

Intelligent wireless network selection in Internet of Medical Things (IMoT)

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ABSTRACT

Wireless Sensor Networks (WSNs) are becoming increasingly popular in the deployment of Internet Medical of Things (IMoT). Their applications include collecting vital data such as heart rate, blood pressure, blood glucose level, and oxygen saturation, in order to monitor vital parameters. Apart from these, WSN are normally used in traffic monitoring and management in smart cities, applications in smart home control, manufacturing plants, airport terminals, fire safety at shopping malls, environment sensing, etc. Sensor nodes are wireless communication devices using low-power protocols (e.g., ZigBee, Bluetooth Low Energy) that are linked to a local gateway device, which then transmits the data to cloud-based platforms for storage and analysis. A variety of WSN techniques such as Bluetooth, Wi-Fi, LoRa, etc. are available to implement such as Ad hoc or infrastructure networks. Selection of a proper WSN technique is important for meeting the Quality of Service (QoS) issues for various applications based on the available wireless networks. This paper proposes techniques for selection of WSN in IMoT applications for achieving better quality of services for audio, picture and data applications.

Keywords: Wireless Sensor Networks, Quality of Service, Internet of Things, Bluetooth, WiFi, LoRa.

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I. INTRODUCTION

IoT is now extensively used in the medical field, especially for patient care. This domain is commonly referred to as the Internet of Medical Things (IMoT). Various wearable and implantable devices, such as continuous glucose monitors, blood pressure monitors, SpO₂ sensors, and respiratory monitoring systems, are available in the market. These devices utilize specialized sensors to measure specific physiological parameters. The sensed data are converted into suitable electrical signals and transmitted to smart devices, including laptops, smartphones, and hospital monitoring systems [10].

As part of the Internet of Medical Things (IMoT) architecture, Wireless Sensor Networks (WSNs) play a critical role by enabling continuous and real-time acquisition of physiological data in order to build a network of connected devices designed to support health care. Typically, in an Internet of Things (IoT) system, WSNs are used as body area networks (BANs) that are comprised of wearable or implantable sensor nodes, and these sensors collect vital data such as heart rate, blood pressure, blood glucose level, and oxygen saturation, in order to monitor vital parameters [11]. Using wireless communication protocols such as ZigBee,

Bluetooth Low Energy, or Mesh, these sensor nodes transmit data wirelessly to a local gateway device, which sends it to a cloud-based platform for storage and analysis [9]. Once the data is gathered, it is sent to the cloud platform in view of data analysis and storage.

Wireless Sensor Networks are autonomous types of networks in which the sensor nodes are deployed in spatially distributed areas. WSN networks consist of nodes which sense the physical environmental parameters depending on the applications for which they are configured. These physical parameters may include temperature, humidity, vibrations, motion etc. These physical parameters are sensed by the specialized types of sensors which will convert the physically sensed parameters to analogous electrical signals. These signals are converted into the digital format for proper handling and processing by the controller. These digital data are further processed by controllers present inside the WSN node in order to send the information of present conditions to remote stations through the wireless transceiver to internet gateway for monitoring and suitable action if needed [1][7].

WSN is an integral part of the IoT network, which offers sensing capability to IoT networks. Therefore sometimes WSN is called as one of the “sensing layers” of the IoT

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networks. In the initial state, the WSN node senses the environmental conditions and then further processes the collected data through the processing unit.

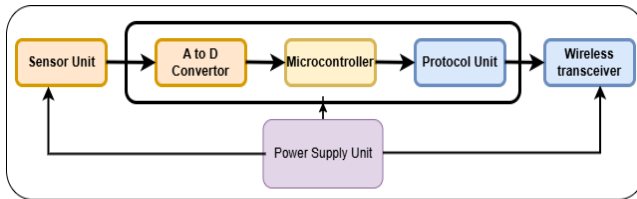


Figure 1: A Typical WSN Node

The processed information is further sent to the internet through the IOT gateway on the cloud for the proper storage and further action. Typically, wireless sensor nodes are employed in order to monitor environmental conditions. One of its applications is industrial networks where it is very difficult to monitor continuously by human beings.

