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Research Article

Design and Evaluation of Wireless and IoT based Healthcare System

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Abstract

Currently, several solutions are available for monitoring patient health using body sensors. In hospitals, healthcare wireless sensor networks (HWSNs) offer support to access these sensors to allow for continuous patient monitoring. Healthcare wireless sensor networks (HWSNs) are a specific field of wireless sensor networks when applied to healthcare solutions. In HWSNs it is important to have continuous access to the patients' sensors. This feature allows for close control over the patients' health. Then, if an abnormal behavior occurs in the monitored human parameters, the system can detect it and alert the medical staff immediately. In healthcare wireless sensor network, the sensors are attached to the patient for periodically monitoring of patient. In healthcare scenarios it is important that technology may be focused on the patients' quality-of-life. The use of HWSNs improves patients health monitoring. These technologies can be used for patient monitoring in both a real-time and continuous manner. The health monitoring is simplified by using MATLAB software. Patient uses MATLAB software to diagnosis the disease and giving the precaution to the patient instantly without any effort or any other torcher to the patient. This is very important to the patient like, who cannot walk or stand for long time and mostly for the critical condition patient who can't wait for a second. A smart healthcare service system based on the Internet-of-Things (IoT) has great usefulness for patients and business potential; however, a comprehensive platform is still missing. In this research, an intelligent, IoT based healthcare system, is proposed and analysed by MATLAB program. In particular, the platform involves intelligent observer of the patient with communication capability enabled by passive radio-frequency identification (RFID) and actuation capability enabled by functional materials, and flexible and wearable bio-medical sensor device (Bio-Patch) enabled by the state-of-the-art inkjet printing technology and system-on-chip. The proposed platform seamlessly fuses IoT devices (e.g., wearable sensors, intelligent medicine packages, etc.) with in a bed of the patient or home healthcare services for improved user experience and service efficiency. The feasibility of the implemented iHome Health-IoT platform has been proven in field trials.

Keywords: *IoT, Wireless sensor network, RFID, frequency generator*

1. Introduction

The next wave in the era of computing will be outside the realm of the traditional desktop. In the Internet of Things (IoT) paradigm, many of the objects that surround us will be on the network in one form or another. Radio Frequency Identification (RFID) and sensor network technologies will rise to meet this new challenge, in which information and communication systems are invisibly embedded in the environment around us. These results in the generation of enormous amounts of data which have to be stored processed and presented in a seamless, efficient, and easily interpretable form. This model will consist of services that are commodities and delivered in a manner similar to traditional commodities. Cloud computing can provide the virtual infrastructure for such utility computing which integrates monitoring devices, storage devices, analytics tools, visualization platforms and client delivery.

The cost based model that Cloud computing offers will enable end-to-end service provisioning for businesses and users to access applications on demand from anywhere. Smart connectivity with existing networks and context-aware computation using network resources is an indispensable part of IoT. With the growing presence of WiFi and 4G-LTE wireless Internet access, the evolution toward ubiquitous information and communication networks is already evident. However, for the Internet of Things vision to successfully emerge, the computing paradigm will need to go beyond traditional mobile computing scenarios that use smart phones and portables, and evolve into connecting everyday existing objects and embedding intelligence into our environment. For technology to *disappear* from the consciousness of the user, the Internet of Things demands:

