AN OVERVIEW OF WIRELESS BIOMEDICAL SENSOR NETWORKS

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Abstract

The growing body of research on Wireless Sensor Networks (WSNs) has given medical gadgets a whole new meaning. Advances in microcontroller technology are mostly to blame for this. The relevance of WSNs in fields including health, psychology, fire prevention, security, and even the military is attributed to its status as one of the century's great technological advancements. The capacity to follow, monitor, research, comprehend, and respond to any specific occurrence or incident is this technology's key benefit. A wireless health system's main goal is to provide trustworthy data as quickly as possible. The extensive body of work on Wireless Biomedical Sensor Networks (WBSNs) research is surveyed in this review, along with examples from theoretical and empirical literature, as well as experimental and non-experimental studies. In order to provide a coherent and accessible overview of WBSNs, the review includes a broad range of objectives, including the definition of ideas, a study of theories, failures, and less favorable elements. Some of these systems are now on the market, while others are still being researched. This study also seeks to determine the WSN attributes relevant to healthcare.

Keywords: WBSN, Node Sensor Wireless Network, Biosensors, WSN

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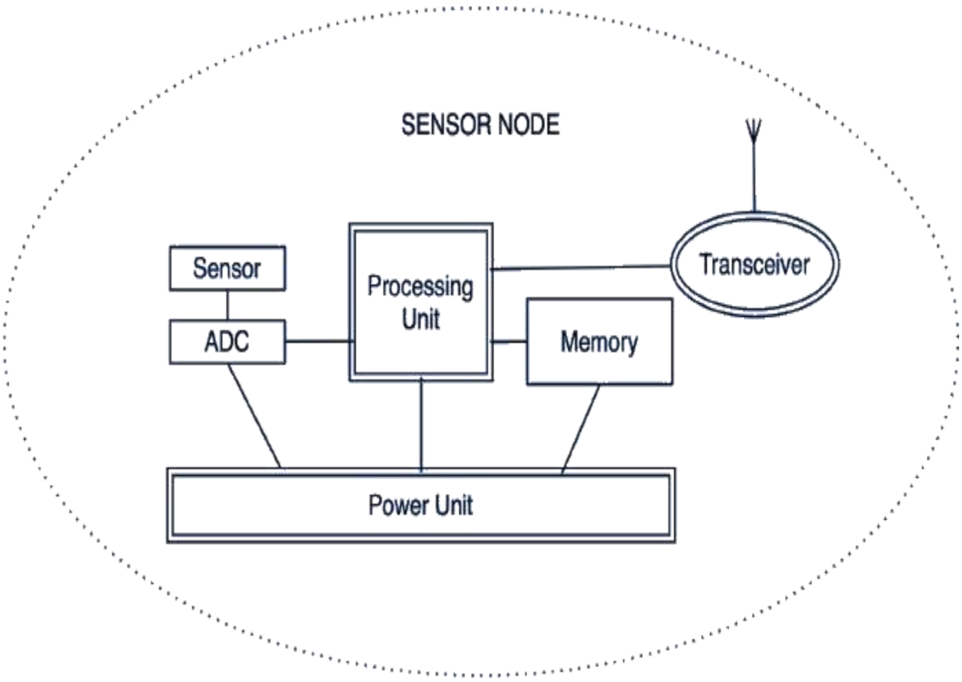
1. Introduction

The elderly population is growing and getting older, and life expectancy is increasing due to advances in healthcare. However, over 850 million people around the world suffer from chronic diseases and may spend a significant portion of their savings on healthcare. Prevention is often better than treatment, so continuous monitoring is important. The aging population in developed countries is putting pressure on healthcare budgets and presenting challenges for health systems, particularly for older people living alone or in nursing homes. The development and use of medical devices has been aided by the growth of research in wireless sensor networks (WSN), which have a wide range of applications including health, psychology, fire prevention, security, and the military. WSN can allow for continuous health monitoring using wireless networks that transmit vital signs over short distances, and new telemedicine systems are using technologies like 802.15 and 802.16 to provide life-saving services through the distribution of medical information. Wireless sensors can be used to gather physiological signals from patients in hospital or home care settings, but the design of WSN for medical purposes must consider accurate traffic models to properly manage network traffic, congestion, interference between nodes, and energy expenditure. There are currently no traffic models that specifically address medical WSN applications. This review discusses the opportunities provided by the increased research in WSN for the development of medical devices.

2. The fundamentals of WSN

Wireless sensor networks (WSNs) are made up of a large number of small, lightweight, battery-powered sensor nodes that are deployed over a geographical area. These nodes are equipped with sensors that can monitor various physical or environmental conditions, such as temperature,

Figure 1: The Elements of Sensor node in WSN



humidity, pressure, and object motion. Each node consists of four main components: a power unit, a transceiver unit, a sensing unit, and a processing unit. Some nodes may also have additional components, such as a power generator or location finding system. The nodes communicate wirelessly with each other and can operate in one of four modes: transmission, reception, idle listening, or sleep. Collision can occur when two or more nodes transmit at the same time. WSNs often operate at a frequency of 900 MHz and use an operating system like TinyOS, which is written in the programming language NesC. WSNs belong to the broader category of sensor networks that use distributed sensors to gather information about specific entities. Within a WSN, there may be both sensing nodes (nodes that are sensors) and non-sensing nodes (nodes that are not sensors). Sensing nodes have four operating modes: transmission, reception, idle listening, and sleep. Collision occurs when two or more nodes transmit at the same time.

