

## A Review and Research Towards the Reliable Wireless Network Technologies in Medical Applications

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**Abstract:** The development of wired and wireless technology, especially the wireless devices have occupied the e-health care area with a wide range of capability. Improving the quality of patient life, doctor-patient adeptness, wireless technology enables to monitor the patient information remotely and give them patient clear health information by clinicians, making it available anywhere, anytime. In this paper, we discuss the advantages, challenges and standards of using wireless technology devices for medical applications purpose.

**Key words:** Wireless medical applications • Wireless networks • Sensor networks • Zigbee • Bluetooth • WPAN • WiFi and patient management

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### INTRODUCTION

Wireless network technology has been constantly improving with time and increasingly finding its way into all aspects of our daily life. Recently, interest has been rapidly increasing in wireless systems in the field of medical applications. With alternatives of wired technology, a number of advantages including: ease of use, risk of infection, risk of failure, patient discomforts reduced. Wireless technology will bring new applications in medical markets such as heart rate monitors, blood pressure monitors are essential instruments in intensive care. In the e-healthcare field, frequent access and saving of cost are two of the important issues in these days.

Wireless technologies have something to contribute towards helping with both of these issues. The e-healthcare system is continuously getting more complex. Number of patients died as a result of unnecessary medical errors [1]. When manually inspecting the patient disease, most of the time physicians and clinicians without knowing the patient history and medical procedures the results are error-prone. The wireless technology tools can help to eradicate the above mentioned problem. The wireless technology tools

can help to give accurate patient data and caregivers for real-time access, patient clinical histories, patient treatments, patient medications, tests, lab results and etc. This paper is discussing about the use of wireless network technology in medical applications.

**Basic Wireless Network Technologies in Medical Applications:** In emergency situations like natural disasters and military conflict where patient's records such as previous medication history, identification and other vital information are essential, the wireless technology could be the best solution for emergency situations. In the wireless networks field, innovative and new applications are being thought of in medical domain as well as e-healthcare. In addition to that the use of wireless technology can manage both the equipment and patient details.

A patient who is located remotely can be cared by communicating the patient status in real time to caregivers. In e-healthcare system the medical device management seems to be one of the complex tasks as there is a possibility of mismatching in real time. Wireless technology is solving the problem of communicating the result from one machine to another.

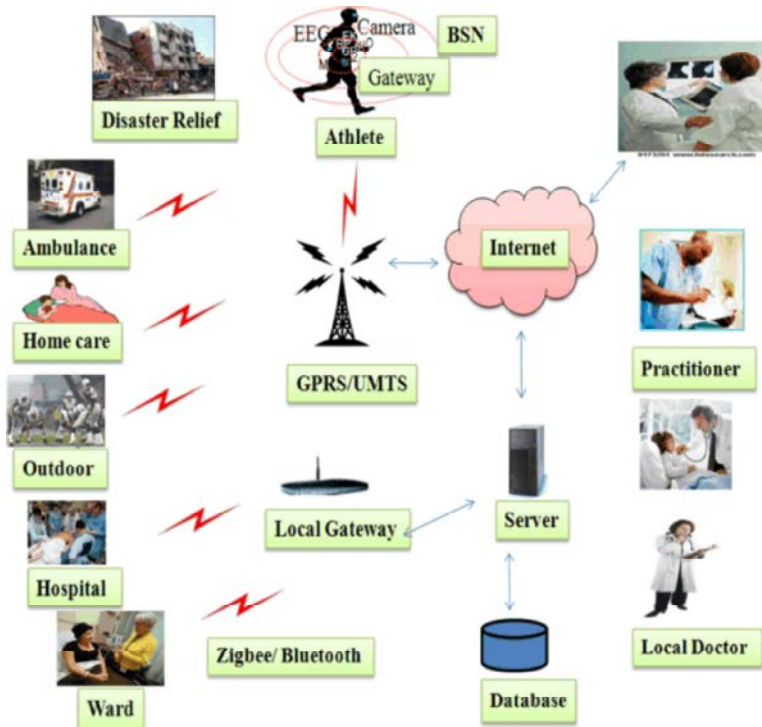


Fig. 1: Healthcare Application using wireless medical sensor networks

Due to convenience and flexibility requirements wireless is the preferred medium in medical applications. With the help of hand held devices in which wireless network technology is integrated, to identify the problem, track the patient medication history and consult the fellow doctors the amount of time will be reduced significantly. Moreover, databases of patients that can be built up by continuous medical monitoring will be accessed and updated easily. As a result, the amount of paper work required and the duplication of patient record will be dropped down.