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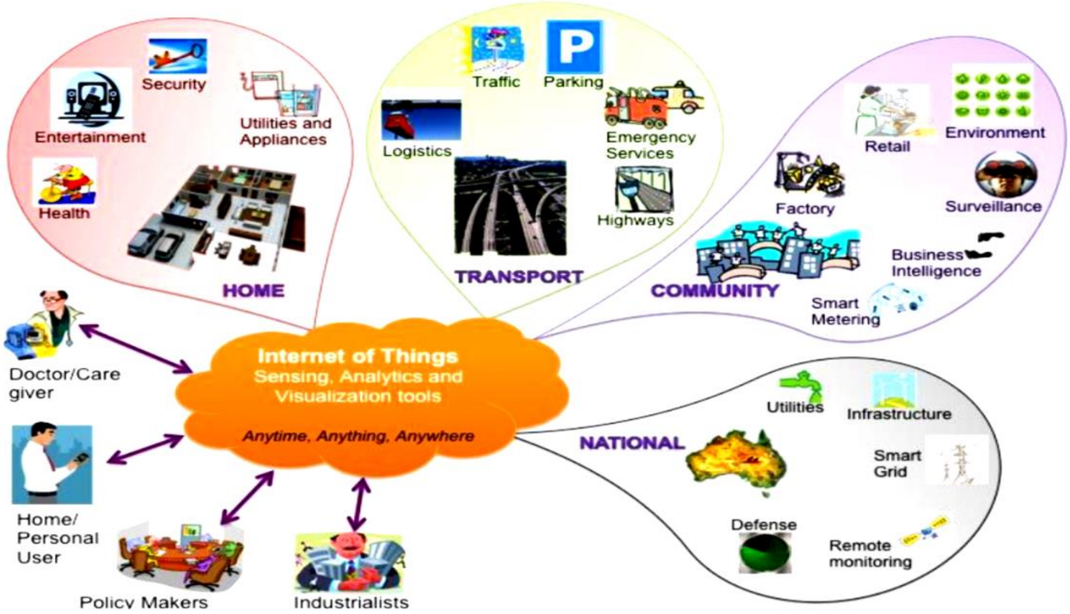

Figure 1: Internet of Things Schematic showing the end users and application areas based on data

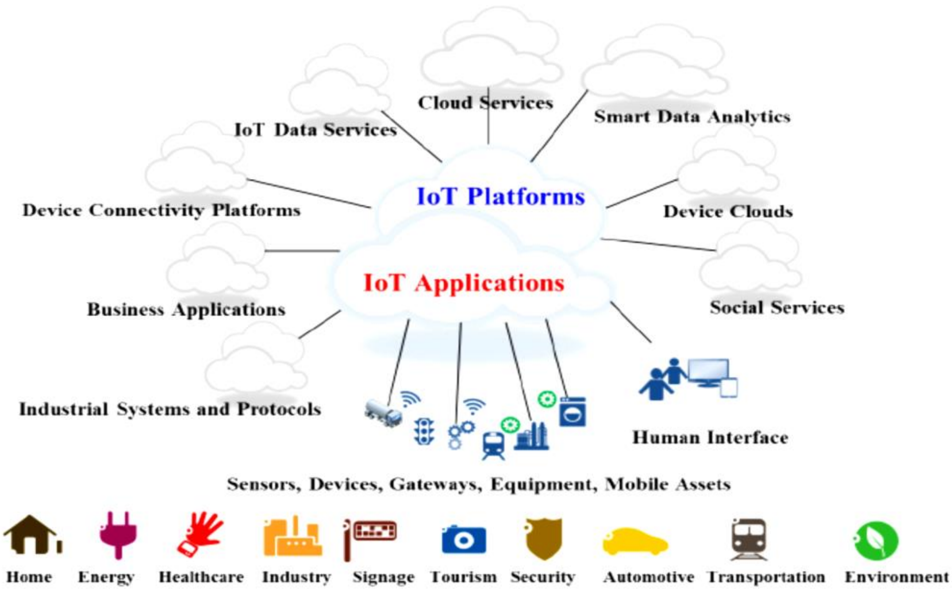

Figure 2: Internet of Things Integration of Platforms and Applications

(1) A shared understanding of the situation of its users and their appliances,
(2)Software architectures and pervasive communication networks to process and convey the contextual information to where it is relevant, and
(3) The analytics tools in the Internet of Things that aim for autonomous and smart behaviour. With these three fundamental grounds in place, smart connectivity and context-aware computation can be accomplished (Coyle, *et al.,* 2010).