2.1. Use cases for WSNs

Wireless sensor networks discover packages in lots of regions along with commercial automation, automotive industry, precision agriculture, and medical monitoring. They can successfully be used in healthcare for health monitoring, smart nursing homes, in-home assistance, telemedicine, and wireless frame vicinity networks.

a. Health Monitoring:

WSNs can be used to display a affected person inside the medical setting or at home regardless of the patient's or a caregiver's vicinity. Monitoring system is regularly vital to constantly monitor a patient's critical parameters inclusive of blood strain, heart rate, frame temperature, and ECG. Sensors and area tags can be used to music both healthcare employees and patient. Since prevention is higher than remedy, coping with wellness in preference to contamination is paramount. To acquire this, individual fitness tracking is wanted at a periodic interval. Due to the reality that the gadget is wi-fi, it's far flexible and it isn't required that the patient be restricted to his mattress [5]

b. Wireless Body Area Networks:

They cover actual-time healthcare records collecting acquired from extraordinary sensors. Important capabilities of those networks consist of wireless verbal exchange protocols, frequency bands, statistics bandwidth, encryption, energy consumption, and mobility. A regular wireless body location community is shown in Figure 2 [6]. The design of wearable sensors allows person to continuously screen physiological information aided via WSNs in healthcare. A body area community maintains fitness monitoring for the duration of the patient's live at the sanatorium or domestic. It may be useful for emergency cases, where it sends facts about the affected person's fitness to the healthcare issuer. It also can help human beings by way of presenting healthcare services together with memory enhancement, medical records get admission to, most cancers detection, asthma detection, and tracking blood glucose [7].

c. At-home Healthcare:

This addresses the social burden of the growing old populace. It is finished by means of using medical WSNs. Longevity has given upward push to age-associated disabilities and diseases. Providing quality healthcare to aged populace has end up an important social and economic issue. At-domestic healthcare offers low-cost care to the elderly while they live independently [8].

d. Telemedicine:

Telemedicine is a technique that improves patient participation, reduces costs, and enhances access to healthcare. Telemedicine has come a long way since it first appeared in the late 1950s, giving elders the option to age in place. Additionally, people who live in remote locations who previously had trouble reaching a doctor can now do so electronically.

Information may be sent instantly from one computer screen to another between doctors and patients. They may even view and record information from medical equipment that is located far away. Without needing to schedule an appointment, patients may consult a doctor for diagnosis and treatment using telemedicine software. Patients can consult a doctor from the convenience of their own home.

It is a medical method that lets in clinical work to be finished using records and communication technology. Telemedicine the use of WSN has currently come to be a fashion in healthcare. It refers to the provision of healthcare offerings and schooling over a distance using information and conversation technologies. It lets in for faraway clinical critiques. The use of telemedicine reduces the overall cost of healthcare.

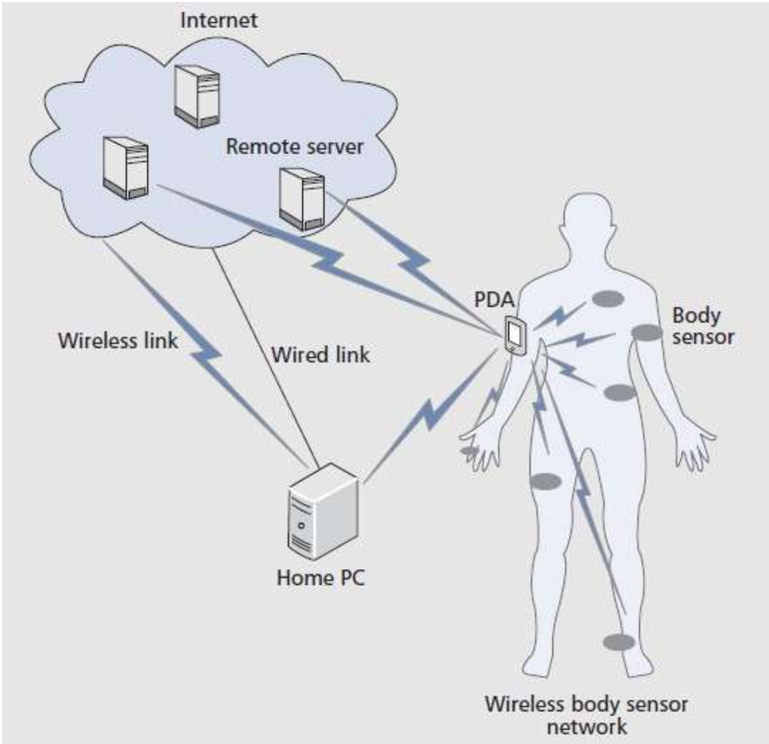


Figure 2: WBSN

2.2. Advantages

WSNs in healthcare have the subsequent advantages:

Flexibility: The system collects and communicates facts wirelessly with minimum enter from the affected person. It isn't required that the patient be constrained to his mattress.