Medical applications in wireless systems environment are not only focused by e-health care provider also used to direct towards academic, research, industry and development.

**Present and past Wireless Technologies of Medical Applications:** Recently, the wireless networks technologies in medical applications are used widely. In this regard, we will discuss about present and past wireless networks technology used in the area of medical applications. As shown in Figure-1, wireless medical sensor networks carry the promise of caretaking across wide variety of e-healthcare applications such as ambulatory monitoring, elderly people at home care monitoring and clinical monitoring, etc.,

**WBAN (Wireless Body Area Network):** One of the most promising applications that wireless sensor network pioneers thought to be fit to wireless sensor technology in e-healthcare/medical application. Easy to conceive where the patients carry a sensor that can detect health-related parameters such as heart rate, glucose level and monitor the patient continuously via wireless network. Researchers are also imagined a scenario where many sensors are placed on human body, wirelessly connected and sharing information. The concept is called BAN (Body Area Network). BAN is low powered integrated circuits and wireless networks, low powered physiological sensor platforms that can be integrated in Body Area Networks (BANS).

In the medical application field, these devices can be attached to patient bodies to collect patient health information such as Electro Cardio Gram (ECG), Blood pressure, glucose level etc., [2]. Inside and outside the hospitals, BAN's can be used to monitor the patients who are in critical conditions and transmitted over the internet to their doctors in real time. As shown in Figure-2, illustrates an example of data flow in integrated WBAN system.

**RFID (Radio Frequency Identification):** Hot topic in recent days is Radio Frequency Identification (RFID) technology. The RFID tags are used in hospitals to keep

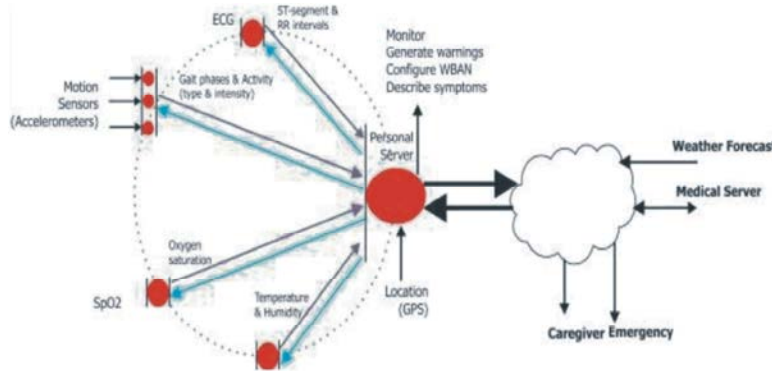


Fig. 2: Dataflow in computer assisted physical rehabilitation system

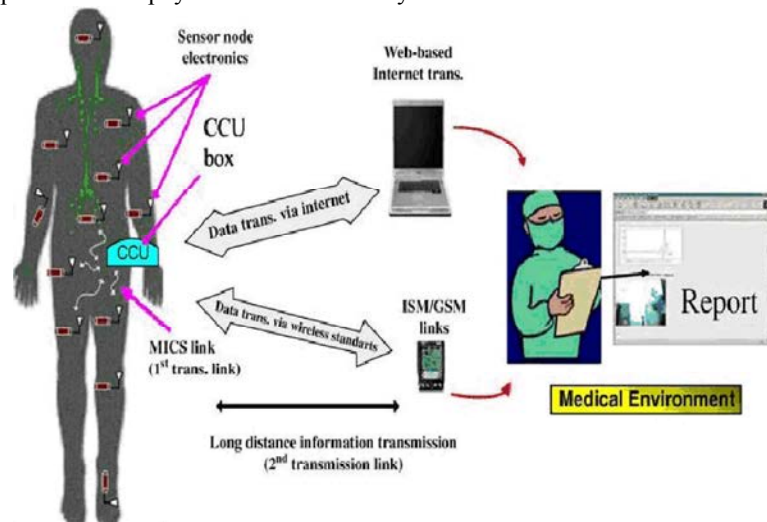


Fig. 3: A medical sensor network application [9].

track of equipment and also planted on patient's body. The doctor's can easily identify the location of the patients with the help of RFID tags. The advantage of using RFID tag is low powered radio devices that don't need the battery power and thus have potential uses in storage areas.

