Performance analysis of Wireless Sensor Network using Zigbee Pro for Remote patient monitoring Application

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Abstract – Remote patient monitoring is an eHealth service, which is used to collect and transfer bio signal data from the patients to the eHealth service provider (e.g., healthcare center). Having timestamps that are robust and reliable is essential for remote patient monitoring in order for patient data to have context and to be correlated with other data. The usage of WSNs will overcome the need of patients to be stationery for their vital parameters to be measured. In this paper the network performance is studied and analyzed based on various performance parameters like sensor node density, communication duration, Packet Delivery Ratio (PDR), throughput, average network delay and energy consumed etc. By comparing obtained performance with required performance, choose appropriate node density, data transmission rate and communication duration for establishment of Zigbee based WSN for patient monitoring.

Index Terms – Remote patient monitoring, eHealth, telehealth, time standards, Wireless Sensor Networks (WSNs), PDR, Throughput, Latency, Energy consumption, Ns-2.

1. INTRODUCTION

Care of critically ill patient, requires spontaneous & accurate decisions so that life protecting & lifesaving therapy can be properly applied. Statistics reveal that every minute a human is losing his/her life across the globe. More close in India, everyday many lives are affected by heart attacks and more importantly because the patients did not get timely and proper help. In past, WSNs have been used to acquire data for industrial monitoring and diagnostics. Current trends in Telemedicine, Tele care, E-health and E-medicine are aimed towards enhancing the present healthcare systems to continuously monitor the health of patients through almost real time updates of their medical records.

Wireless sensor network (WSN) is a network of a large number of self-organizing nodes distributed in some region. It is a rapidly developing area with a wide range of potential applications like environmental monitoring, medical systems, battlefields, biometrics, industrial control, smart spaces etc. Each node in a WSN is equipped with one or more sensors, a processor, and some memory and low-power radio. They are small in size, light weight and low cost.

The sensors sense the surroundings and send the information to the base station (or sink) either directly or through intermediate nodes. The end user can get the information from the base station.

Wireless Sensor Networks (WSNs) are becoming an integral part of healthcare systems, as they can overcome the need for patients to be stationary while their vital parameters are being checked .Wearable physiological sensors can be placed on patient's body to constantly monitor vital parameters of the patient such as body temperature, blood pressure, respiratory rate etc., and transmitted to the doctor over a wireless network. With the help of such networks, doctors, nurses and care takers can remotely and constantly monitor the health of the patients. Also, patients can move around within a given area while their vital parameters are being checked. Wireless sensor networks application for physiological signals communication transmission has many technologies such as the Infrared, Bluetooth and Zigbee, etc. Because the angle limit problem of the infrared transmission, and the infrared have not be used for Physiological signal transmission. Although Bluetooth is better than ZigBee for transmission rate, but ZigBee has lower power consumption.

Hence, ZigBee is generally used for 24 hours monitor of communication transmission systems. Compared to Bluetooth, ZigBee provides higher network flexibility and a larger number of nodes, and a better transmission range with low power consumption. Large number of nodes enables the expansion of such systems. Recently, ZigBee-based wireless networks were tested in various applications.

Before establishing a network for patient health monitoring, it is essential to predict the behavior of the designed network in different network conditions with the help of different network scenarios. Network simulations play an important role in studying the network performance under different

network conditions. Network simulator tools give provision to perform such network analysis. Ns2 is a discrete event simulator, actively used in networking research .In this paper, a Zigbee based sensor network for patient monitoring system is simulated in ns2.34. The performance of the simulated network is analyzed in terms of PDR, average network delay (latency), throughput and energy consumption. The obtained performance is analyzed in comparison with the required performance of physiological signals used for patient health monitoring in practical.

2. TECHNOLOGIES USED IN REMOTE PATIENT MONITORING

Remote Patient Monitoring is new way to monitor the patient's health outside any conventional clinical settings. It can help in measuring patient's health and their behavior with automated sensors delivering a complete and different level of insight. This can truly help in patients receive.

- TELEMETRY

Collected at remote or inaccessible points and transmitted to receiving equipment for monitoring.

- TELE HEALTH

The patient has a central system that feeds information from sensors and monitoring equipment

- WIRELESS SENSOR NETWORK

Networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring.

- PULSE OXIMETRY

For monitoring a person's O2 saturation. In its most common Trans missive application mode, a sensor device is placed on a thin part of the patient's body.

2.1. How it will work?

Patient care is the focus of many clinical disciplines medicine, nursing , pharmacy, nutrition, therapies such as respiratory, physical, and occupational, and others. Although the work of the various disciplines sometimes overlaps, each has its own primary focus, emphasis, and methods of care delivery. Each discipline's work is complex in itself, and collaboration among disciplines adds another level of complexity. In all disciplines, the quality of clinical decisions depends in part on the quality of information available to the decision-maker.