Always-on: The physiological and surroundings statistics can be monitored continuously making an allowance for actual-time response by means of caregivers. The WSNs permit sufferers to be monitored and remain continually below clinical manipulate.

Self-organization: Physicians can exchange the task of the community as clinical needs trade.

Low-cost: Using WSNs in healthcare affords a low-price conversation infrastructure this is suitable for monitoring.

2.3. Challenges

Although healthcare programs of WSN have sizable advantages, they faces a few demanding situations such as low strength, restrained computation, low bandwidth, dependable information transmission, non-stop operation, interference, node mobility aid, vulnerability, security, timely delivery of records, protection, privacy, congestion, and regulatory restraints. WSN gadgets are normally confined in phrases of strength, computation, and conversation. The low amount of energy at once limits computation. WSNs are at risk of numerous sensor faults and this vulnerability hinders efficient and well-timed reaction in healthcare packages. Security is a vital problem for any system, specifically in healthcare WSNs, wherein we're coping with sensitive clinical records of individuals. Security breach in healthcare packages of WSNs is a primary concern [10]. Privacy is another main difficulty of patients and the finest barrier to digital healthcare deployment. Healthcare packages impose constraint on give up-to-stop reliability, which measures how nicely they system performs within the presence of disturbances. Congestion must be curbed because it impacts flow of information and put off in statistics delivery. The integration of multiple sensing gadgets working at extraordinary frequencies reason interoperable trouble.

3. Node Sensor WSNs

In recent years, the availability of wearable health monitoring gadgets has increased dramatically. Nevertheless, these systems have substantial drawbacks. Holter monitors, for example, are simply used for data gathering; offline processing and analysis of this data is performed separately. This rendered the device unsuitable for long-term illness monitoring and early detection. Multiple sensors are prevalent in physical rehabilitation systems; however the wires linking them may impede the patient's mobility and comfort.

Recent advancements in the integration and reduction of physical sensors, embedded microcontrollers and radio interfaces on a single chip, wireless networking, and micro-fabrication have increased interest in health monitoring and rehabilitation. Figure 3 illustrates the variables that made WBSN possible.

Scales, blood pressure monitors, and blood glucose monitors, to name a few, can all communicate with one another thanks to established protocols for interoperability in the field of personal health monitoring. The IEEE 11073-20601-2008 standard and its modification, IEEE 11073-20601a-2010, serve as the basis for this set of recommendations. ZigBee Alliance's Personal, Home, and Hospital Care (PHHC) profile is dependent on ongoing work being done by IEEE 11073 to enable compatibility with medical equipment.

