

# **Comparative Analysis of Healthcare Monitoring System Using Wireless Body Area Networks**

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**ABSTRACT:** Healthcare Monitoring System expected to reduce healthcare expenses by enabling the continuous monitoring of patient health remotely during their daily activities. Healthcare applications based on Wireless Sensor Networks are gaining high popularity all over the world due to their features like flexibility, mobility and ease of constant monitoring of the patient in both outside and inside the body. The main focus of such system is remote monitoring of patient, inside and outside the hospital room and in ICU in the sense of implantable feature. Recent developments in combining sensors, communication systems, and other fields such as cloud computing and Big Data analysis have provided the perfect tools to develop cutting edge systems for improving energy efficiency and consumption. Smart homes, smart sensors, and Internet of Things are just a few examples of these technologies that will lead to more sustainable and more resilient energy systems. This research work will focus on the Wireless Sensor Networks in terms of emerging wireless technologies which means supporting infrastructure and technology and challenge design issues and as well as security, mobility and energy consumption.

**KEYWORDS:** Healthcare, Wireless Sensor, ZigBee, SHM Nodes, Wearable Body Area Network, Security and Energy consumption.

## **I. INTRODUCTION**

Different wireless technologies are used in medical applications such as WBAN, WPAN, WWSN etc., and Wireless Body Area Network (WBAN) is a widely using technology used in medical applications with continuously operating sensors, which measures the patient physiological signals such as mobility, blood pressure, heart rate and glucose levels, etc., Two categories of wireless sensor networks namely wearable and implanted are present in the field. Wireless body area network is used to capture the patient's sensitive data so need to secure them in a proper way from unauthorized access. This paper concerns of major social implications like privacy and security. It mainly focuses on the causes and effects of these two issues. Basically, Wireless Sensor Network (WSN) is a wireless network consisting of spatially distributed autonomous devices that use sensors to monitor physical or environmental conditions. These autonomous devices, or nodes, combine with routers and a gateway to create a typical WSN system. Sensor networks are the key to gathering the information needed by smart environments, whether in buildings, utilities, industrial, home, shipboard, transportation systems automation, or elsewhere. Recent terrorist and guerrilla warfare countermeasures require distributed networks of sensors that can be deployed and have self-organizing capabilities. Body-area networks can collect information about an individual person's health, fitness, and energy expenditure. In such applications, running wires or cabling is usually impractical.

A sensor network is required that is fast and easy to install and maintain. The smart gateway is designed to enable WSN and public communication networks to access each other with seamless internetworking. To address the fast growing sensor technology in this area, a new field known as Wireless Body Area Networks (WBAN) has emerged. Applications of wireless sensor networks mainly focused on the monitoring of health status of patients have been in demand and various projects are in the development and implementation stages. Different types of network

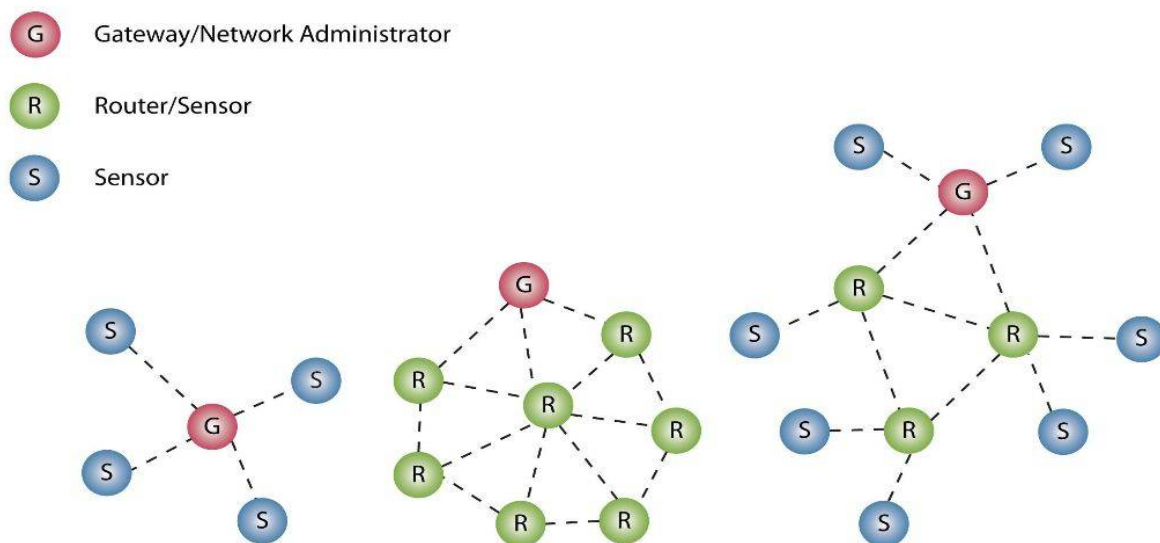
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topology scenario are shown in Figure 1. Here major types such as star, ring and tree topology are chosen as sensor networks.



