1.INTRODUCTION

Wireless networking is an exciting area and it has completely invaded our homes and environment during the last decade due to cheap equipment and easily implementable standards.In 1965 the co-founder of Intel Gordon Moore said that the number of transistors that could be fit onto an integrated circuit would double every second year. This has later on been called the Moore’s law and since this statement there has been a doubling every two years leading to today’s possible miniaturization of hardware. Sensor networks with small energy-efficient nodes have become reality and a whole new world of applications has emerged. In 1998 the Smart Dust project started at Berkeley in California and run for three years. The goal of the project was to create autonomous sensing communication nodes as big as a cubic millimeter to be used in a massively distributed sensor network. The application areas for this project were diverse ranging from weather/seismological monitoring on Mars to smart office spaces. Because this project was the first of its kind it is widely known and several other big projects have theirs origin here.

Wireless body area networks (WBAN) was first presented by T. G. Zimmerman in an article from 1996 but he gave these body networks the name wireless personal are network (WPAN) from the beginning. Later on PAN was redefined to be, e.g., cable replacement for up to 10 meters (e.g., Bluetooth) and the name WBAN evolved instead. WBAN is still in its infancy and there is a lot of research going on. A WBAN will be a network containing sensor nodes monitoring , e.g., vital signs of the human body and a more intelligent node capable of handle more advanced signal processing etc., which all sensors report theirs data to. The sensor nodes could be on the body (wearable) as well as implant (inside the body). Healthcare will be the really dominating application area for WBANs and as soon as a really technology breakthrough is done within WBAN there will be no end of the numerous of applications that will reach us through the healthcare domain. One big issue that has to be solved is the battery life time, which must be attacked from two ways; better battery technologies and more energy- efficient hardware design. The first application domain of WBAN within healthcare will probably be monitoring patients suffering from chronic diseases such as diabetes in order to have a more precise treatment in terms of medication. This preliminary study will try to shed some light over general questions that arise in all kinds of application domains when using low-power sensor networks where the nodes communicate wirelessly. Up to date there is no standard specifically intended for WBANs. IEEE chartered a new subworking group within 802.15 to bring a WBAN standard forward in November 2007.The closest standard that can be used today for WBANs is the IEEE 802.15.4 providing a medium access layer and physical layers which could be used for building an application on top. However, there exists a plethora of transceivers, sensors and microcontrollers that can be used for sensor networks. These are though proprietary solutions for unlicensed frequency bands and they are hard to compare since they are exactly proprietary. Some solutions from manufacturers provide complete sensor nodes with a whole protocol stack while others have only chip sets for sale. A standard is not always the most efficient technical solution but it is a good starting point in order to achieve interoperability between different product vendors and application architects have more than one manufacturer to choose from.

2.HISTORY

BAN technology is still an emerging technology, and as such it has a very short history. BAN technology emerges as the natural byproduct of existing sensor network technology and biomedical engineering. Professor Guang-Zhong Yang was the first person to formally define the phrase "Body Sensor Network" (BSN) with publication of his book Body Sensor Networks in 2006. BSN technology represents the lower bound of power and bandwidth from the BAN use case scenarios. However, BAN technology is quite flexible and there are many potential uses for BAN technology in addition to BSNs.

Some of the more common use cases for BAN technology are:

• Body Sensor Networks (BSN)

• Sports and Fitness Monitoring

• Wireless Audio

• Mobile Device Integration

• Personal Video Devices

Each of these use cases have unique requirements in terms of bandwidth, latency, power usage, and signal distance. IEEE 802.15 is the working group for Wireless Personal Area Networks (WPAN) . The WPAN working group realized the need for a standard for use with devices inside and around close proximity to the human body. IEEE 802.15 established Task Group #6 to develop the standards for BAN. The BAN task group has drafted a (private) standard that encompasses a large range of possible devices.

In this way, the task group has given application and device developers the decision of how to balance data rate and power. Figure 1, below, describes the ideal position for BAN in the power vs data rate spectrum.