The term Internet of Things was first coined by Kevin Ashton in 1999 in the context of supply chain management. However, in the past decade, the definition has been more inclusive covering wide range of applications like healthcare, utilities, transport, etc. Although the definition of Things' has changed as technology evolved, the main goal of making computer sense information without the aid of human intervention remains the same. A radical evolution of the current Internet into a Network of interconnected *objects* that not only harvests information from the environment (sensing) and interacts with the physical world (actuation/command/control), but also uses existing Internet standards to provide services for information transfer, analytics, applications, and communications. Fuelled by the prevalence of devices enabled by open wireless technology such as Bluetooth, radio frequency identification (RFID), Wi-Fi, and telephonic data services as well as embedded sensor and actuator nodes, IoT has stepped out of its infancy and is on the verge of transforming the current static Internet into a fully integrated Future Internet.

The Internet revolution led to the interconnection between people at an unprecedented scale and pace. The next revolution will be the interconnection between objects to create a smart environment. Only in 2011, the number of interconnected devices on the planet overtook the actual number of people. Currently there are 9 billion interconnected devices and it is expected to reach 24 billion devices by 2020. A schematic of the interconnection of objects is depicted in Figure 1, where the application domains are chosen based on the scale of the impact of the data generated. The users span from an individual to national level organizations addressing wide ranging issues.

IoT technologies are expected to foster innovation in a number of core European industrial sectors, including healthcare and wellness, factory automation/smart manufacturing, sustainable energy, mobility, food production and distribution, environmental monitoring, buildings, living environments, wearables, smart cities, etc. (Atkinson, 2014).

The information presented summarizes the exploitable results that can be used as reference input to the IoT LSPs implementations in different application areas. The goal is fostering commercial and industrial opportunities in the future IoT applications.

In this paper we are design and developed an IOT based healthcare system and also evaluate and verified it by MATLAB program.

The Internet of Things (IoT) is an emerging technology which is generally recognized as representing a revolution in Information and Communication Technology (ICT). It is expected to have a wide range of applications in various industrial sectors, including healthcare (Xu *et al*., 2014b; Yang *et al.,* 2014). According to the latest Hype Cycle of newly emerging technologies, IoT was in one of the top three 'innovation trigger positions' in 2014, showing atendency to grow towards the peak of the Hype Cycle (Burton & Willis, 2014). The Internet of Things Strategic Research Roadmap is based on the following definition:

The Internet of Things allows people and things to be connected anytime, anyplace, with anything and anyone, ideally using any path/network and any service

(Guillemin & Friess, 2009). The concept of IoT can be regarded as *an extension of the existing interaction between humans and applications through the new dimension of things communication and integration* (Guillemin & Friess, 2009). There is a broad range of key opportunities for applications in different industries, such as healthcare, intelligent building (i.e. green building), product and brand management, retail and logistics management, people and goods transportation, and so on. Ultimately, IoT is expected to include 26 billion connected units, and incremental revenue generated by suppliers of IoT products and services are expected to exceed US$ 300 billion, mostly in services, by 2020 (Gartner, 2013).

2. Methodology

Machine-to-Machine (M2M) communications constitute the basic communication paradigm in the emerging Internet-of-Things (IoT) and involve the enabling of seamless exchange of information between autonomous devices without any human intervention. The services facilitated by M2M communications encompass personal, public, and professional spaces and scenarios of interest include smart power grids, intelligent spaces, smart cities, industry automation, and health care just to name a few. The increasing popularity of services and systems based on the use of M2M communications has been fuelled in part by the utility of the applications they facilitate, as well as by the continued fall in the prices of autonomous devices capable of sensing and actuating.

Hardware required for the research are RFID (Passive RFID mechanism), biometric wireless sensors for sensing, processing and doing transceiver performance, comparator, microcontroller, frequency generator and buzzer alarm.

2.1 Network Architecture of Internet of Things

There are three IoT components which enables seamless ubicomp:

a) Hardware - made up of sensors, actuators and embedded communication hardware

b) Middleware - on demand storage and computing tools for data analytics and

c) Presentation - novel easy to understand visualization and interpretation tools which can be widely accessed on different platforms and which can be designed for different applications.

In this section, we discuss a few enabling technologies in these categories which will make up the three components stated above.