**Figure 1: Types of Network Topologies.**

Paper is organized as follows. Section II describes related works carried out under Healthcare Monitoring System area. Comparative study based on Wearable Body Area Network techniques such as ZigBee, SHM, WBAN are discussed in Section III. Section IV presents conclusion.

## II. RELATED WORK

Uttara Gogate, Jagdish W. Bakal presented a cost and energy efficient 3 tier model for healthcare based on WSN to remove limitations of wired system and to use wireless technology efficiently. Their system continuously monitor the patient's body parameters like temperature and pulse rate and after detecting abnormal readings of any of the parameter, generating sms or email alert to the physician, duty nurse and close relative of the patient for emergency handling. Different available wireless standards are compared for the intermediate communication among the three tiers of the system based on various parameters. After comparing with the existing wireless technologies, they aimed to incorporate the recently developed ZigBee standard (IEEE 802.15.4) in their sensor network design using Arduino boards for tier 1 communication and WiFi existing in the hospital for tier2 communications. Finally tier 3 includes internet facility to transmits the patient's data to doctors, observers, dean or outside the hospital via Internet for expert advice and diagnose. Collected data is used for current monitoring system for hospital staff and also for long term data storage on Hospital's Centralized Server.

Kahtan Aziz et al focus on monitoring the patient's blood pressure, and his body temperature through GSM and GPS technologies. In their analysis death rates due to hypertensive heart disease shows that the blood pressure was a crucial risk factor for atherosclerosis and ischemic heart diseases. Their system will track, trace, monitor patients and facilitate taking care of their health; so efficient medical services could be provided at appropriate time. By using specific sensors, the data will be captured and compared with a configurable threshold via microcontroller which is defined by a specialized doctor who follows the patient; in any case of emergency a short message service (SMS) will

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be sent to the Doctor's mobile number along with the measured values through GSM module. Furthermore, the GPS provides the position information of the monitored person who is under surveillance all the time.

Ms. Hoda Ramin Hossein, Prof. S.S.Shaikh outline a model that uses Near Field Technology to address the patient information, an android application that will monitor the health parameters of the patients and a doctor application that will be able to view the patients data with the help of NFC tags and take actions accordingly. Their model will use a web server for storing the entire sensitive data of patients. Unlike Servlets that allows only clients of Java technology to be interfaced, their web server architecture will allow clients of various different technologies to be interfaced. Their system has overcome the disadvantages of using RFID system by using NFC tags. The servlets architecture has been replaced by the web service architecture which opens a space for other technologies to be implemented rather than being only java. Also the patient's status is automatically generated and stored in the cloud server and also alerts are generated if the patient is in a serious condition or unconscious state. Currently it is possible to conclude that for providing a better solution to the field of m-healthcare in many hospitals, NFC promises appear to be credible.