The process of care begins with collecting data and assessing the patient's current status in comparison to criteria or expectations of normality. Through cognitive processes specific to the discipline, diagnostic labels are applied, therapeutic goals are identified with timelines for evaluation, and therapeutic interventions are selected and implemented. At specified intervals, the patient is reassessed, the effectiveness of care is evaluated, and therapeutic goals and interventions are continued or adjusted as needed. If the reassessment shows that the patient no longer needs care, services are terminated.

2.2. Advantageous and Disadvantageous

Advantages

1. Increased access to health care
2. Minimized personal and healthcare delivery costs
3. Reducing hospital visits and duration of hospital or even sometimes avoiding hospitalization
4. Early detection of deterioration
5. Anytime access and analysis of real-time data
6. Avoiding complications
7. Maintaining patient independence.
8. Doctors are also benefited largely with the help of RPM.

Disadvantages

1. It's disruptive; it just pops up as a thing you need to take care of. When patients' batteries need to be replaced, they need a preoperative evaluation.
2. They can cause emotional problems if they fire inappropriately and cause complications, such as infection. We know certain patients are at risk, but we don't know how much risk they have.
3. We want to have access to all the available new technology and new clinical trials. If you implant devices from only one manufacturer," Knight continued, "and their devices are suddenly recalled, then you've invested all your eggs in one basket and you're in trouble. You diffuse the risks and problems associated with device recalls and alerts.
4. Patient data need to remain private and must be used healthcare purposes only, and with the patients' consent. But if you create a healthcare database, someone will probably want to make use of it immediately.

2.3. Applications

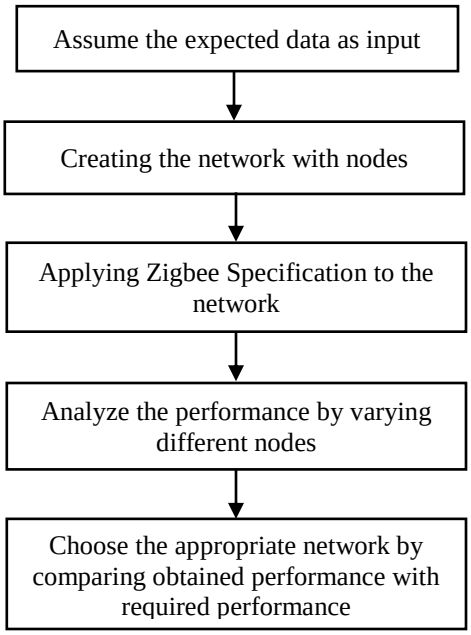
Physiological data such as blood pressure and subjective patient data are collected by sensors on peripheral devices. Examples of peripheral devices are: cuff, pulse, and glucometer. The data are transmitted to healthcare providers or third parties via wireless telecommunication devices. The data are evaluated for potential problems by a healthcare professional or via a clinical decision support algorithm, and

patient, caregivers, and health providers are immediately alerted if a problem is detected.

1. Dementia and falls
2. Diabetes
3. Congestive heart failure
4. Infertility.

3. NETWORK SYSTEM IMPLEMENTATION AND MODELLING

3.1. Plane of execution



3.2. Throughput

In general terms throughput is the rate of production or the rate at which something can be processed. It represents the average rate of successful packet of information received at the destination. It is also defined as the entire data received by destination node from source divided by total time taken by destination to receive the last packet.

$$Throughput = \frac{Number\ of\ delivered\ packets * packet\ size * 8}{Total\ simulation\ duration}$$

When used in the context of communication networks, such as Ethernet or packet radio, throughput or network throughput is the rate of successful message delivery over a communication channel. The data these messages belong to may be delivered over a physical or logical link or it can pass through a certain network node. Throughput is usually measured in bits per second (bit/s or bps), and sometimes in data packets per second (p/s or pps) or data packets per time slot.

The system throughput or aggregate throughput is the sum of the data rates that are delivered to all terminals in a network. Throughput is essentially synonymous to digital bandwidth consumption; it can be analyzed mathematically by applying the , where the load in packets per time unit is denoted as the arrival rate (λ), and the throughput, in packets per time unit, is denoted as the departure rate (μ).

3.3. Packet delivery ratio

The ratio of packets that are successfully delivered to a destination compared to the number of packets that have been sent out by the user.

$$PDR = \frac{S1}{S2}$$

Where, S1 is the sum of data packets received by the destination and S2 is the sum of data packets generated by the each source.