2.1.1 Radio Frequency Identification (RFID)

RFID technology is a major breakthrough in the embedded communication paradigm which enables design of microchips for wireless data communication. They help in automatic identification of anything they are attached to acting as an electronic barcode. The passive RFID tags are not battery powered and they use the power of the reader's interrogation signal to communicate the ID to the RFID reader. This has resulted in many applications particularly in retail and supply chain management. The applications can be found in transportation (replacement of tickets, registration stickers) and access control applications as well. The passive tags are currently being used in many bank cards and road toll tags which are among the first global deployments. Active RFID readers have their own battery supply and can instantiate the communication. Of the several applications, the main application of active RFID tags is in port containers for monitoring cargo.

2.1.2 Wireless Sensor Networks (WSN)

Recent technological advances in low power integrated circuits and wireless communications have made available efficient, low cost, low power miniature devices for use in remote sensing applications. The combination of these factors has improved the viability of utilizing a sensor network consisting of a large number of intelligent sensors, enabling the collection, processing, analysis and dissemination of valuable information, gathered in a variety of environments. Active RFID is nearly the same as the lower end WSN nodes with limited processing capability and storage. The scientific challenges that must be overcome in order to realize the enormous potential of WSNs are substantial and multidisciplinary in nature. Sensor data are shared among sensor nodes and sent to a distributed or centralized system for analytics. The components that make up the WSN monitoring network include (Shahamabadi *et al.,* 2014).

a) WSN hardware-Typically a node (WSN core hardware) contains sensor interfaces, processing units, transceiver units and power supply. Almost always, they comprise of multiple A/D converters for sensor interfacing and more modern sensor nodes have the ability to communicate using one frequency band making them more versatile.

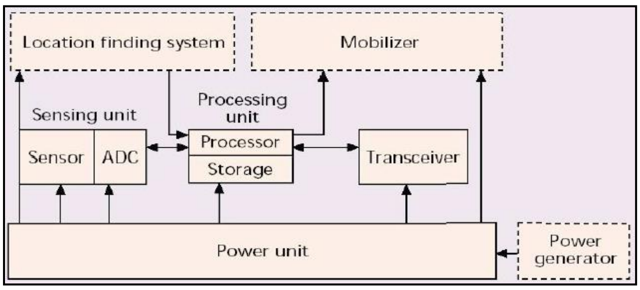

Figure 3: High-level sensor node architecture

b) WSN communication stack - The nodes are expected to be deployed in an adhoc manner for most applications. Designing an appropriate topology, routing and MAC layer is critical for scalability and longevity of the deployed network. Nodes in a WSN need to communicate among themselves to transmit data in single or multi-hop to a base station.
c) WSN Middleware - A mechanism to combine cyber infrastructure with a Service Oriented Architecture (SOA) and sensor networks to provide access to heterogeneous sensor resources in a deployment independent manner. This is based on the idea of isolating resources that can be used by several applications.

d) Secure Data aggregation - An efficient and secure data aggregation method is required for extending the lifetime of the network as well as ensuring reliable data collected from sensors. As node failures are a common characteristic of WSNs, the network topology should have the capability to heal itself.

2.1.2.1. Addressing schemes

The ability to uniquely identify Things'is critical for the success of IoT. This will not only allow us to uniquely identify billions of devices but also to control remote devices through the Internet. The few most critical features of creating a unique address are: uniqueness, reliability, persistence and scalability.

Every element that is already connected and those that are going to be connected must be identified by their unique identification, location and functionalities. The current IPv4 may support to an extent where a group of cohabiting sensor devices can be identified geographically, but not individually. The Internet Mobility attributes in the IPV6 may alleviate some of the device identification problems; however, the heterogeneous nature of wireless nodes, variable data types, concurrent operations and confluence of data from devices exacerbates the problem further (Jara *et al.*, 2010).