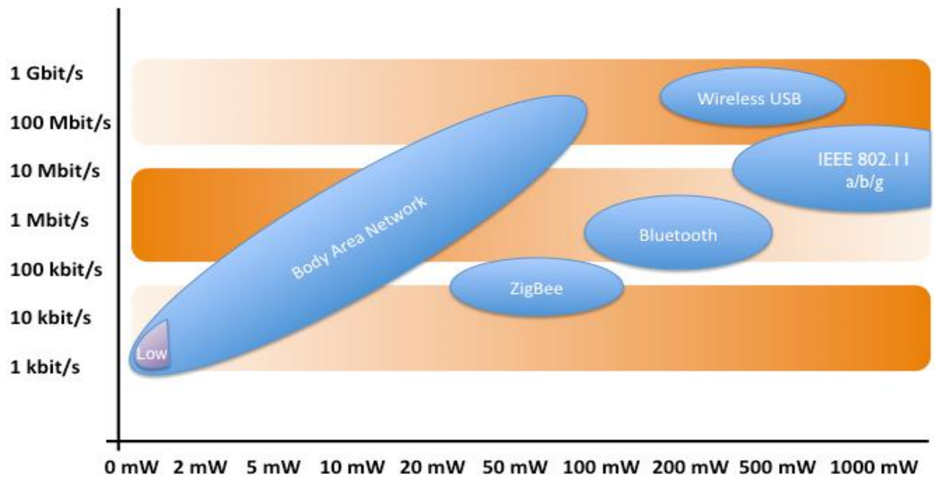
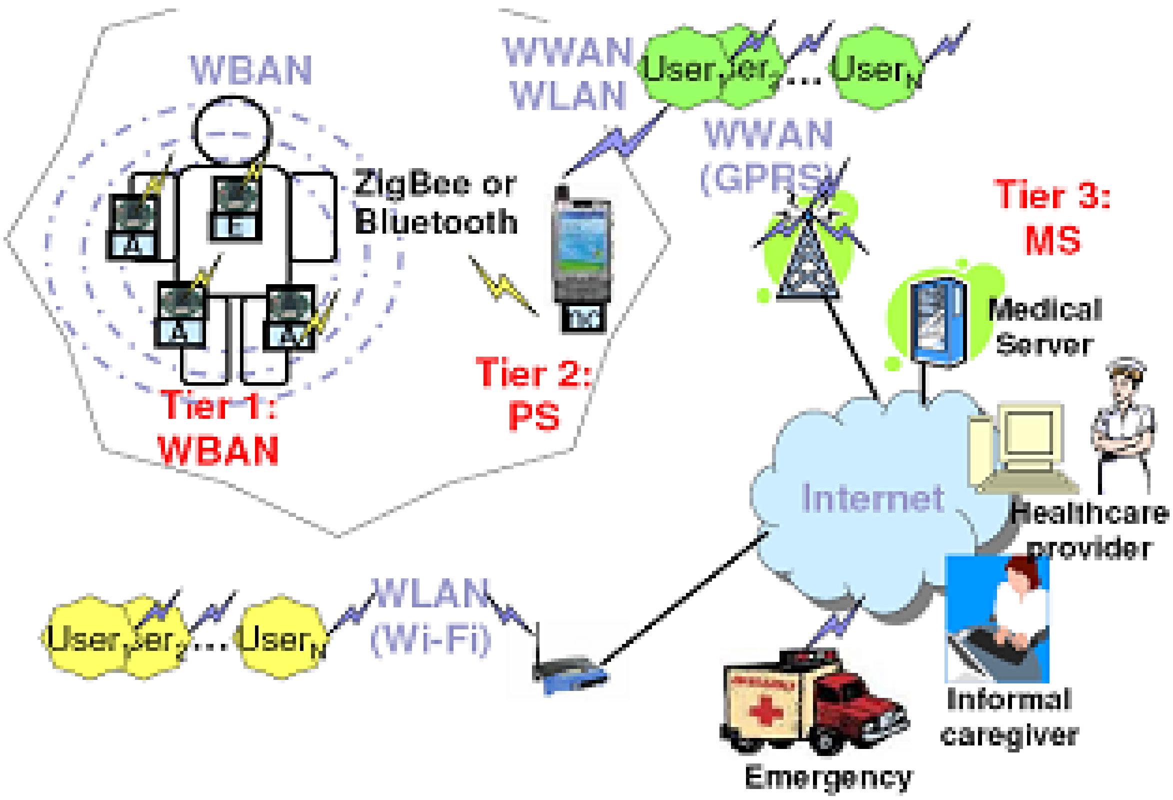