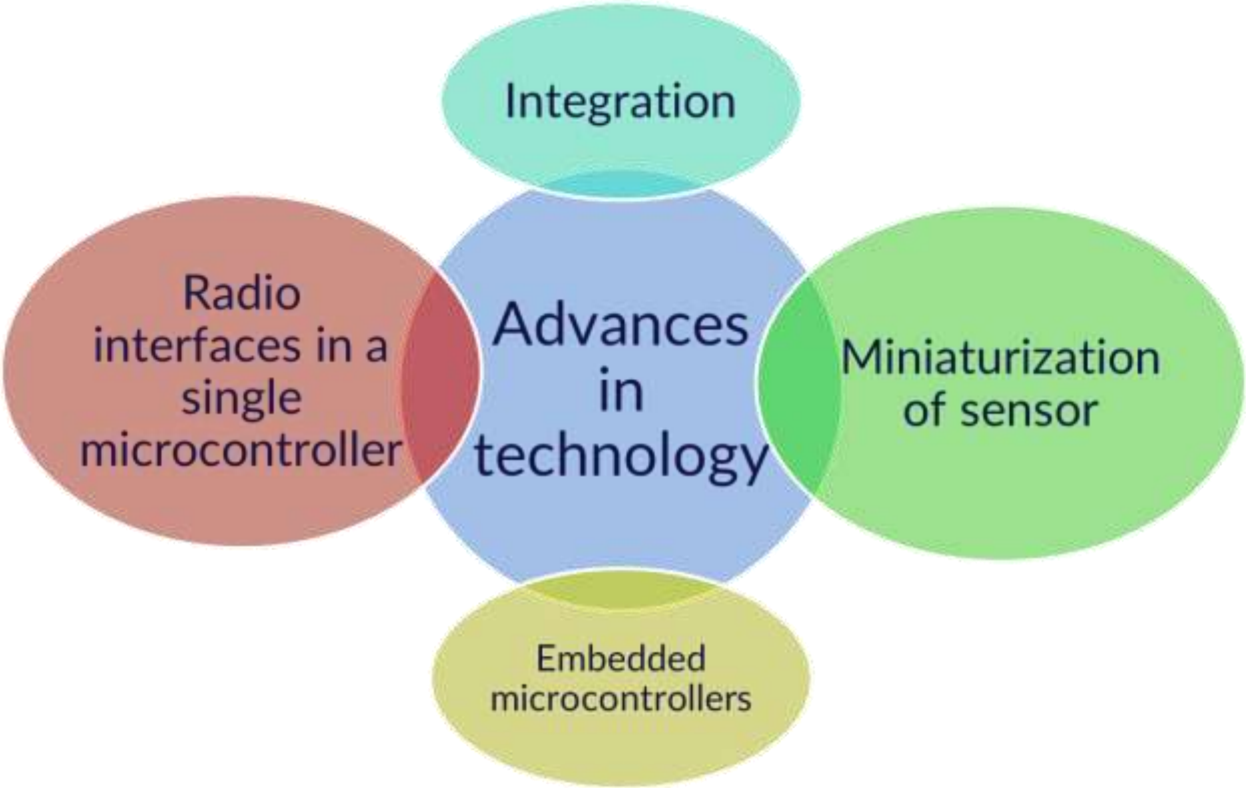


Figure 3: Improvements in WSNs have allowed for the development of WBSN.

Table 1: Distinct difficulties exist with WSN and WWBAN.

	WSN	***WWBAN***
Scale	Wide are coverage (m/km)	Limited by the human body (m/cm)
Node number	Huge number of nodes for coverage	Limited number of pervasive nodes
Purpose	Multiple sensors, each perform dedicated tasks	Single sensors, each perform multiple tasks
Exactitude	Compensated by the redundancy	Accurate measurements are required by each node
Magnitude	Small size preferable but not a major limitation	Pervasive monitoring and need for miniaturization
Subtleties	Exposed to extremes in weather, noise, and asynchrony	Exposed to more predictable environment
Event detection	Early adverse event detection desirable; failure often reversible	Early adverse events detection vital; human tissue failure irreversible
Capriciousness	Much more likely to have a fixed or static structure	Biological variation and complexity means a more variable structure
Data Security	Lower level wireless data transfer security	High level wireless data transfer security required to protect patient information

	required	
Power source	Accessible and likely to be changed more easily and frequently	Inaccessible and difficult to replace in implantable setting
Energy Rumma gig	Solar, and wind power	Motion (vibration) and thermal (body heat)
Catastrophe	Nodes often disposable	Difficult replacement of implanted nodes
Admittance	Sensors more easily replaceable or even disposable	Implantable sensor replacement difficult and requires biodegradability
Biocompatibility	Not a consideration in most applications	A must for implantable and some external sensors. A chemical reaction with human tissue that mayhave the biosensor. Increase cost
Context Awareness	Not important with static sensors	Very important, because physiology is sensitive to context change
Wireless technology	Blueetooth, Zigbee, GPRS, Wireless LAN, RF	Low power wireless required
Data transfer	Loss of data during wireless is compensated bynumber of sensors used	Loss of data more significant, and may require additional measures to ensure QoS and real-time data interrogation capabilities

4. Wireless Biomedical Sensor Network

Thanks to technological advancements, sensors, integrated microcontrollers, and radio functionalities can now be combined into a single microcontroller; wireless sensor networks and micro fabrication had already made it possible to create a new generation of WSNs that are well-suited to a wide range of uses. The field of healthcare monitoring represents among of this highly promising and consequential application domains.

Companies in the IT industry have taken note of the growing need for this kind of innovation and are developing m-health solutions like eWatches and LifeShirts to meet the need. Therefore, healthcare applications of wireless sensor networks provide valuable market-based services to hospitals and other healthcare institutions doing public and private sector research.

5. Applications of Measurements in Medicine

Consequently, people wants to understand their physiological state, which makes early detection crucial for situations in daily life as well as for monitoring illness or a patient's vital signs to survive harsh circumstances or scenarios. The sensors must be able to measure or detect the many metrics and illnesses that are of relevance. These are some examples of parameters that can now be measured:

a. Cancer detection: Although there is now no proven method for preventing cancer, its discovery is nonetheless important. Nitric oxide, which influences the circulation in the region around a tumour, is expelled by cancer cells, according to studies [9].

b. Monitoring of Glucose Levels: A biological sensor can test glucose levels. This approach may provide a more reliable, precise, and non-invasive assessment of diabetes [9].

c. Asthma: Sensors may identify airborne allergens and continually update the patient or doctor on the situation. The site also gathers data from the network of national air quality monitoring stations [9].

d. Preventing medical errors: Every year, some 98,000 individuals pass away as a result of medical mistakes. These hospital fatalities happen as a result of medical mistakes made by staff members. The "E-nightingale project" makes utilisation of networked wearable environmental sensors to lessen medical errors and comprehend nurses' activity [9].

e. Cardiovascular illnesses and heart rate monitoring: Discreet sensors may be applied to patients, providing doctors with access to essential information they need to build a treatment plan and keep tabs on their wellbeing. The goal of heart rate monitoring is to save a lot of lives. A heart attack claims the lives of almost 50% of firefighters [13]. The medical application in question enables monitoring of the firefighter's working environment and heart rate in order to assess their suitability for such situations. Since the electrodes can function when in touch with the chest while damp, using chest straps with electrodes may save the lives of many firefighters. The same purpose may be served by utilising specialised wristwatches, the efficacy of which can only be determined when they are activated manually or when the start button is pushed. These wristwatches employ the oscillometric approach to calculate the user's blood pressure and heart rate. There is no officially recognised practical use, however, that one may wear while working, and this presents a significant issue [14].