2.1.4 Data storage and analytics

One of the most important outcomes of this emerging field is the creation of an unprecedented amount of data. Storage, ownership and expiry of the data become critical issues. The internet consumes up to 5% of the total energy generated today and with these types of demands, it is sure to go up even further. Hence, data centers that run on harvested energy and are centralized will ensure energy efficiency as well as reliability. The data have to be stored and used intelligently for smart monitoring and actuation. It is important to develop artificial intelligence algorithms which could be centralized or distributed based on the need.

2.1.5. Visualization

Visualization is critical for an IoT application as this allows interaction of the user with the environment. With recent advances in touch screen technologies, use of smart tablets and phones has become very intuitive. For a lay person to fully benefit from the IoT revolution, attractive and easy to understand visualization has to be created. As we move from 2D to 3D screens, more information can be provided in meaningful ways for consumers.

3. Proposed methodology

In the hospital, patient has to wait long time to monitor by the doctor. In the case of critical condition patient cannot wait. In any condition of patient's, they have to wait for appointment to the doctor then the patient can meet to the doctor and then the patient getting the treatment and medicine through the doctor's prescriptions. Another problem in the existing system is patient want to meet with the doctor he or she must go to the hospital. There is only one to one communication with the doctor only. For example like, first the patient's detect symptoms then they was gone to the hospital then taken appointment to meet the doctor for diagnosis then they was call by appointment number one by one. After this the patient had been given treatment by doctor.

Hence for this kind inconvenience to the patient there is need to develop a software that get a input via sensor like temperature, Blood pressure, pulse rate or any other sensor's. This provides predicted precaution to the user. The predicted precaution is in the text format so that user can read it whenever he wants. For the critical condition patient who can't wait for a second. In this, patient is a user and we develop software that get input from sensor's and provide precaution to the user or patient.

3.1 System Architecture

3.1.1 System Architecture of Sensor Network

Most common architecture for WSN follows the OSI Model. Basically in sensor network we need five layers: application layer, transport layer, network layer, data link layer and physical layer. Added to the five layers are the three cross layers planes as shown in Figure 4.

3.2 Proposed Algorithm

The proposed system has four steps.
s
1) Step 1: Sensing data: biometric sensors collect the data of blood pressure, body temperature, pulse rate and heart beats.
2) Step 2: Comparison of data: Collected data are compared with the reference saved data of different parameters. Here four comparators used for four parameters.
3) Step 3: Analysis: After comparison of the data, all differences send to the microcontroller and microcontroller analysed it and give signal to the frequency generator.
4) Step 4: Frequency generation: When the sensed data is differ from the reference data microcontroller send signals one after one for generation of the alarming signal. Frequency generator generates 1MHz. frequency for buzzer alarm and 2 MHz. for activate auto phone call.

3.2.1 Algorithm

First of all, the wireless sensor nodes are establishment of on body of patient. Sensor nodes sense the physical data (body temperature, blood pressure and pulse rate) and transducer convert collected data into electrical signal.