Figure : - Data Rate vs PoweR

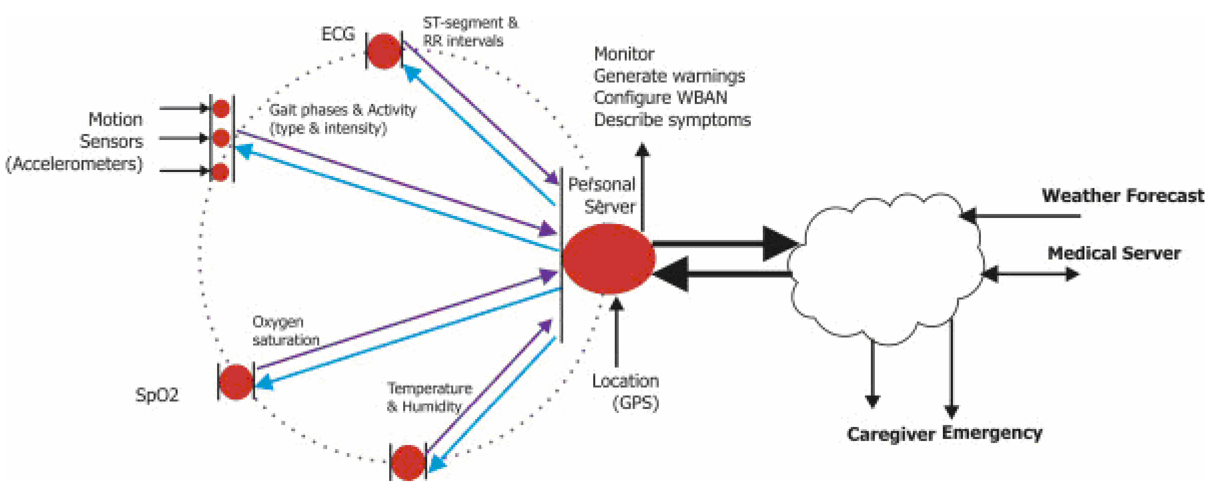
As you can see the range of BAN devices can vary greatly in terms of bandwidth and power consumption. The BAN draft requirements, displayed below, add a common set of requirements as to ensure that all devices conform to a similar set of behaviors yet still encompass a wide variety of devices as previously mentioned.

3.ARCHITECTURE OF BODY AREA NETWORK



The WBAN system is divided into three levels. The lowest level consists a set of intelligent sensors or nodes. These are the reduced function devise. These can only communicate with there parent device and cannot act as parent. The second level is the personal server (Internet enabled PDA, cell-phone, or home computer). These are full function devices. And they can communicate with there children as well as with the external network. The third level encompasses a network of remote server which is the remote application to which data or information is transferred.

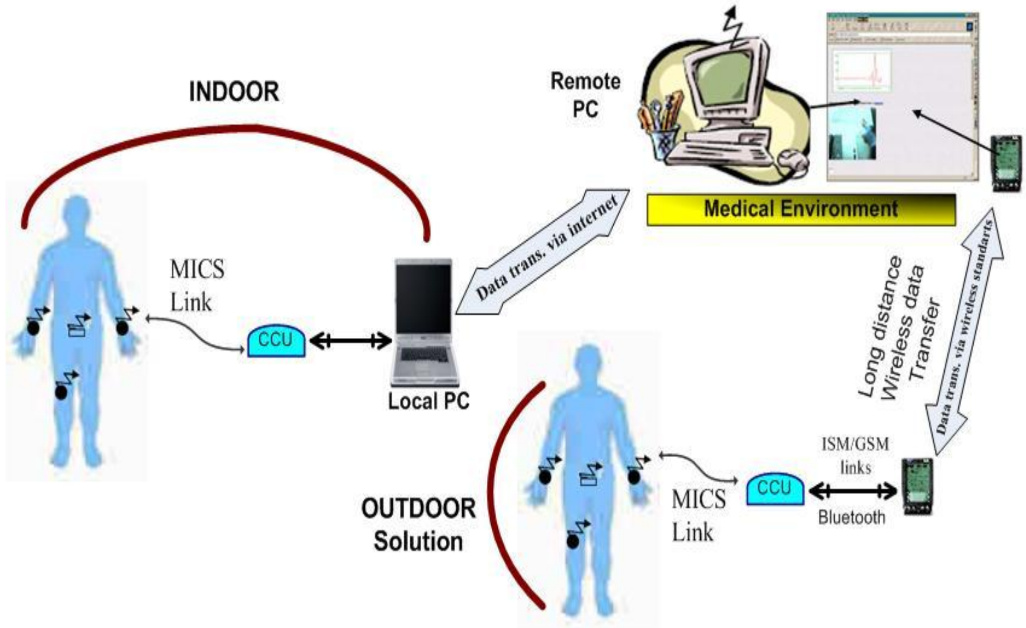
- The lowest level is consists a set of intelligent sensors or nodes which are the reduced function devise. In the non-medical field, wearable devices such as a headset, mp3 player, a game controller, etc can be included in this level.
- The second level is the mobile personal server that has full function devices like Internet enabled PDA, a cell-phone. It communicates with the external network lowest level devices. Additionally, it can display the analyzed information on a screen with an option.
- The third level includes external network of remote servers which provides various application services. For example, the medical server keeps electronic medical records of registered users and provides various services to the users, medical personnel, and informal caregivers