De-Thu Huynh, Min Chen proposed an energy efficiency solution for WBAN based on ZigBee applying Healthcare Monitoring System. Particularly, they utilized the ZigBee standard working in beacon enable mode to obtain the adaptive duty cycle. Consequently, the energy consumption in idle-mode is avoided, as well as the total energy consumption of sensors is also decreased and extended network lifetime. The simulation results conducted by OPNET Modeler show that their method can save efficient energy consumption of WBAN while the QoS is ensured in terms of network performances in long-term Healthcare Monitoring System. Finally they have proposed an energy efficiency solution for WBAN based on ZigBee applying Healthcare Monitoring System. In particular, it utilised the ZigBee standard working in beacon-enable mode to obtain the adaptive duty cycle by exploiting the BeaOrder (BO) and SupFraOrder (SO). Therefore, overall energy consumed in sleep-mode is avoided, as well as the overall energy consumed by sensors is decreased and extended network lifetime. It has been shown via simulation that their solution can save efficient energy consumption of ZigBee based WBAN while the QoS is ensured in long-term Healthcare Monitoring System.

Audace Manirabona, Saadi Boudjit, Lamia Chaari Fourati proposed a scheduling strategy at the coordinator of a WBAN based Health Monitoring System called Priority-Weighted Round Robin. Their proposed scheduling strategy provides good results in terms of reducing delay of emergency and medical data. Simulation and analytical results for peer-networks involved in a WBAN based HMS show that, if PWRR is set, the behavior of WIFI, WIMAX and LTE networks remains the same in keeping all flows as per their priorities by mitigating the end-to-end delay. Moreover, it was shown that the increase of the arrival rate of emergency flows increases the delay of these latter too whereas the emergency flows have low arrival rate though in reality. It was also noticed that all data flows have lower delay in PWRR than in FIFO except the nMD flow whose delay increases if its arrival rate exceeds 0.45, hence the importance of considering the transmission rate of all involved flows. Ultimately, the WBAN based Health Monitoring System should implement a scheduling mechanism at the coordinator and the PWRR seems to be the better candidate.

## III. DISCUSSION

### ❖ ZigBee:

Basically, ZigBee based WBAN can supply continuous healthcare monitoring while the necessary requirements of a Healthcare Monitoring System is ensured. It using very low transmission power and it will do not affect patient's health. The characteristics of ZigBee devices are tiny, light-weighted and low power which increase the comfort of patient and provide longer Healthcare Monitoring System. In this fashion, the energy consumption will be a main problem in employment of WBAN based on ZigBee applying Healthcare Monitoring System. One of the energy-effective methods in WBAN is utilizing the IEEE 802.15.4 ZigBee standard which represents as the well-known technology for low cost and low power consumption in WBAN. Specially, the IEEE 802.15.4 standard defines the physical and wireless medium access control layers, while the network and application layers are described by the ZigBee specification. In their work, they assumed that the physical layer operated in 2.4 GHz frequency and bit rate of

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250 Kbps, which allows working in two modes (e.g., beacon-enabled and non beacon enabled mode) and will be chosen by a WBAN Coordinator. Beacon-enabled mode is very beneficial because it can expand battery lifetime of sensors by orders of magnitude as result of varying the periods of time when a sensor is active (receiving or transmitting) or inactive (i.e. the low power mode without turning to “off-mode”). Moreover, the operation of WBAN in beacon-enabled mode can assure the real-time by using Guaranteed Time Slots (GTS) method, which guarantees the collision-free and forecasts the shared wireless medium access. Therefore, when concerning with real-time and energy saving aspects, the beacon-enabled mode should be utilized.