The PDR corresponds to the ratio between the number of erroneous received packets and the total number of transmitted packets. However, the Zigbee communication protocol is equipped with an error control mechanism, to reduce the loss of data. This mechanism is based on the use of automatic repeat request (ARQ) techniques. More precisely, the Zigbee protocol requires up to three packet retransmissions in the absence of an ACK from the destination node.

3.4. Latency

Latency is defined as the time delay between the cause and effect of some physical change in the system being observed. The delay of a packet in a network is the time it takes the packet to reach the destination after it leaves the source. Average network delay is affected with change in sensor node density, while it remains almost constant over the simulation duration for a given node density.

The second set of measurements carried out with a Z-Wave network is relative to the delay. The delay per packet is calculated as the average (over the measurements) time interval between the beginning of a transmission of a packet and the beginning of the transmission of the following packet..

3.5. Energy conception

The Energy consumption is the consumption of energy or power. It is measured in Joules. Energy consumption is nothing but the lifetime of battery. The energy consumption rate for sensors in a wireless sensor network varies greatly based on the protocols the sensors use for communications.

Advances in wireless communication technology are enabling the deployment of networks of small sensors. These sensor networks have applications in military monitoring, health,

industrial control, weather monitoring, commodity tracking, home control, etc. As promising as this technology seems, many design issues must yet be resolved before Wireless Sensor Networks become fully functional. A critical constraint on sensors networks is that sensor nodes employ batteries.

A second constraint is that sensors will be deployed unattended and in large numbers, so that it will be difficult to change or recharge batteries in the sensors.

4. RESULTS AND DISCUSSIONS

The following parameters are measured for the Zigbee based wireless sensor network to remote patient monitoring

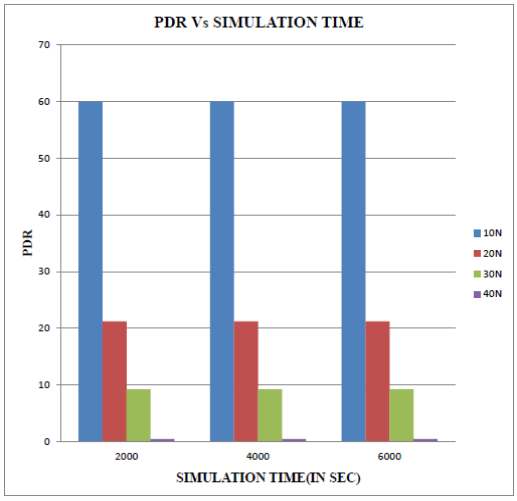


Figure 1 PDR Vs Simulation Time

It is observed that PDR decreases as the number of nodes increases and remains constant for different simulation durations.

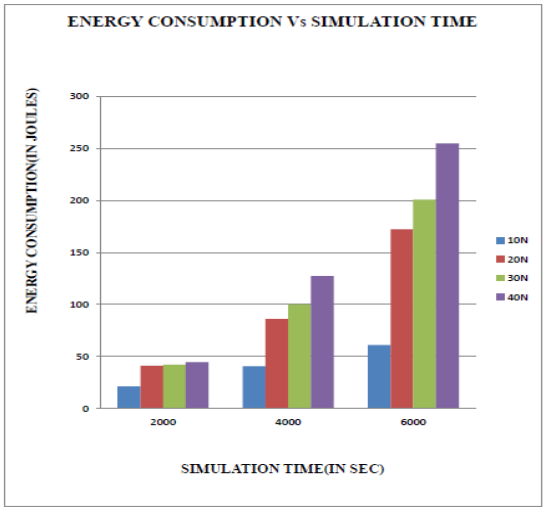


Figure 2 Energy Consuption Vs Simulation Time

It is observed that Energy Consumption increases as the number of nodes increases and also as simulation durations increase.

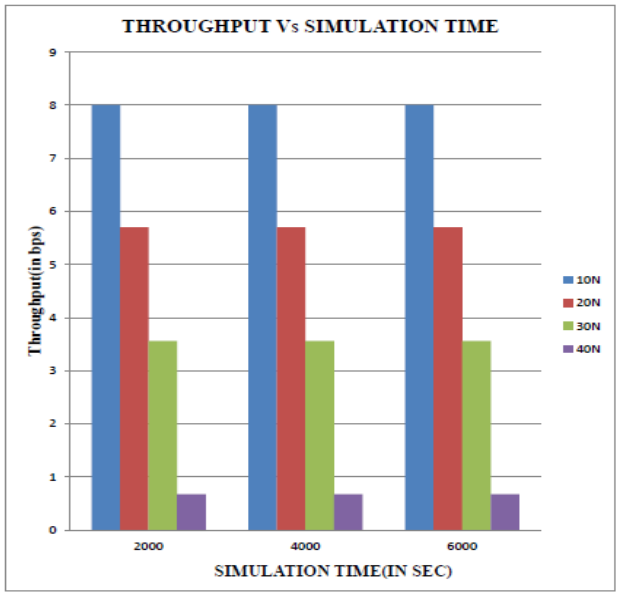


Figure 3 Throughput Vs Simulation Time

It is observed that throughput decreases as the number of nodes increases and remains constant for different simulation durations.