f. Alzheimer's, depression, and the elderly: In these cases, it is possible to spot unusual occurrences, such falling, and notify friends, family, or the closest hospital. Accelerometers may be used to track these motions, and it can transmit real-time data via the ZigBee protocol or through GSM. It may also employ RFID readers to manage the patient's inputs and outputs; for example, sound sensors can detect movements and call for help, and light sensors can check when a refrigerator door opens to track how often a patient receives food [15].

g. Stroke and post-stroke: The Portuguese Stroke Society (Sociedade Portuguesa do Acidente Vascular Cerebral) estimates that three persons in Portugal experience a stroke every hour, making strokes the country's leading cause of death. Each year, 700,000 individuals in the US suffer from strokes, and 275,000 of them die away. Cognitive, linguistic, perceptual, sensory, and motor capacities are all impacted by strokes [9]. The lengthy recovery process goes on after you leave the hospital. Wearable sensors, typically equipped with accelerometers, can be used to monitor people who are housebound, predict some serious clinical conditions, such as motor disabilities affecting the hands, arms, legs, or other parts of the body, and provide accurate assessments to direct the rehabilitation process [16].

h. Epilepsy Early seizure detection: The University of Chicago Medical Center created a tool called Mobi that may identify alterations in electrical brain impulses before a seizure. The gadget transmits a warning to a receiver in response to signals it detects in order to safeguard the patient [17].

i. Artificial retina: 100 electrically signal-producing microsensors are inserted into the eye. The signals are transformed into a chemical reaction by the supporting tissue, mimicking the behaviour of typical retinal light stimulation [17].

j. Home monitoring: There are several scenarios in which WSN applications might lead to the development of new medical systems. These sectors include clinical trials, in-home support, augmented research, and smart nursing homes. These advantages of home monitoring allow patients to maintain their privacy and dignity while offering convenience. The apps are useful since you can get these services while you're at home. The smart homecare network and family members may now join the established healthcare team thanks to WSN. Home monitoring may provide a patient with memory aids and other patient care services that strike a balance between regaining lost freedom and maintaining safety [18].

k. Mobihealth: This is a WSN application for healthcare that enables remote patient care. This is relevant when there is a need for extensive clinical study and more careful consideration in order to guarantee that the patient's health may be enhanced. It guarantees that a patient doesn't have to be physically present at a treatment center to get the recommended medical care [19].

These are a few of the variables that may be assessed for medical purposes; however all of these measures have a variety of uses. These metrics' measurement is still being developed, and others need to be enhanced to improve quality of life.

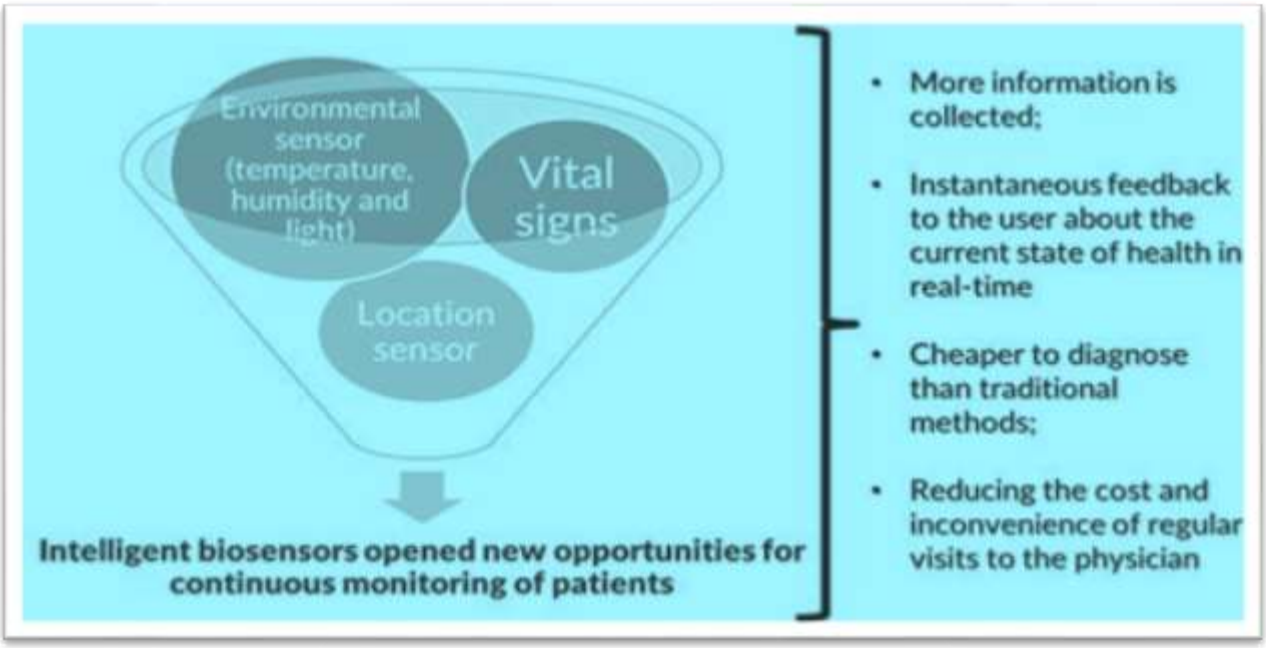
6. Essential Points for Healthcare Applications