4.APPLICATIONS OF BAN

➢ HEALTH CARE

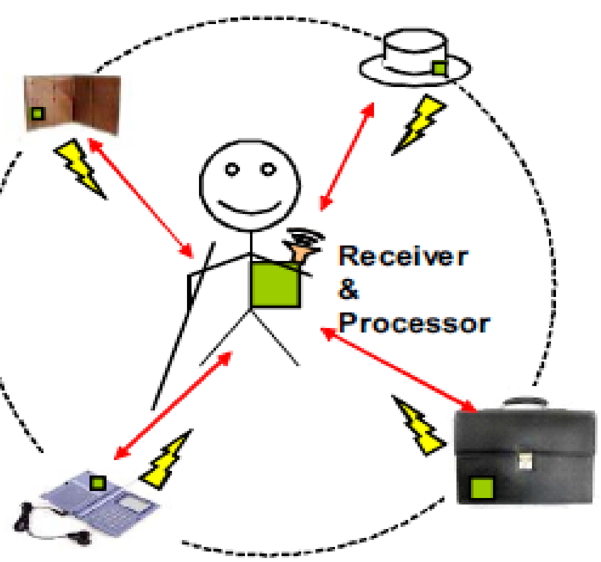
In our wireless body area network (WBAN) or wireless body sensor network (WBSN) project, we develop wireless sensor devices that have the capability to monitor physiological parameters from patient bodies by means of different communication standards. The project targets both implanted and on-body (i.e. external) nodes. Hardware and software designs are being developed for high performance and fault tolerant wireless devices that will expand our ability to monitor and track conditions of patients in healthcare area. The following figure shows a detailed structure of the system that is being designed. In our wireless body sensor network project, MICS (Medical Implant Communication Service) band, WMTS (Wireless Medical Telemetry Systems). and UWB band are used between one CCU (central control unit) and sensor nodes. These three bands were particularly chosen in our design to eliminate the strong interference from other telecommunication devices as reliable communication and accurate monitoring are very crucial for patients' lives. However, we are working to interface our devices with other wireless standards such as WLANs, ZigBee (IEEE 802.15.4), 433 MHz ISM, mobile networks (e.g. GSM) or Bluetooth (IEEE 802.15.1) in order to extend the applications in different environments as shown in the figure below.



Currently, cardiovascular problems represent a major cause of death in the entire world. The great interest in developing clinical devices to detect and continuously monitor cardiovascular diseases is somewhat limited, as transient abnormalities cannot always be monitored. However, many of the diseases associated with the cardiovascular system are related precisely to transient episodes rather than continuous abnormalities, such as transient surges in blood pressure, arrhythmias, *etc*. These abnormalities cannot be predicted because their analyses, even through stress tests, often do not detect them in a reliable and timely manner using conventional protocols. Therefore, these events must be monitored under actual living conditions to diagnose some heart conditions. The result of this approach is to improve the patient's quality of life and change patient behavior patterns, resulting in a reduction of therapy costs.

➢ ASSISTED LIVING

Introduces wireless sensor networks for Ambient Assisted Living as a proof of concept. Our workgroup has developed an arrhythmia detection algorithm that we evaluate in a closed space using a wireless sensor network to relay the information collected to where the information can be registered, monitored and analyzed to support medical decisions by healthcare providers. The prototype we developed is then evaluated using the TelosB platform. The proposed architecture considers very specific restrictions regarding the use of wireless sensor networks in clinical situations. The seamless integration of the system architecture enables both mobile node and network configuration, thus providing the versatile and robust characteristics necessary for real-time applications in medical situations. Likewise, this system architecture efficiently permits the different components of our proposed platform to interact efficiently within the parameters of this study.