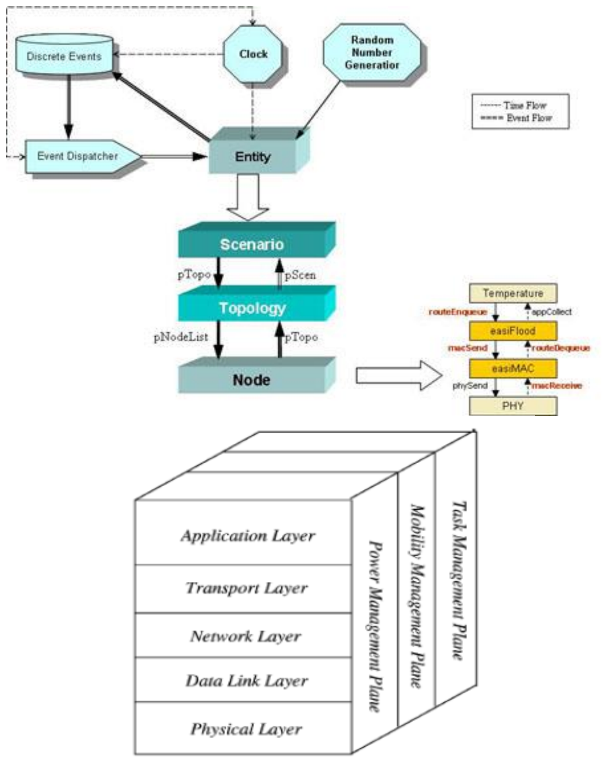

Figure 4: WSN Architecture andUsed Layers in WSN Architecture

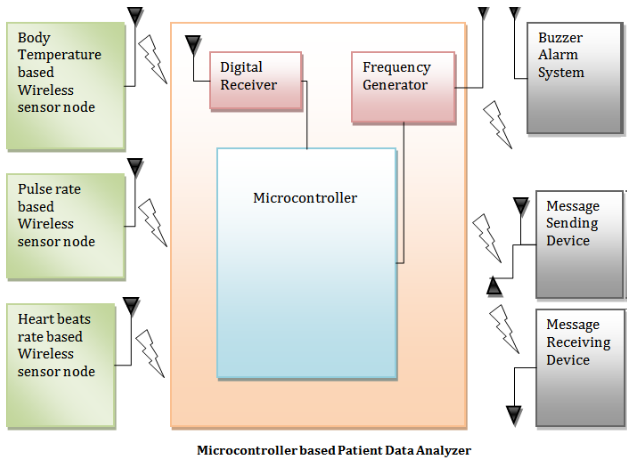

Figure 5: System Architecture

Pulse rate, body Temperature and Heart beats data is converted into the electrical signal of 5 volt. Then electrical signals were converted into the digital signal for wireless communication. For this purpose first of all Electrical signal send to the A/D convertor which converts the signal from Analog electrical to Digital using 256 quantization level then uses Up-sampling to convert the signal into samples by 64k samples/s. After sampling, the signal is encoded the data to enable error correction (an FEC encoder may include a binary convolution encoder followed by a puncturing device). After this the Modulate signal by 366 data bits are transmitted at 1 Mbps and modulated using Gaussian frequency shift keying (GFSK). GFSK effectively transmits +150 kHz signal relative to the carrier for a 1bit, and a -150 kHz signal for a 0 bit. The carrier signal is generated in the Simulink model by a baseband MFSK block set to 79 symbols and a separation of 1MHz. If a hop frequency value 0 is input, a -39MHz complex sinusoid is generated. If a 1 is entered, a -38 MHz complex sinusoid is generated and so on. Then modulated signal is transmitted with wireless carrier frequency i.e. 2.4 GHz. Sanded signal was received and demodulate it by GFSK demodulator and send this data to the microcontroller where it was compare with the reference data the comparison process is shown in the figure 6. When compared data found that there are any mismatches with the reference data then microcontroller activated the frequency generator for generating activation frequency for buzzer alarm and massage sending device.

1. Establishment of wireless sensor node on the body
2. Collect physical data from body
3. Convert collected physical data into electrical signal
4. Convert analog electrical signal into digital signal
5. Modulation by GFSK and transmitted with wireless carrier frequency i.e. 2.4 GHz
6. PDA received signal
7. Demodulation of the signal by GFSK demodulator and found actual data
8. Actual body data (body temperature, pulse rate and heart beats) sends to microcontroller for analysis
9. If body-temp <99.5 and body-temp>97
   Then condition is idle and patient is ok and data discarded
   Else instruct to frequency generator to activate alarming device
10. If pulse rate< 100 pulses per minutes and pulse rate >60 pulses per minutes
    Then condition is idle and patient is ok and data discarded
    Else instruct to frequency generator to activate alarming device
11. If heart beats < 85 beats per minutes and heart beats >65 beats per minutes
    Then condition is idle and patient is ok and data discarded
    Else instruct to frequency generator to activate alarming device
12. Activation of the frequency generator
    First continuous to non-idle signal 1 MHz frequency generated for buzzer alarm
    And then generate 2 MHz frequency for activation of massage sending device
13. Both signal generated alternate way till system was not deactivated by any observer.
14. End