**WPAN (Wireless Personal Area Network):** The wire replacement and short distance ad hoc connectivity which is the bluetooth technology is considered a Wireless Personal Area Network (WPAN). This technology is impending uses in the medical field using WPANs [3-5] in the standard 802.15.4. Within the patient's room in the hospital, these short range networks can be deployed, so that the doctor or nurses can monitor the patient history in real time without visiting the patient room. Which saves them time and gives them the opportunity to take care of more patient's health. This is also a very good technology for short range communication, for example, in home e-healthcare.

With many advantages including low-power consumption, small size, simple protocol, wide compatibility and so on, this technology is applied to many medical applications including telemedicine system, pervasive and continuous patients monitoring and wireless-integrated medical devices.

**Sensor Networks:** Zigbee is an example of another sensor network technology combined with WBAN's in the medical domain [6, 7]. It is a smaller scale network that can be placed on human clothing (or other objects). Code Blue project is the best example of a medical application of sensor networks [8]. In the natural sciences field, sensor networks are being used to monitor the wild life and other occurrences. These devices are very cheap and can be deployed anywhere in large numbers. As shown in Figure-3, it illustrates a medical sensor network application [9].

**Wireless LAN (802.11):** In medical applications, the first and oldest wireless technology is wireless local area network (WLAN), namely IEEE 802.11. This Wireless LAN technology is used in many hospitals, corporate offices and technical universities. In hospitals, the wireless LAN technology is used to transfer the patient data around the hospital. Data communication between the medical devices is also made using this channel. Nowadays, WLAN are used to provide this service in almost US hospitals.

**WiMAX:** The IEEE 802.16 standard, WiMax is created by the WiMAX forum which has very strong-security wireless data transmission over up to 50 km long distance [10]. This is an excellent choice for telemedicine service for both fixed and mobile environments. Radiology and scanning high quality medical images are transmitted. The best example of this technology is pre hospital management systems, the doctors can prepare and arrange the medicines before the patient reaches the hospital. The patient diagnostic images could be transmitted using this technology.

**Challenges of Wireless Medical Applications:** With the improvement of wireless device technology, it can increase the medical care quality and reduce medical errors, improve the efficiency of caregivers and comfort of patients. Medical field is bringing the advantages to the existing e- healthcare services [11]. However, these have several key research challenges such as various types of network communication infrastructure, fault-tolerance, data integrity, low-power consumption, transmission delay, node failure, etc.

Patient health monitoring is a hot application of wireless network, the patient's disease are monitored with inside and outside the hospital. WBAN with sensors is used to monitor patients in critical conditions inside hospital. Outside the hospital, the network can transmit patient's vital signs to their physicians over internet in realtime [10], Researchers and industries are investing huge amount of money and effort for real-time patient monitoring field. It's not a new topic in wireless medical applications but this applications basically use biomedical sensors which monitors the electro-cardiogram (ECG), blood oxygen level, pressures, glucose, coagulation, body weight, heart rate, ECG etc., Home monitoring systems [11] can reduce the hospital stay of patient and increase patient safety and mobility.

The centralized server stores periodic and continuous patient's data. Physicians can access the patient's information remotely, to save large amount of time for doctors as well as patients.

#### **Standards Used in Wireless Medical Applications**

**IEEE Standards:** The primary goals in IEEE (Institute of Electrical and Electronics Engineers) standard's are providing interoperability for patient-connected medical devices and facilitating the efficient exchange of vital signs and medical device data in all health care environments [12]. Some other IEEE standards are given below in Table-1 [13].

**ISO Standards:** Standards are issued by International Standard Organization (ISO) to provide guidance for implementation, use and management of wireless communication and computing equipment in healthcare facilities. The following standards are up-to-date standards issued by ISO given below in Table-2 [14].

**ASTM Standards:** ASTM (American Society for Testing and Materials) issued ASTM F1220-95(2006), a standard guide for emergency medical services system (EMSS) [15]. Some ASTM standards used in wireless medical systems are given below in Table-3 [15].

The other standards are currently being developed in the research community.

**Future Trends in Wireless Medical Applications:** New wireless medical applications are designed purely for social health care benefits i.e. reducing interference to daily life when dealing with long term patient care. Some of these applications include: Patient Homecare, Context-Sensitive Medicine and iRevive [16, 17].