Advances in wireless, sensor design and energy storage technologies have contributed significantly to the expanded use of Wireless Sensor Networks (WSN) in a variety of applications. Integrated micro-sensors with onboard processing and wireless data transfer capability, the most important components of WSNs, have already existed for some time . However, at present, more efficient designs have successfully integrated a wide range of sensors. These sensors can monitor a large variety of environmental factors that can affect health including temperature, humidity, barometric pressure, light intensity, tilt, vibration and magnetic field intensity among others, using short-distance wireless communications.

The enormous cost of providing health care to patients with chronic conditions requires new strategies to more efficiently provide monitoring and support in a remote, distributed, and noninvasive manner. Diverse European projects such as the “HealtService24 Project” are trying to improve the quality of medical attention by providing remote medical monitoring. These types of projects are currently developing mobile monitoring systems and integrating remote monitoring into their healthcare protocols to provide expanded healthcare services for persons who require monitoring and follow-up, but do not require immediate medical intervention or hospitalization.

The importance of monitoring patient health is significant in terms of prevention, particularly if the human and economic costs of early detection can improve patient independence, improve quality of life, and reduce suffering and medical costs. The early diagnosis and treatment of a variety of diseases can radically alter healthcare alternatives or medical treatments. Prevention and effective control of chronic diseases has proven repeatedly to be more cost effective than conventional treatments at medical facilities. This is particularly true with chronic and incapacitating illnesses such as cardiovascular disease or diabetes. In the case of cardiovascular disease, 4% of the population over 60 and more than 9% of persons over 80 years of age have arrhythmias, or abnormal heart rates, which require occasional diminutive electrical shocks applied to the heart. Sensors can identify at-risk patients by monitoring and transmitting their real-time cardiac rhythms to medical professionals who can subsequently determine whether or not they require a pacemaker to assist establish and maintain normal sinus rhythm.

Body sensor networks used to manage diabetes will one day involve implanted sensors, not only to monitor patient glucose levels, but also to administer insulin in a timely fashion. In sum, the abovementioned chronic diseases exemplify the need for biochemical and physiological continuous monitoring.

Initial applications of WBANs are expected to appear primarily in the health care domain, especially for continuous monitoring and logging vital parameters of patients suffering from chronic diseases such as diabetes, asthma and heart attacks.

- A WBAN network in place on a patient can alert the hospital, even before he has a heart attack, through measuring changes in his vital signs.
- A WBAN network on a diabetic patient could auto inject insulin though a pump, as soon as his insulin level declines, thus making the patient 'doctor-free' and virtually healthy.
- Other applications of this technology include sports, military, or security. Extending the technology to new areas could also assist communication by seamless exchanges of information between individuals, or between

individual and machines. Imagine businesspeople exchanging business cards, just with a handshake, with the help of BAN sensors. These applications might become reality with the WBAN implementation very soon.

5.ADVANTAGES

A WBAN can include a number of physiological sensors depending on the end-user application. Information of several sensors can be combined to generate new information such as total energy expenditure. An extensive set of physiological sensors may include the following:

• an ECG (electrocardiogram) sensor for monitoring heart activity

• an EMG (electromyography) sensor for monitoring muscle activity

• an EEG (electroencephalography) sensor for monitoring brain electrical activity

• a blood pressure sensor

• a tilt sensor for monitoring trunk position

• a breathing sensor for monitoring respiration

• movement sensors used to estimate user's activity

• a "smart sock" sensor or a sensor equipped shoe insole used to delineate phases of individual steps .

Coverage is confined to distances of no more than 2 or 3 metersThe power transmission levels are very low. Low power contributes to long battery life and reduces the levels of interference with other technologies. Equally important, operating with low power levels reduces health risks.

BANs can provide interfaces for diagnostics, for remote monitoring of human physiological data, for administration of drugs in hospitals and as an aid to rehabilitation

In the future it will be possible to monitor patients continuously and give the necessary medication whether they are at home, in a hospital or elsewhere.