Figure 6: Proposed Algorithm

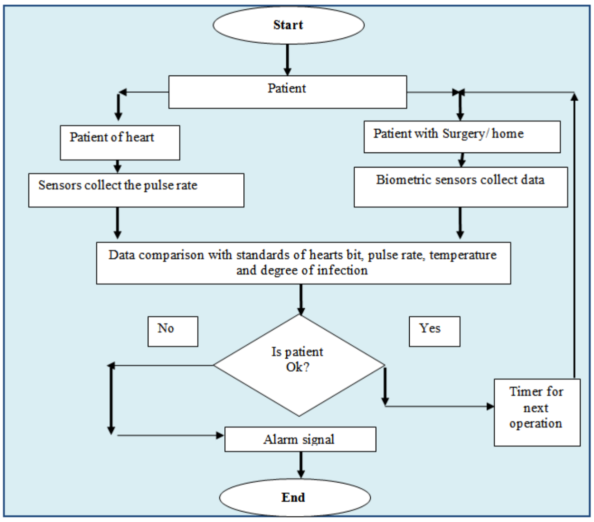

Figure 7: Flowchart of the algorithm of the healthcare system

From the workflow the patient is user which attaché the pulse sensor then pulse sensor sense the pulse rate and recorded it and then from association rules it check the other symptoms with the high or low pulse rate then for example if patient have high pulse rate then it check for symptom like dryness, hair loss, weight gain or weight loss then by using this system we get directly prediction like chances of hyperthyroidism, heart disease, lung disease, stress or any other disease.

4. Results and Discussion

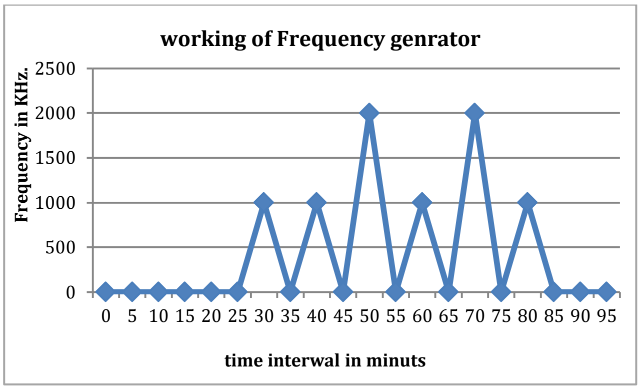

Figure 8: Generation of the frequency

A Frequency generator activated when the difference of the comparator is more or less than the reference limit of the parameters. When the difference values of the comparators for the parameters had crossed lower or upper limit then microcontroller did not activate the frequency generator.

It waited for the next value; if next values also perform the same character then microcontroller activated the frequency generator for the generation of 1 MHz. frequency to activate pizzoelectric buzzer alarm.

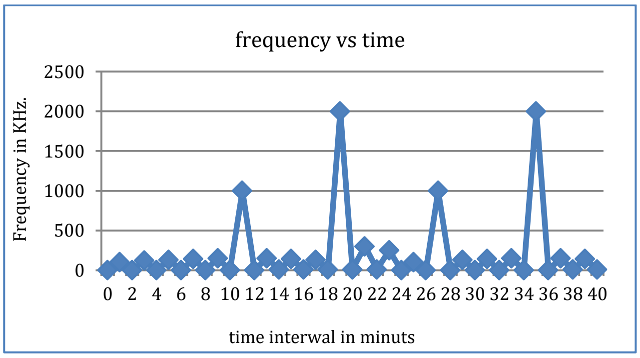

Figure 9: Performance of the frequency generator

But when the system is did not deactivated by the attendant within five minutes then frequency generator generates a frequency of 2 MHz. for the activation of the auto phone call system. The performance of the alarming system explained in the figure 8 and 9.