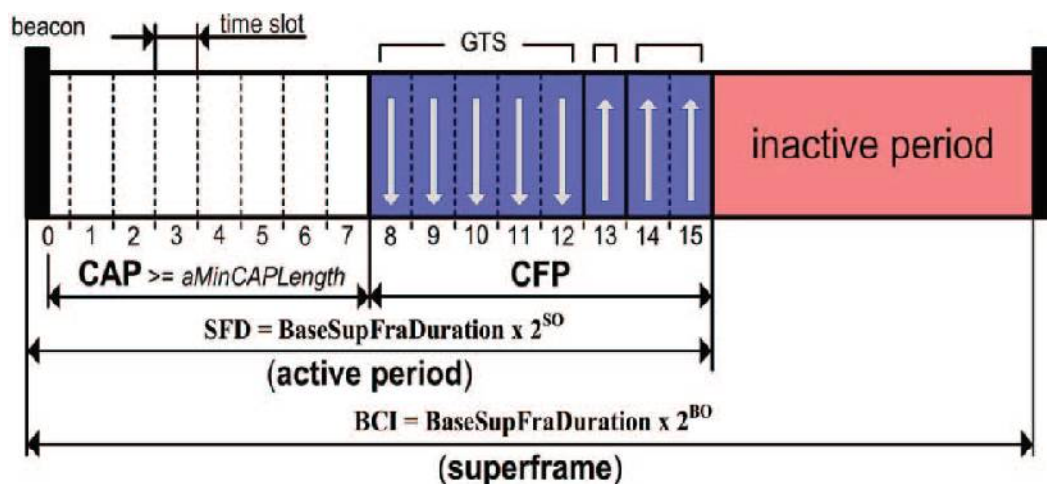


Figure 2: Super frame Structure [8]

When the IEEE 802.15.4 ZigBee standard operated in beacon-enabled mode, the WBAN Coordinator periodical sent beacon-frames every BeaInterval (BCI) to recognize its WBAN, to synchronize sensors which are connected with it, to characterize the super-frame structure (Figure 2) which includes an active-period and an optional inactive-period. The SupFraDuration (SFD) represents the active-period which is partitioned into 16 time slots in the same size. And the active-period may be further partitioned into a Contention Access Period (CAP) and an optional Contention Free Period (CFP) which included Guaranteed Time Slots (GTS). If CFP is not using, the sensors aspire to interacting in CAP period should be emulated to others by using a slotted CSMA/CA method. In the case using CFP, GTS should assigned by the WBAN Coordinator aim to obtain low-latency or individual requirements of bandwidth. In the optional inactive-period, the sensors can go into the low-power mode (idle-mode) for saving more energy consumption. In this mode, there are no changes in data frames. The structure of super-frame is defined by two parameters, BeaOrder(BO) and SupFraOrder(SO), which will determine the length of super-frame and its active-period, respectively.

### ❖ Wearable Wireless Body Area Network:

Next one, Wearable health monitoring systems allow an individual to closely monitor changes in her or his vital signs and provide feedback to help maintain an optimal health status. If integrated into a tele-medical system, these systems can even alert medical staff when life-threatening changes occur. In addition, patients can benefit from continuous long-term monitoring as a part of a diagnostic procedure, can achieve optimal maintenance of a chronic condition, or can be supervised during recovery from an acute event or surgical procedure. Long-term health monitoring system can capture the diurnal and circadian variations in physiological signals. These variations are a very good recovery indicator in cardiac patients after myocardial infarction method. In addition, long-term monitoring can confirm adherence to treatment guidelines (e.g., regular cardiovascular exercise) or help monitor effects of drug therapy for particular patients. Other patients can also benefit from these systems; for example, the monitors can be used during physical analysis after hip or knee surgeries, stroke analysis, or brain trauma analysis in order to recover fully by using monitoring systems.