- Used for detection of chronic diseases.
- Also we can use in military for security purposes.
- Assists seamless communication between individual and peoples.

6.CHALLENGES

BAN technology is still emerging and there are a lot of problems left to solve. Setting aside ethical issues like privacy, there are still plenty of technical challenges that we must overcome before BAN will become an effective solution. The BAN draft submissions have defined solutions for a lot of the basic wireless network protocols, but there is still a large amount of research that must be done to effectively propagate a signal in and around the human body. The last challenge BAN technology faces is actually a problem of Human-Computer Interaction (HCI) and how to make the technology usable.

- **Interoperability**: WBAN systems would have to ensure seamless data transfer across standards such as Bluetooth, ZigBee etc. to promote information exchange, plug and play device interaction. Further, the systems would have to be scalable, ensure efficient migration across networks and offer uninterrupted connectivity.

§ **System Devices**: The sensors used in WBAN would have to be low on complexity, small in form factor, light in weight, power efficient, easy to use and reconfigurable. Further, the storage devices need to facilitate remote storage and viewing of patient data as well as access to external processing and analysis tools via the Internet.

§ **System and device-level security**: Considerable effort would be required to make BAN transmission secure and accurate. It would have to be made sure that the patient's data is only derived from each patient's dedicated BAN system and is not mixed up with other patient's data. Further, the data generated from WBAN should have secure and limited access.

§ **Invasion of privacy**: People might consider the WBAN technology as a potential threat to freedom, if the applications go beyond 'secure' medical usage. Social acceptance would be key to this technology finding a wider application.

§ **Sensor validation**: Pervasive sensing devices are subject to inherent communication and hardware constraints including unreliable wired/wireless network links, interference and limited power reserves. This may result in erroneous datasets being transmitted back to the end user. It is of the utmost importance especially within a healthcare domain that all sensor readings are validated. This helps to reduce false alarm generation and to identify possible weaknesses within the hardware and software design

§ **Data consistency**: Data residing on multiple mobile devices and wireless patient motes need to be collected and analysed in a seamless fashion. Within Body Area Networks, vital patient datasets may be fragmented over a number of nodes and across a number of networked PCs or Laptops. If a medical practitioner's mobile device does not contain all known information then the quality of patient care may degrade

7.CONCLUSION

Up to date there is no available standard for wireless body area network (WBAN) and specifically not any intended for medical applications. A WBAN intended for medical applications could be seen as a wireless sensor network since most medical applications will rely on sensors collecting data about, e.g., the heart and the brain. As such the sensor nodes must be kept simple in order to fulfil requirements on energy-efficiency and long battery life time. Things that influence the battery life time is the duty cycle of the sensing node, i.e., the active time period of the sensor node. To conserve energy the sensor node should be kept as long as possible in power-down or sleep mode. A drawback with long sleep periods is the clock drift implying that a node must also be awake longer once it wakes up due to clock drifting apart from other sensor nodes in the network making a rendezvous in time more complicated. The communication protocols within the node should be kept simple not requiring a lot of computation and also more advanced data/signal processing should be avoided in the sensor node.

The higher frequency that is used for communication the smaller antenna can be used, which is an advantage when a sensor node must have a small form factor. A single medical application using wireless communication will probably not have its own frequency band from the beginning because this is too expensive and therefore it is directed to the license-free bands; see Table 4 for a summary of these bands. However, when medical applications have found their niche it can be possible to apply for licenses in the future when it is beneficial, however, medical implants already today has its dedicated band at 402-405 MHz. The license-free bands have requirements on the output power and duty cycle. The output power, which a node can use for transmitting in the license-free bands, is quite small (<100mW) compared to for example a mobile telephone that can have peaks of 1-2 W during transmission. Therefore, the SAR value should not be of any problem in a WBAN. The higher frequency that is used the higher attenuated by the body the signal will be and this is a drawback. Here more channel measurements should be done on the human body to find out how a better signal reception could be achieved. Perhaps it is impossible to utilize higher frequencies due to the attenuation the body is causing. In Sweden the hospitals can decide to prohibit wireless networks even though they are designed according to the regulations of a certain license-free frequency band. This is due to that fact that other medical equipment could be sensitive to electromagnetic radiation. Therefore a discussion with a big hospital would be beneficial in order to determine a suitable frequency band for a WBAN.

8.REFERENCES

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9.COMMENTS