The significant data that can be collected from the existing systems for use in medical applications is yet another area of interest with regard to WSN. In this context, a term like WBSN is one that is given a lot of weight. The Wireless Body Area Network (WBSN) is also known as the Wireless Body Area Network (WBAN), and it makes use of a wireless architecture that combines many Body Sensor Units (BSUs) with a single Body Central Unit (BCU). Wearable computing devices that are still under development make up this network. Since the WBAN is an on-body sensor, its high sampling rates result in substantial energy consumption (i.e., short battery life), and the addition of wireless devices raises the energy consumption even more. In this kind of architecture, the condition of multiple patients is continuously monitored in real time. It may therefore keep track of physiological data. However, there were a number of difficulties while designing this kind of application. For instance, the user-friendly communication between the sensors must be dependable, interference-free, and flexible. The development of the patient monitoring system's diagnostic tools must be taken into account as WBAN expands [12].

A WWBAN may include a number of physiological sensors that track vital signs, environmental sensors (temperature, humidity, and light), and a position sensor. The WWBAN is made up of cheap, light, and small sensors, and it may provide long-term, discrete, and ambulatory health monitoring with immediate input to the user on the user's present health and their medical data in real-time. A computerized system like this may be used to monitor rehabilitation in a variety of illnesses and perhaps provide early disease identification. Intelligent cardiac monitors, for instance, may advise patients of their medical status or provide information to a specialist service after a catastrophic incident. WWBAN enables a revolution in medical research by transferring all acquired data when incorporated into a more comprehensive telemedicine system with the patient's medical records. Quantitative examination of varied circumstances and patterns is made possible by the vast quantity of physiological data that has been gathered [7].

Intelligent biosensors' recent downsizing breakthroughs have created new possibilities for patient continuous monitoring [9]. Unobtrusive, small wearable sensors gather a lot of data automatically, cutting down on the expense and discomfort of frequent doctor visits [9].

Figure 4 demonstrates how WSN has access to relevant data for therapeutic diagnostics.
Figure 4 shows a resume of relevant material from WBSN.



7. Medical Applications of WSN

The innovations utilized in WSN, including as sensors and navigation systems like GPS, have a broad range of applications and can be employed in practically all health-related fields [5]. As shown in figure 5, for instance, the wireless data connection uses ad hoc routing and bidirectional radio frequency communication to enable each patient's node to communicate data to a base station even when they are outside of its direct radio range.

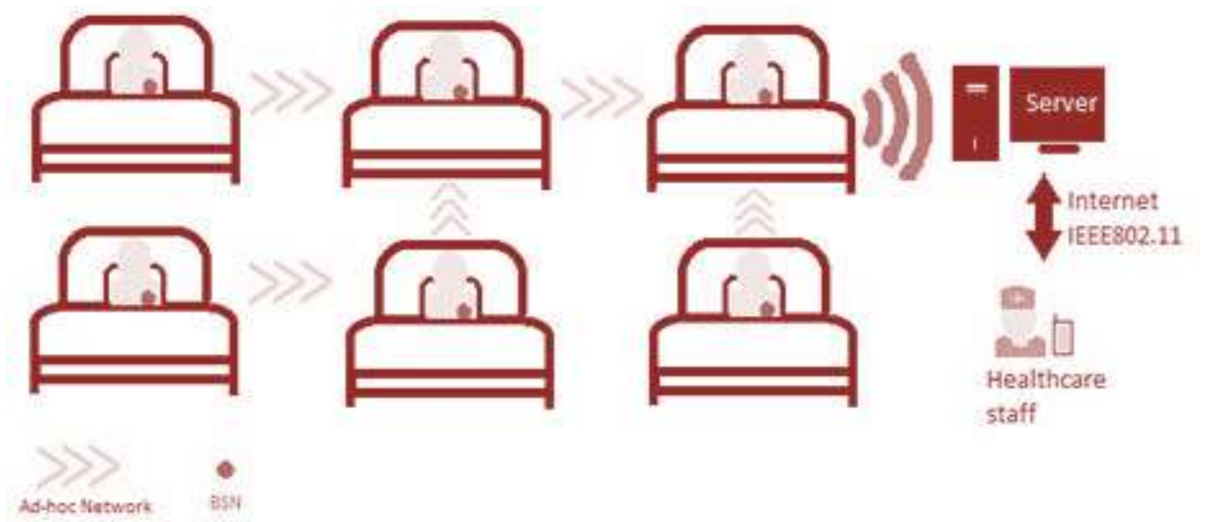


Figure 5 shows an illustration of a WSN-based healthcare architecture.

