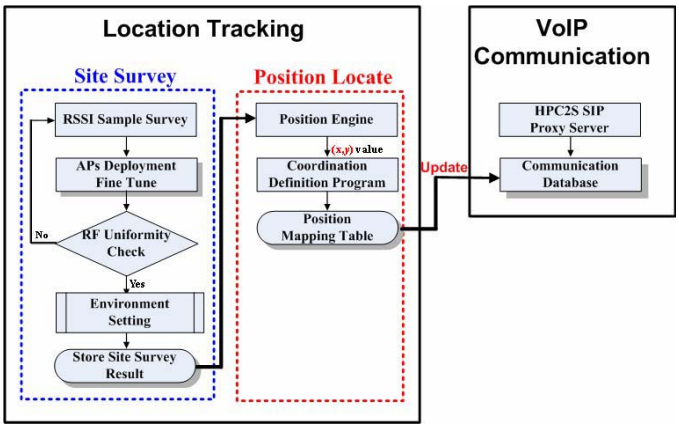

Figure 2. Process of location-aware VoWLAN system flow chart

The ***site survey*** results will be imported into position engine in advance. In ***position locate*** phase, a position engine locates each tag with 2 coordinates (x, y). Then the X,Y value will be input into the *"coordination definition program"* to get the corresponding room/zone. Once location server obtained the room/zone number, it will look up the *"position mapping table"* to get the SIP URL.

Eventually, as long as the URL of the communication database is updated, SIP server will get the new URL and then forward the VoWLAN calls to the located position. Fig.3 shows that how the EHPC2S SIP server works when a session initialized one number service and location-aware call forwarding service.

IV. DISCUSSION

To illustrate the effective communication of EHPC2S, the signaling and a scenario are shown in Fig.4, respectively. Laboratory medicine needs to notify the doctor when the patient is abnormal. First she dials the number 333 to call the doctor in charge. The doctor's personal number 333 had been registered at two different locations, one is the network address of the SIP phone in his office and the other is the address of his mobile SIP phone in the locker of MRI unit. According to One Number service, the server sends the INVITE request to the two locations first in parallel (i.e. one number service).

Unfortunately, the doctor is busy in MRI unit, none of the calls is answered and the INVITE from the server is timeout. SIP server then queries the location server about the doctor's location information. The response indicates where the doctor is and the SIP phone number of closest area to the doctor is 666 belongs to ward. Afterward, the SIP server can issue an INVITE message to 666 (i.e. call forwarding). Nurses in the ward can help the doctor answer the phone and let him know what happened. It is one of the smart communication services of EHPC2S, including one number service and location-aware call forwarding. Callers can have much more easier way to contact with callees, consequently save time to check where callee would be and his extension number.

The proposed EHPC2S supports many similar scenarios aimed at providing context awareness and enhancing communication. For example, an internist needs to consult with one surgeon about patient's MRI image; first he calls surgeon's number with "One number service". Instead of returning to surgeon's office to pick up the phone, SIP server will ring his personal SIP phone and location server update his location simultaneously. After the surgeon understands what purpose is, he can enter the nearest meeting room via the location server. Then they can initialize a detail consultation by CSCW technology further. Thus location awareness is full of variety in medical application.

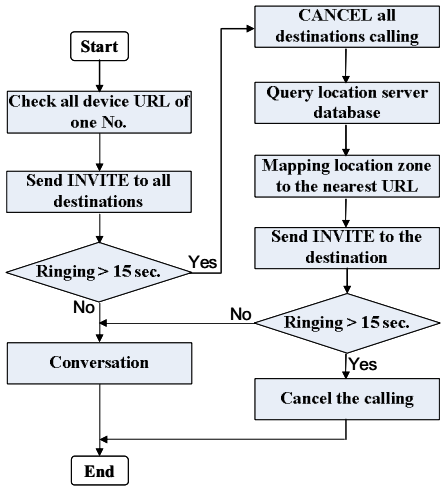

Figure 3. System flow of one number service and the location-aware call forwarding service

V. CONCLUSION

It has been demonstrated that effective communications among members of care team is essential in the delivery of high quality of patient care. A location-enabled VoWLAN service may further bring seamless connections for medical professionals to communicate and collaborate with each other efficiently. According to location-aware function, call forwarding service will be performed correctly. There is no need to wait for finding someone results in saving more time consumption and human resource, decreasing the opportunity of medical errors. The convergence of voice and context information is a trend to build up an intelligent platform to increase the quality of medical care service.

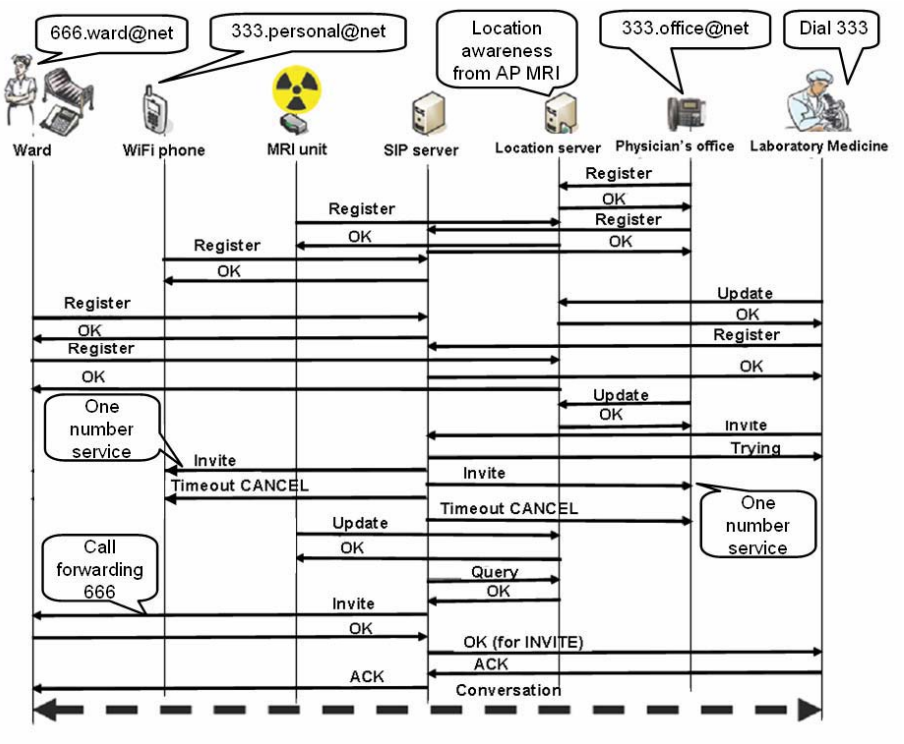

Figure 4. Signaling of One Number Service and the Location-aware Call Forwarding service

In this article, we have proposed an intelligent hospital call system, which is an integration of a ubiquitous wireless network infrastructure, a SIP-based VoIP system, and location-awareness mechanism. EHPC2S provides a timely and effective communication among the care professionals to improve quality of patient care. What is more, it gives noise cancellation, achieves the serenity in the wards or ICU, and improves medical service quality. Nurses can also provide complete patient care without interferences. There are many potential applications can be implemented over this system, such as emergency rescue team formation, readily information exchange, etc. We are developing the context awareness relative system and the results will be reported in future occasions.

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