Wireless sensor networks are limited to geographical area while the IoT technology, which is also called as a global technology, can cover large geographical areas. From the application point of view, the Wireless Sensor Networks (WSN) are employed only for the monitoring while Internet of Things (IoT) types of the networks are normally used to process the information for automation purposes depending upon the algorithm. IoT infrastructure may have a strong decision-making capability based on the triggers generated by the acquired information for the automation task [2]. IoT networks are also called as a group of interconnected smart devices. The type of devices can be Smartphone or some smart sensing unit of device capable of data collection, storage, and processing which can be connected through the internet. Search scenarios also come into the category of IoT networks. WSN nodes can be considered as one of the smart devices, hence it can be an integral part of IoT networks.

In the wireless sensor network, the nodes are deployed at a shorter distance. Hence their communication protocol range may be limited depending upon the distance or geographical area. The IoT network sends information at a global level. Hence, the type of protocol used has the capability and features that are needed for long-distance communication protocols. Basically, the IoT services starts from the data collection from the devices which is continuously sensing that data and further data is represented in a suitable digital format for the further processing and analysis. Before the collection of data, the IoT services must ensure that the proper amount of storage is available for this incoming data or storage is also required for the processing and analysis.

Network Communication Overview



Figure 2 WSN and IoT

Proper wireless technologies are needed for the efficient data transmission and reception with no errors. IoT services should select the proper wireless technology according to their communication range and the amount of power consumption. After the processing and analysis, the IoT services should offer that data to activate or actuate that control action for that IoT application is intended to design. Therefore proper selection of WSN technology for a given application requires intelligent decision to meet the QoS requirements of the given services/ applications.

This paper is organized as follows. Section 1 describes the introduction section of the wireless sensor networks and the internet of things. Section II describes the various wireless technologies available for wireless sensor networks. Section III gives the detail overview about the drug delivery system used in IMoT. Section IV depicts the typical scenario of IoT networks. Section V describes various IoT services and their Quality of Services (QoS) requirements in section VI. The paper is concluded in the section VII.

II. WIRELESS TECHNOLOGY FOR WSN

Figure 1 shows that for proper communication with the internet or nearby WSN nodes, each wireless sensor network node should have wireless transceiver, which continuously transmit and receive the processed information, depending upon the hardware and software configuration, and also on the communication mode setting, e.g. full duplex or half duplex mode.

WSN nodes have many constraints like if nodes are deployed in sensitive areas and in remote areas where human intervention is very difficult once the node is deployed. Therefore, for the transmission/reception of the proper information to/from WSN nodes, it is necessary that we select the proper wireless technologies for WSN nodes to increase the lifetime of the Network. WSN nodes are constraint by limited capability of hardware, minimum processing power as well as the minimum amount of power back up. Therefore, a special type of operating system is designed for WSN node called as tiny OS, having the limited amount of instruction and

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operation capability, including the sensing, processing, transmission and reception.

Therefore, Selection of proper wireless technologies for WSN networks is very important so that the limited amount of hardware and operating system available inside the WSN node completes the task with a minimum power. This wireless technology actually depends upon the range of communication technology.