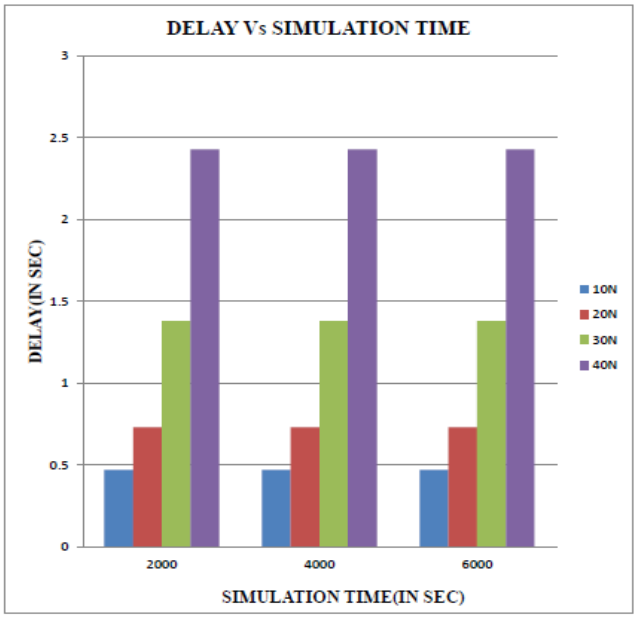


Figure 4 Delay Vs Simulation Time

It is observed that delay increases as the number of nodes increases and remains constant for different simulation durations.

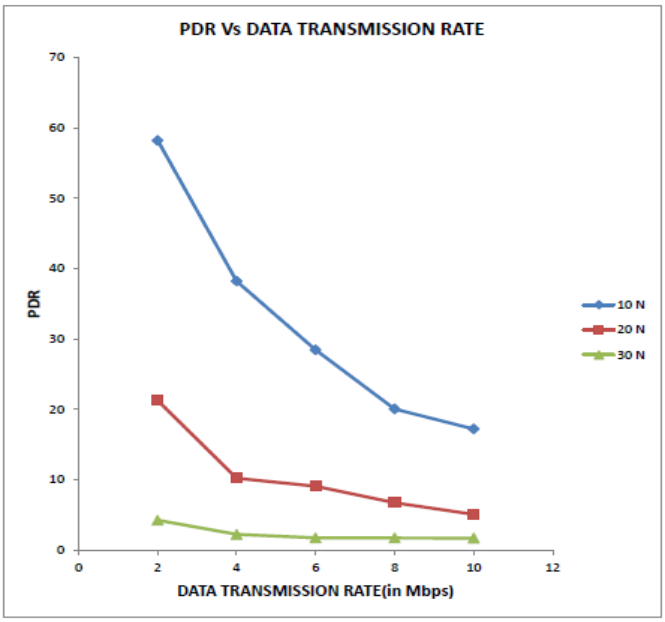


Figure 5 PDR Vs Data Transmission Rate

It is observed from the obtained results that there is almost exponential decrease in PDR with increased data transmission rate. Also, as node density increases, PDR decreases.

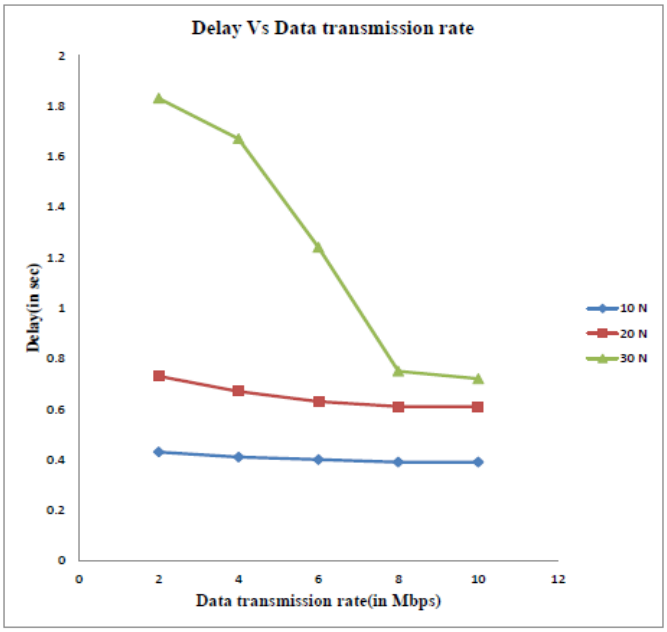


Figure 6 Delay Vs Data Transmission Rate

The obtained results show that average network delay decreases with increase in data transmission rate, while delay observed at higher node density is more than that observed at lower node density.