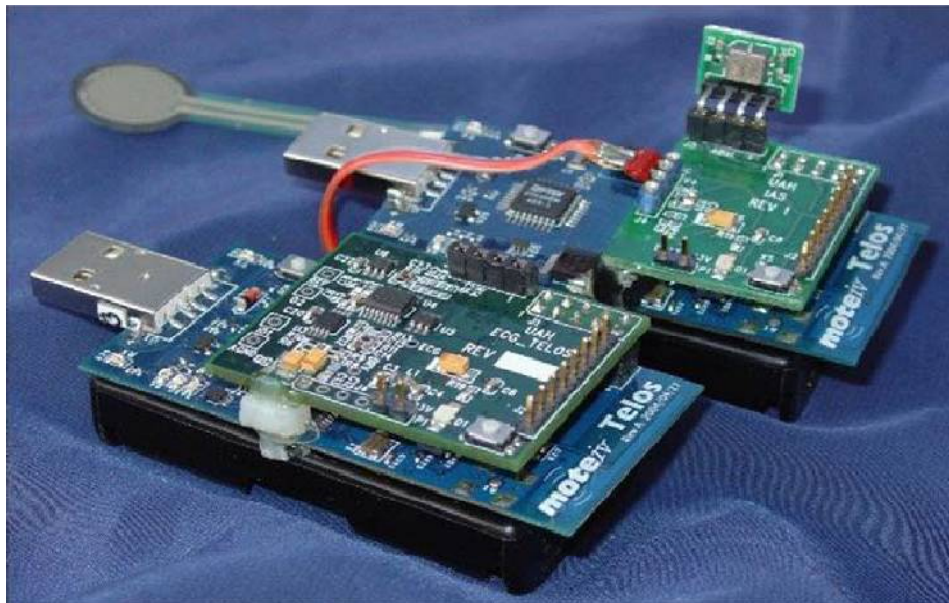


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**Figure 4: ActiS sensors with customized daughter boards [17].**

Above figure ActiS sensor which is designed with customized daughter boards. They described a general Wireless Wearable Body Area Network architecture as well as our prototype WWBAN designed using Telos motes and application-specific signal conditioning modules. The prototype consists of several motion sensors that monitor the user's overall activity and an ECG sensor for monitoring heart activity. Every sensor that included in this process will send the information to the storage level.

## ❖ SHM nodes:

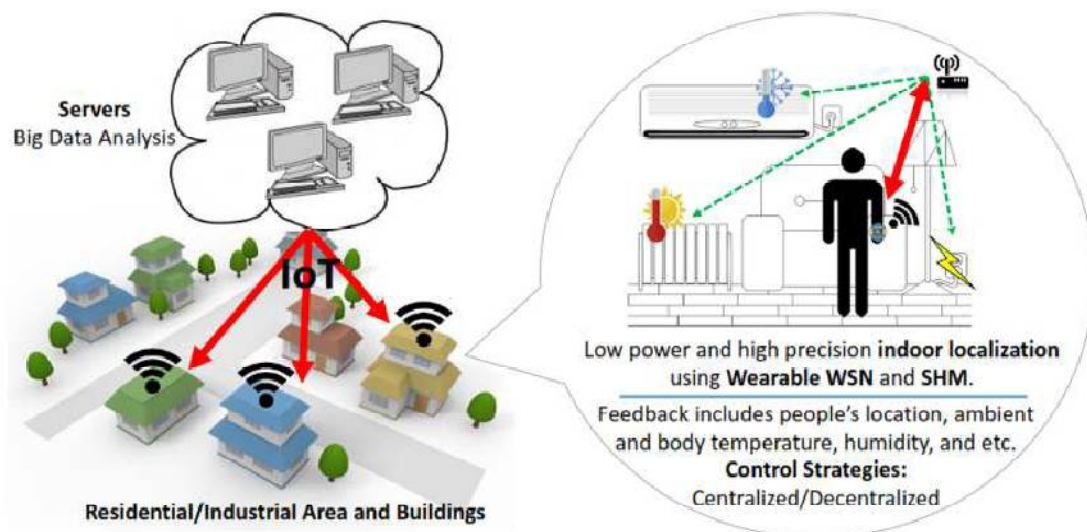
Another relevant work related to the concept is SHM nodes. These customized SHM nodes have been used for general structural health monitoring and also provide a platform for constructing the wireless sensor network including wearable nodes and other energy meters and monitoring sensors (e.g. light, heat, electricity, and so on). SHM nodes can measure vibration, displacement, ambient humidity and temperature as their general features for SHM nodes. They also have been equipped with an ultra-wideband (UWB) radio frequency module that has been used for real-time indoor localization and transferring data between the wearable nodes and the SHM nodes. As a part of an IoT-based device, SHM nodes have Wi-Fi modules in order to transfer data through the Internet. For situations where Wi-Fi connection is not available, SHM nodes can send and receive data through the on-board quad band GSM/GPRS data. Following figure describes the working procedure of SHM nodes with respect to wearable sensor nodes, SHM nodes working through IoT based procedure.