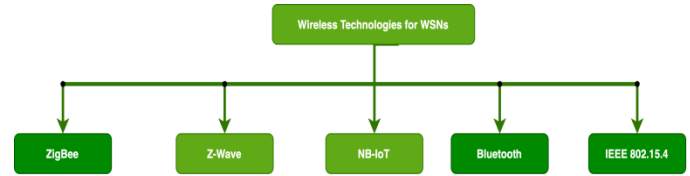


Figure 3 Supporting Wireless Technologies for WSN

TABLE I VARIOUS WIRELESS TECHNOLOGIES FOR WSN

S. No.	Wireless Technology	Communication Range	Frequency	Data Rate	Standard	Power Consumption
1	ZigBee	10-100 m	915 MHz 868 MHz, 2.4 GHz	250 Kbps	IEEE 802.15.4	Low
2	Z Wave	30-100 m	908 MHz, 868 MHz	9.6-100 Kbps	ITU-T G.9959	Very low
3	Bluetooth	10-100 m	2.4 GHz	1-3 Mbps	IEEE 802.15.1	Medium
4	BLE	10-100 m	2.4 GHz	125 Kbps - 2 Mbps	IEEE 802.15.1	Very low
5	IEEE 802.15.4	10-100 m	915 MHz 868 MHz, 2.4 GHz	20-250 Kbps	IEEE 802.15.4	Low

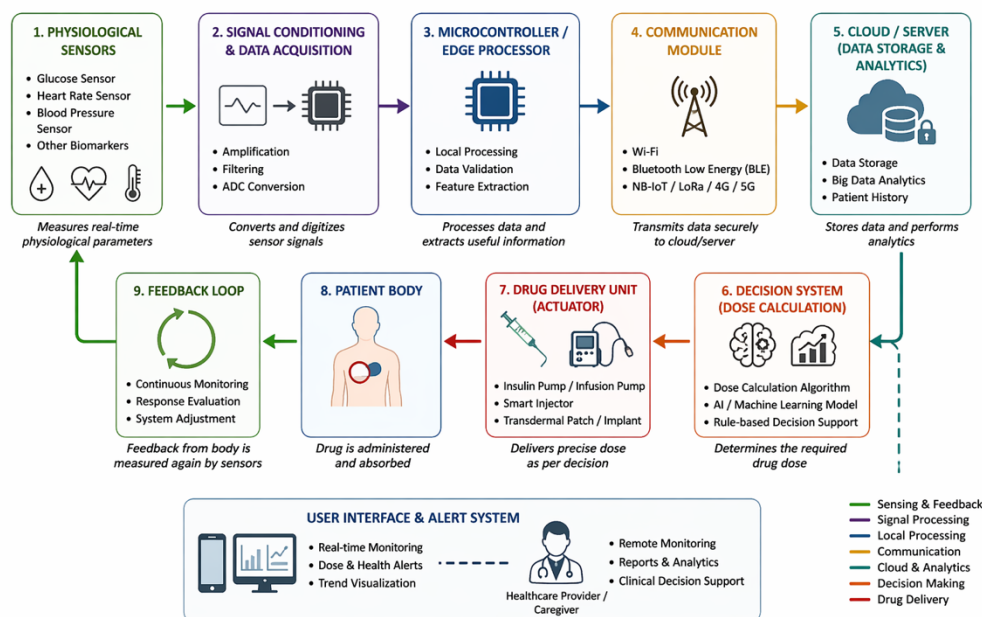
Figure 3 depicts the various types of wireless technologies that can be used for WSN networks. Some of the most of popular technologies are Zigbee, Z wave, Bluetooth and IEEE 802.15.4. Table I describes the various technical parameters of the wireless technologies mentioned in Figure 3.

III. IoT BASED DRUG DELIVERY SYSTEM

There are numerous applications of IMoT technology, such as real-time remote patient monitoring, which assists healthcare providers in managing patient conditions

effectively. One example is the continuous glucose monitor (CGM), which tracks blood glucose levels at regular intervals and updates the data to a diabetologist. This enables timely detection of hyperglycemia and hypoglycemia conditions. The real-time exchange of data facilitates more precise diagnosis and immediate medical intervention. Furthermore, robotic-assisted surgeries are increasingly performed, particularly in orthopedic procedures such as knee replacement, where smart sensors integrated into robotic arms enable minimally invasive

IoT-BASED DRUG DELIVERY SYSTEM (CLOSED-LOOP)



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and highly precise surgical operations.