**Patient Homecare:** The new area of wireless networks for medical applications is patient homecare [18]. Patient homecare and remote monitoring has a central role in the emerging medical applications of wireless technology. Some other medical applications are Medicine intake tracking, Remote ECG collecting and monitoring, Remote blood pressure and weight monitoring.

**Context-Sensitive Medicine:** Management of resources become more intelligent when using Active RFID-tags. For example, machines needing servicing can automatically inform the technician. The position of equipment, doctors,

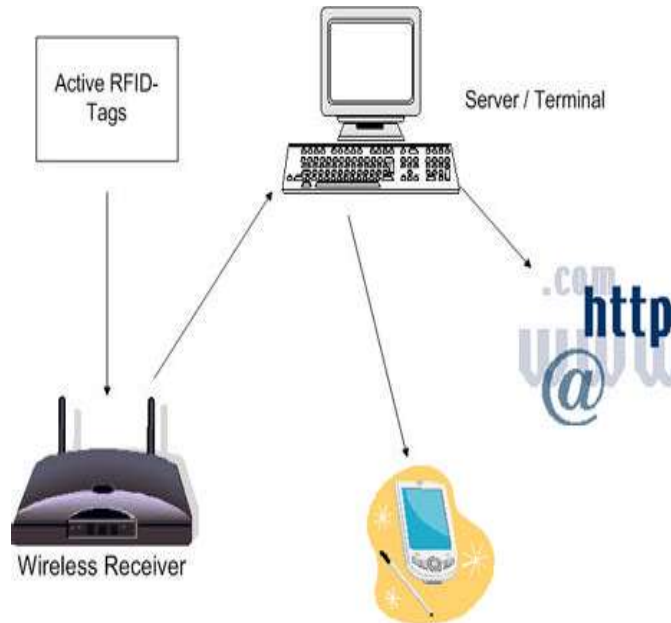


Fig. 4: Architecture of a sample system based on Context-Sensitive Medicine idea

Table 1: IEEE standard wireless medical applications [13]

IEEE Standard	Health Informatics	Technology
IEEE 1073.0.1.1	Point of care medical device communication	Guidelines for the use of RF wireless technology
IEEE 1073.3.5	Point of care medical device communication	Framework and overviewstructure for wireless medical data transport using personal area, Local and wide area networks.
IEEE 1073.3.5.3	Point of care medical device communication	RF wireless and local area network (wLAN)
IEEE 1073.3.5.5	Point of care medical device communication	RF wireless – Wide area (Mobile Phone) network (wWAN).
IEEE 1073.2.1.3	Point of care medical device communication	Application profile-clinical context management (CCoM).
IEEE 1073.1.3.16	Point of care medical device communication	Device specialization display device.

Table 2: ISO standard wireless medical applications [14]

ISO Standard	Health Informatics	Technology
ISO/TR 21730:2007	Health Informatics	Mobile wireless communication and computing technology in healthcare facilities
ISO 17090-3:2008	Health Informatics	Policy management of certification authority
ISO 11073-90101:2008	Health Informatics	Electronic health record communication
ISO 11073-90101:2008	Health Informatics - Point-of-care medical device communication	Part 90101: Analytical instruments -- Point-of-care test
ISO 21549-6:2008	Health Informatics	Patient healthcare data

Table 3: ASTM standard wireless medical applications [15]

ASTM Standard	Technology
ASTM E 2369-05	Standard Specification for the Continuity of Care Record (CCR)
ASTM F1220-95(2006)	Standard Guide for Emergency Medical Services System (EMSS) Telecommunications
ASTM F1258-95(2006)	Standard Practice for Emergency Medical Dispatch

patient etc. inside a hospital can be traced in real-time. This allows the patients to move around freely. It also allows doctors and nurses to tend to more patients. The Figure-4 describes a basic architecture based on the Context-sensitive medicine platform.

devices can capture vital signsinformation in real-time and store using VitalDust technology (CodeBlue) [19] or send them to acentral server.

## CONCLUSION

**iRevive:** It is a commercial project based on the CodeBlue research project from Harvard [19]. The central database server is synchronized using mobile device. These mobile

In this paper, we discussed about the advantages of wireless devices for medical applications purpose and challenges involved in this technology. We have also

identified standards being used in wireless medical applications and location of wireless network in e-healthcare system.

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