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**Figure 3: Working Procedure of SHM Nodes [18]**

Here low power and high precision are gathered through Wearable WSN and SHM nodes which are observed through indoor localization. Feedback of patients will be absorbed through that nodes and it will be sent to centralized storage section. Feedback includes patient's location, body temperature, humidity, blood pressure, heart rate and increase the level of comfort such as heating and cooling points, etc. Using their proposed system, data have been collected in order to obtain the following items.

1. Real-time localization of people inside the building in order to:
  - Change the lighting status and heating/cooling set points based on the distribution of people.
  - Modify the energy load based on the presence/absence of people in different areas.
2. Collecting data like near body temperature, humidity, and heart rate are in order to:
  - Modify the set points based on the body temperature and body activity level.
  - Provide the highest level of convenient for habitants.
3. Obtaining user feedback in order to:
  - Modify the control strategies based on the people's preferences.
  - Increase the level of comfort.

## Achievements

- Obtaining real-time feedback from the people and adding new human-based parameters to the control states and decision variables of an energy consumption of the control unit.
- Adaptation of the energy consumption profiles based on the obtained data like distribution of people as a new state variable in order to increase the energy efficiency and also to improve people's level of comfort.
- Increasing the flexibility and functionality of the current solutions and presenting an intelligent system that can adapt itself to the energy state of the system in real-time.

These collected data from them will lead to an adaptive and intelligent energy consumption optimization which works besides with their current existing optimization tools. Compared to existing ones their proposed work gives more accuracy of results.

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**Table 1: Advantages and Disadvantages of Sensor nodes in Wireless Body Area Network**

S.No	METHOD	ADVANTAGES	DISADVANTAGES
1	ZigBee	<ul style="list-style-type: none"> <li>Low cost</li> <li>Low Transmission power</li> <li>Portable size</li> <li>Low power consumption</li> </ul>	<ul style="list-style-type: none"> <li>Optional to see inactive timing</li> <li>Consumption rate low when system is idle</li> </ul>
2	WWBAN	<ul style="list-style-type: none"> <li>Send periodic updates</li> <li>Inexpensive</li> <li>Lightweight</li> </ul>	<ul style="list-style-type: none"> <li>High storage</li> <li>Repeated data storage cause waste of memory</li> </ul>
3	SHM Node	<ul style="list-style-type: none"> <li>High energy efficiency</li> <li>Low power consumption</li> <li>Separate sensors for temperature and light settings</li> </ul>	<ul style="list-style-type: none"> <li>Controlled by IoT based devices</li> <li>Works well with internet only</li> </ul>

Above table describes the advantages and disadvantages of three different sensors based on Wireless Body Area Networks. These three came under the category of wearable sensors which are specially made for power consumption and security problem.

## IV. CONCLUSION

Wireless Body Area Network is the prominent technology and plays an important role in developing Healthcare Monitoring System as wearable method. Therefore, more and more research is needed on WBAN to realize the Healthcare Monitoring System which will bring to a lot of advantages in caring the patient's health. Nowadays consuming high power brings more money consumption which results user suffers lot. In order to overcome that limitation several concepts are discovered. In this paper, three different concepts are taken for analysis which are based on cost and power consumption. Moreover all the three sensor nodes use low power to process and produce likely results. Each sensor node having some pros and cons which are based on their working performance and also based on locality made. This paper addressed several key technical issues such as sensor node, network time synchronization, and energy conservation. Further efforts are necessary to improve QoS of wireless communication, reliability of sensor nodes, security, and standardization of interfaces and interoperability. In addition, further studies of different medical conditions in clinical and ambulatory settings are necessary to determine specific limitations and possible new applications of this technology.

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