The pictorial representation shown in the figure illustrates an IoT-based closed-loop drug delivery system for automated, real-time drug administration tailored to individual patients. The system involves sensing physiological parameters, transmitting data to the cloud, and analyzing it in comparison with historical data. Based on this analysis, control signals are generated and sent to actuators for precise drug delivery according to the patient’s condition.

Sensors: Sensors detect physiological parameters and convert them into electrical signals. Various sensors are available for measuring parameters such as blood glucose level, blood pressure, and heart rate.

Signal Conditioning: The output generated by sensors is typically analog in nature, often weak and susceptible to noise. Therefore, appropriate signal conditioning and data acquisition techniques—such as amplification, filtering, and analog-to-

digital conversion (ADC)—are required before transmitting the signals to the processing unit.

Actuation (Drug Delivery System): Actuators such as insulin pumps, smart injectors, and infusion systems deliver drugs based on control signals received from the cloud. These systems integrate electronic and mechanical components to ensure precise drug administration.

Feedback Mechanism: After drug delivery, continuous monitoring of the patient’s physiological state is necessary. A closed-loop feedback system enables real-time adjustment of drug dosage according to the patient’s condition, improving safety and effectiveness.

User Interface and Alert System: A user interface is required

Figure 4 Drug Delivery System in Internet of Medical Things (IMoT)

Processing Unit: Processing is performed using microcontrollers or embedded systems designed for medical applications. In addition to signal processing, these systems perform normalization and feature extraction. Edge processing reduces latency and bandwidth usage during cloud transmission.

Communication Media: Reliable data transmission between devices and the cloud is essential. Various communication technologies, including Wi-Fi, Bluetooth, and 4G/5G cellular networks, are used depending on application requirements. Proper selection of communication protocols is crucial for ensuring efficiency and reliability.

Cloud and AI: The cloud provides sufficient storage and computational resources for handling large volumes of patient

data. Machine learning models can analyze sensor data to identify patterns and predict necessary changes in drug dosage. AI algorithms are used to compute the optimal drug dose based on real-time input data.

to monitor patient health parameters in real time. It supports abnormality detection and sends alerts to healthcare providers. Visual displays and alarm systems are essential components of an effective drug delivery system.

IV. IOT NETWORKS

Wireless sensor networks have a limited range of communication while IoT networks have a broad range of communication. Wireless sensor networks can be considered as a sub part of the IoT network system. The IoT network is a global perspective in which the sensor devices collect the information, process it with some controlling unit, and the information is transmitted to the cloud through the internet for the automation and controlling purpose depending upon the applications. The meaning of “smart” is that the device which is capable to communicate over the internet and should be having some sensing capability.

TABLE II WIRELESS TECHNOLOGIES FOR IOT

S. No	Wireless Technology	Communication Range	Frequency	Data Rate	Standard	Power Consumption	Security Options
1	ZigBee	10-100 m	915 MHz 868 MHz, 2.4 GHz	250 Kbps	IEEE 802.15.4	Low	AES-128

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2	Z Wave	30-100 m	908 MHz, 868 MHz	9.6-100 Kbps	ITU-T G.9959	Very low	AES-128
3	Bluetooth 5.0	10-100 m	2.4 GHz	2 Mbps	IEEE 802.15.1	Low	AES-128
4	IEEE 802.11n	50-100 m	2.4 GHz, 5 GHz	150 Mbps - 10 Gbps	IEEE 802.11	High	WPA2/WPA 3
5	LoRaWAN	3-15 Km	433/868/915 MHz	0.5-50 Kbps	IEEE SA - P1451.5.5	Very low	AES-128
6	NB-IoT	2-10 Km	700 MHz-2.6 GHz	250 Kbps	3GPP	Low	AKA and IPSec
7	Cellular technologies	0.5 - 85 Km	2G/3G/4G/5G Frequency bands	10 Kbps - 10 Gbps	3GPP-2	High	3GPP security

Depending upon the range of communication, the IoT network can be classified in the small range and long-range communication system. This classification is based upon the supporting wireless technologies available for IoT networks. Table II describes the various technical parameters of the supported wireless technologies used in IoT networks.