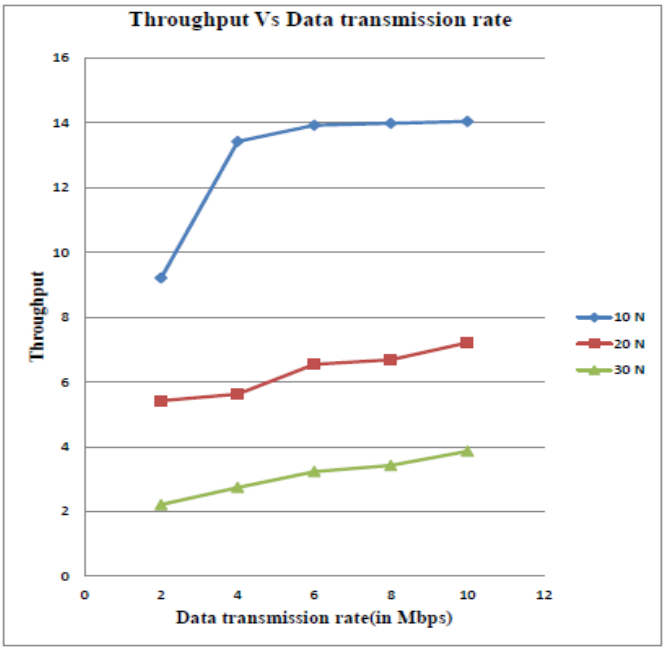


Figure 7 Throughput Vs Data transmission RATE

Network simulations are done for throughput varying in accordance with data transmission rate. It is observed from the obtained results that throughput increases with increase in data transmission rates.

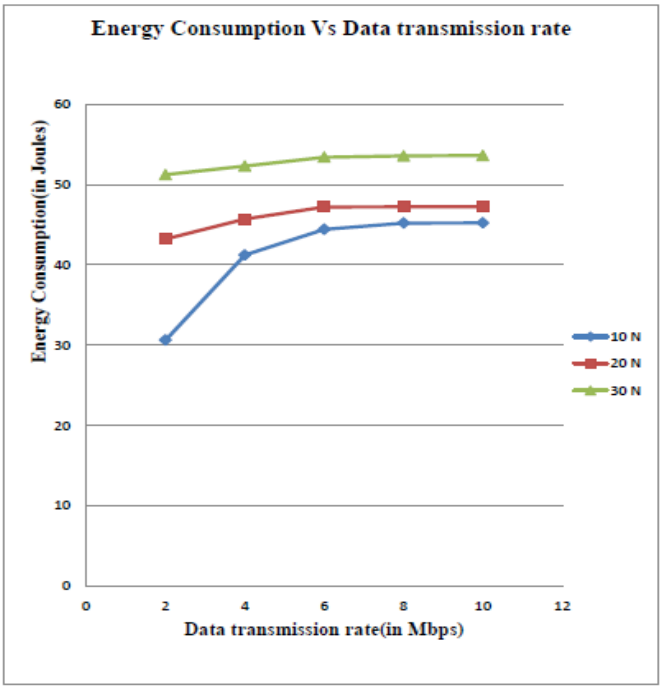


Figure 8 Energy Conseption Vs Data transmission RATE

As seen from the obtained results node energy consumption increases with increased node density and data transmission rate initially. However, at higher data transmission rates consumption of node energy is not affected much and remains roughly constant. This trend is observed for all the node densities.

5. CONCLUSION

In this paper the performance of ZigBee based sensor network for patient monitoring through simulations carried out using ns2.34 simulator tool. Simulations are carried out to study the effect of variation in simulation duration and data transmission rate on network performance. From the obtained results it is observed that PDR and throughput get drastically affected with increase in node density and data transmission rate, when compared to average network delay. Amount of energy consumed is an important parameter for WSNs and its variation is studied with respect to node density, duration of communication and data transmission rate. As expected, energy consumed increases with communication duration.

The performance analysis provided in this project can be used while establishing Zigbee sensor based patient monitoring systems.

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