4.1 Average delay of the system and effect of it on the system

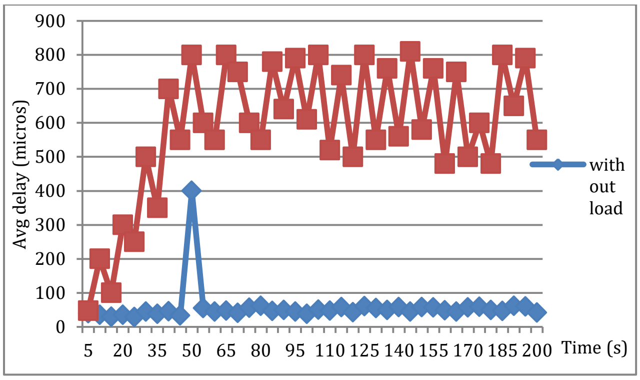

Figure 10: Time VS Average Delay (in s)

The figure 10 shows that the proposed IOT based healthcare system gives less delay compared to manual and existing method and it proves that this method completes the data transmission with less delay due to data compression process. While compression, packet size will be decreased and due to this reason it can transfer much data comparing to existing system in the queue. So the delay is greatly decreased.

4.2 Average throughput of the system and effect of it on the system

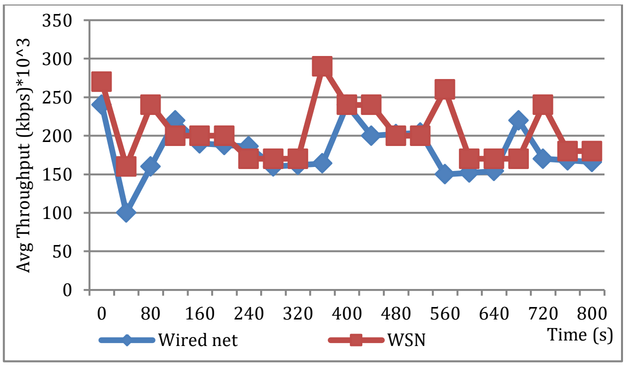

Figure 11: Time Vs Average Throughput

A The figure 11 shows that the proposed IOT based healthcare system gives better throughput compared to existing method and speed of transmission will be high in this method. Due to implementation IOT and Intelligent E-health gateway process it has increased the speed of data transfer due to data compression and fusion process.

4.3 Analysis of transmitted signal by sensor and received signal by PDA

After the observation of the transmitted signal by the biometric sensors with Gaussian carrier frequency and received signal by PDA, it was found that there were large differences between them due to Gaussian noise and path loss in the medium of space. The average transmitted signal was 5 volt while average received signal was 1.092 volt.

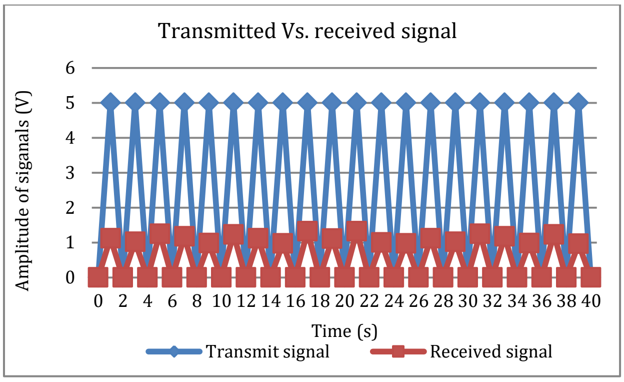

Figure 12: Transmitted Vs. Received signal

Conclusion

Frequency generator activated when the difference of the comparator is more or less than the reference limit of the parameters. When the difference values of the comparators for the parameters had crossed lower or upper limit then microcontroller did not activate the frequency generator. It waited for the next value; if next values also perform the same character then microcontroller activated the frequency generator for the generation of 1 MHz. frequency to activate pizzoelectric buzzer alarm. But when the system is did not deactivated by the attendant within one minutes then frequency generator generates a frequency of 2 MHz. for the activation of the auto phone call system. Performance of the buzzer alarm was very good and a stable oscillator generates the frequency of 2MHz. to activate the GSM system for call and messages. After the observation of the result of MATLAB data it concluded that the proposed IOT based healthcare system has worked properly and the responses of the signal of health data were very good. The wireless network generated by the system is working properly and well-connected and secured its information.

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