Aminian and research colleagues [4] developed a prototype for an omnipresent medical system, which is a system for hospitals. The idea is to attach non-intrusive wireless sensors to a person's body to create a wireless network that can connect the base station linked to the monitoring system with the patient's health state. However, the relay nodes (in the centre) may send the data using a short-range frequency module and do not need to utilise a high-frequency band (RFM). It is crucial to remember that there are designated medical bands, including the Medical Implant Communication Service (MICS). Due to their low power transmissions, body area network applications may be deployed in this 10 meter-diameter range that runs in the 402-405 MHz frequency spectrum [4].

For the purpose of ongoing patient monitoring under their normal physiological circumstances or in the case of older patients with chronic disorders, Tolentino and his colleagues [20] proposed the design of a ubiquitous health system. The main distinction is that it is intended to monitor old people who reside in rural locations or in tiny nursing homes with little medical care, as opposed to monitoring patients in a hospital setting. This WSN ad hoc is connected with current medical practises and technology in real-time remote monitoring to notify the medical team of the patient's health state or to administer medicine by integrating the wireless sensor. Using IEEE 802.15.4 or LR-WPANs, the system transmits wireless data to a base station coupled to a server on an ad hoc network [20]. According to the urgency, Sheltami and his colleagues [21] established a telemetry project with the setting of alert priority. The data processed in the central database is used to update patient profiles in this WSN [21]. In an emergency, emails and/or messages must be sent from the central computer [20]. Mbakop and his colleagues [22] created a system for monitoring patients in real-time that consists of two nodes where vital signs are gathered and wirelessly transferred to a base station, where the data is then stored and displayed on a continuous base station. The main problem in this design is how it will really be used in the future to leverage the patient's motions to generate energy for sensors, which is where the design's greatest innovation lies [22].

At-home memory care

One use of WSN being researched is home monitoring, which may aid with memory and other healthcare and security services in addition to detecting environmental factors that may influence patients [9]. A SMART was created and put into use by Gaddam and his team. It is based on Selective Activity Monitoring (SAM) and incorporates a number of intelligent sensors that talk to one another via common radio protocols. A controller and many carefully chosen sets of wireless intelligent sensors are required by the system. This controller takes input from the sensors and processes it. In various rooms of a home, the chosen sensors are put as monitors in beds, reading lights, and TVs [23].

Walker and his team [15] showed the need of developing a single platform that is reliable enough to serve a multitude of intricate applications. The application of JADE (Java Agent-based Development framework) for the WSN environment, the abstraction of sensors and event types, a user interface for application development, and an architecture for monitoring application states are the fundamental technical contributions of the proposal and platform improvements. This system may keep an eye on a patient's routine, behaviour, and health while defining actions based on the identification of important occurrences. A variety of sensors, including RFID readers installed in entrances, sound sensors for movement detection and aid screams, and light sensors in refrigerators may track how often patients access them to get food [15].

The European Commission launched the WearIT@work project as a comprehensive effort to research "Wearable Computing" as a technology using computer systems built into clothes (wearIT@work). The quick accessibility to patient medical information at any time is one potential use of this research. This may lower the cost of medical exams, provide doctors more flexibility in how they evaluate patients on a daily basis, and in the worst-case scenario, might even save a patient's life [5].

Alarm-Net offers intelligent medical care for preventative healthcare with an adaptive solution for continuous examinations via wireless sensors, building a historical record and protecting the patient's privacy. These sensors may alert users to variations in heart rate, blood oxygen levels, and circadian rhythm, which may indicate changes in a person's need for health care, even if humans cannot notice these subtle changes [24]. Through the consolidation and aggregation of disparate devices in a single architecture, Alarm-Net achieves these objectives [25].

CodeBlue is a wireless infrastructure that Harvard University created with the goal of offering a standard protocol and software architecture in the event of a crisis and enabling wireless patient and rescuer monitoring. Because it incorporates various nodes of wireless device sensors, the CodeBlue is a self-organized platform that is simple to connect to. The system incorporates low-power wireless sensors, and it provides services for credential creation, handoff, position tracking, network filtering, and data aggregation for sensor-produced data. Emergency medical personnel may request data from a number of patients using the straightforward interface [24]. The CodeBlue functions in a variety of wireless devices, from the low-resource PDA to the more powerful PCs, and is built to pass through a broad range of network densities. The ZigBee trading platforms, Mica2, MICAz, and Telos are used in conjunction with the CodeBlue, which features a variety of sensors (including oximetry, ECG, and motion sensors). A support platform has also been developed for lighter sensors to be used in accident monitoring modules in a non-invasive way, despite the fact that researchers believe that such platforms have a good response in research settings but many flaws in real-world scenarios due to the dimensions of the modules and batteries [26].

A distinct but comparable programme, the MEDiSN, utilises a similar design to CodeBlue [27]. A number of physiological monitors (PMs), or nodes, on which the physiological patient data is gathered, are included in the value. Each node includes customizable frequency sensors and delivers physiologically encrypted data to a network of relay stations (RPs). Both the data and the gateway management data are sent by the RPs to the PMs Gateway and one or more PMs, respectively. The RPs automatically setup in a routing tree with PMs in their branches to accommodate this traffic in both directions. RPs are immobile, however PMs may move about and occasionally choose which RP will convey the data best [28].