Consider that an agricultural field is to be monitored from remote places for so many physical parameters, like humidity, temperature, rainfall monitor etc. Based on their values appropriate devices need to be actuated for controlling purposes. Hence, that particular agricultural area needs to be covered with the required amount of wireless sensor nodes in a particular topology deployment and with a proper configuration, including the supporting protocols [8].

The actuators installed in that particular agricultural field will act after receiving real time data from the internet cloud. The IoT network used in such a system offers the advantage of irrigation improvement where the moisture level of soil can be continuously monitored and sufficient amount of water can be supplied in a precise manner. Similarly, amount of fertilization input to plants can be adjusted by suitable controlling techniques through IoT in a particular area of the agriculture field. Hence, the technology used through the IoT increases the production of crops, which will in turn increase the economy.

Other applications of IoT networks are managing smart cities, where the level of traffic management, pollution, uniform water distribution, electricity management and many things can be monitored and controlled for a crowded city. The complete industry can be managed and controlled with the help of Industrial IoT (IIoT) networks. In the healthcare field [3][4], the IOT networks play a vital role for patient monitoring is done through the various IoT devices, for diagnosis and proper drug management/surgery through Robotics actuation technology.

V. IOT SERVICES

Table III mentioned various IoT services and typical wireless technologies designed for their support. All the services are actually designed in a real-time applications where the data is collected, processed, analyzed and further sent to the cloud for processing and then to get feedback necessary action. One the cloud virtual controllers and servers are available.

TABLE III IOT SERVICES AND RELAVENT WIRELESS TECHNOLOGIES

S. No.	IoT Services	Concerned IoT Wireless Technology
1	Home automation, Industrial IoT	ZigBee
2	IoT based Security devices	Z Wave
3	Healthcare IoT, Wearable IoT	Bluetooth 5.0
4	Home/office/industrial IoT	IEEE 802.11n
5	Smart cities, Sensor networks, IoT applications requires high bandwidth	LoRaWAN
6	Smart electrical meters, Smart cities , Industrial IoT	NB-IoT
7	Smart Cities, Healthcare networks, Smart monitoring in Industrial sectors	Cellular technologies

All the automation services, just like home, automation, industrial automation, and some real time, operation like a healthcare application, war based applications need IOT systems where no human intervention is possible. The resources constraint in the IoT devices, the task of competition and analysis is done on the cloud where the virtual controllers and servers are available. All the automation services like

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home automation industrial automation, some real time, application like healthcare monitoring, war type applications where no human intervention is involved.

VI. QOS PARAMETERS

For the performance measurement of any wireless networks, including the Internet of Things (IoT) networks, there are few quantitative parameters called as Quality of Services (QoS) parameters which measure services offered to the end users. This can be broadly explained in IoT networks where the end user expects that particular IoT services with the high speed of processed data with reliable transmission and reception without any latency, jitter and with the accurate result for which that particular application through the IoT technology is designed. There are few Quality of Services (QoS) parameters like delay, latency, energy efficiency, throughput, fairness etc[5] [9].

VII. CONCLUSION

Wireless Sensor Network (WSN) technology is the key technology used in the Internet of Things (IoT) and Internet of Medical Things (IMoT) nowadays. In today's modernization era, communication is going on between the human-machine, machine-machine and vice versa. Then all the types of tasks have been done for this communication is under the control of machine intelligence. All the services e.g. healthcare, industry, defense, environmental monitoring etc. are now under the control of IoT technology. In order to satisfy the Quality of Services (QoS) issues of IoT and IMoT technologies and their offered services, the proper selection of wireless technology is an important aspect in order to satisfy the QoS defined for IoT services. This research paper gives emphasis upon the selection of a particular wireless technology for wireless sensor networks as well as in Internet of Medical Things (IMoT) networks.

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