Additionally, there is the NetCare, a digital initiative that gives people in rural and isolated places access to contemporary digital technologies. The project was created in Portugal by Inovamais in collaboration with Agilus I+D, the engineer at the faculty of Oporto University, the hospital in So Sebastio, and Speculum. This project created a platform for monitoring healthcare services, including ambulances and emergency vehicles, so that doctors could keep an eye on the conditions of numerous patients. On a web application, this data was accessible [29].

Additionally, AID-N manages large-scale occurrences like accidents. Wireless repeaters are placed for an emergency course set in place of APs (access policies) on the wall. The medical team is aware of a specific emergency when APs are flashing green lights [24]. The system is made up of four components called MiTags (expandable wireless sensor platforms and modules). Both short-range and long-range communications are supported by these modules, allowing for the creation of WBANs and mesh networks, respectively. A central server, devices to access the MiTags, and routers for blood pressure, temperature, and SpO2 (arterial oxygen saturation, among other sensors) are supported by the platform [30].

A Finnish business called eHit offers technology and services for remote medical treatment. It is one of the technological components of the Health Gateway, a platform that links a server and a mobile device. The mobile device's job is to gather data from the sensors and transmit it to the server, which is designed to accept data and transmit it for processing. The Patient Care Device Gateway, which is similar to the Health Gateway but allows hospital monitoring without a mobile device using a LAN connection, and theeLink, a module connecting sensors without a Bluetooth connection and thus connected to the mobile device, are some of the additional products in the eHit company's portfolio. For patients who are recuperating from hip replacement surgery, the HipGuard system was created. With the use of wireless sensors, this device keeps an eye on the patient's hip and leg rotation and position. The patient's wrist unit receives the alarm signals. The HipGuard device gives the patient's rehabilitation team important information in real time if his hip and leg postures or rotations are incorrect [17].

Smart sensors and an integrated microsystems (SSIM) project are used in artificial retina. This prosthesis is built using 100 micro sensors, placed within the human eye, and then activated. Control, image identification, and validation needs are met through wireless communication. The underlying tissue transforms the electrical impulses produced by these sensors into a chemical reaction, simulating the retinal behavior when stimulated by light [9].

Vision issues were also addressed by the Georgia Institute of Technology's psychology department, more especially the Georgia Tech Sinification Lab. By focusing on the necessity to swiftly avoid obstacles or certain environmental characteristics, they developed the SWAN project, a useful and portable gadget that incorporates navigation software for persons who are blind or even in environments where vision is restricted [5].

8. Additional Mechanisms in Healthcare

Related methods have been created for the detection of vital signs and various physiological data, including: LifeShirt, Fireline, UbiMon, Satire Project, SMART, HealthGear, MobiHealth/Mobicare, CareNet, Jacket Vital, BikeNet, eWatch, AMON project, MagIC System, Smart Vest, Secure Mobile Computing utilising Biotelemetrics, and Armband SenseWear are a few examples of devices that monitor vital signs.

The endoscopic capsule is yet another technique that has been used. This medical technique for capturing pictures of the digestive system enables a tiny tablet-sized chamber to display images of the inside of the gastrointestinal tract, making it feasible to examine locations where standard endoscopy is not possible [33].

The monitoring of infants is one of the topics that has drawn increased attention from researchers, not only because it is a profitable field but also because there is an increasing need to avoid sudden infant death syndrome (SIDS). The creation Sleep Safe does this by keeping track of the child's sleeping posture and alerting parents [34]. The Baby Glove project is another option for protecting preterm newborns from numerous health problems [36].

The development of wearable devices is facilitated by the usage of WSN in biomedical applications since it makes them lighter and less intrusive by doing away with cords. Computer systems built inside consumer goods that are worn as clothing are called wearable systems. As a result, it is necessary to address a number of factors:

The development of a protocol to provide biological signals in an online database where data may be accessible by doctors;

a. The introduction of procedures and regulations to minimize energy consumption and improve the durability of the monitoring and detection of the data acquired by the sensors.

b. There would be a number of benefits, including speedier test completion, the provision of trustworthy data, cost savings, and ease in administering the exams;

c. In the research and use of methods for authentication and information security [14].

Robustness, security, and interference-free transmission are important protocol criteria, among others. It is thought that wireless sensor networks may play a bigger part in medicine. Smart rooms equipped with wireless sensor networks will soon be able to identify environmental conditions and take preventative action in response to that information. The technology may become ubiquitous, where every person has a computational module capable of interfacing with the smart area's system and preventing health issues.

9. Conclusion

When reading through a number of publications and the study, we can infer that there is still more work to be done in the field of wireless sensor networking. At the near future, medical devices will begin to leverage this technology to enhance their capabilities. Current medical applications based on sensor networks are now in the forefront of research for usage in practical applications. Security concerns are a major worry, and there are still many more substantial obstacles to be solved.

Specialized medical technology with WSN should be a part of the future, improving medical care at home and smart homes while using current infrastructures to gather data in real time. Additionally, the expenses of testing and frequent doctor visits will be greatly reduced by the ongoing collecting of clinical data from patients. The interaction of bioscience, biotechnology, and nanotechnology in the creation of sensors will be another crucial aspect in the future.

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