# PERFORMANCE EVALUATION OF HEALTH MONITORING SYSTEM USING WIRELESS SENSOR NETWORKS

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**Abstract**

The critical patient's health is in-need to undergo continuous monitoring to avoid the happening of unexpected things. There are many monitoring systems are used in the health care system, but those things are concentrating on the patient at the required place. Whenever the patient is unable to reach the regular health check-up hospital, there will be some risk faced by that patient due to the unavailability of his/her health-related data. In this research paper, continuous health monitoring techniques are developed and tested in two different ways. Hospital monitoring and In-house monitoring are the two techniques going to implement and latency and throughput are the parameters, which are going to analyze the performance with the existing algorithms.

**Keywords:** *Wireless Sensor Networks, Healthcare Monitoring, Hospital Monitoring, In-House Monitoring, Latency, Throughput.*

## I. INTRODUCTION

The Wireless Sensor Network is a network, which consists of distributed sensor nodes that monitor specific physical or environmental events, such as temperature, sound, vibration, pressure, or motion, at different locations through wireless technology. The first development of Wireless Sensor Network was initiated by military purposes for battlefield surveillance [6] and nowadays, recent techniques have reduced the size, cost, and power of these sensor nodes beyond the development of wireless interfaces making the Wireless Sensor Network one of the hottest topics of wireless communication. There are several basic components in any Wireless Sensor Network: [9]

1. A group of circulated sensor nodes
2. An interconnecting wireless network
3. A Collecting data from base station to origin
4. A set of computing strategy at the base station to interpret and analyze the received input data from the nodes that are connected.

Wireless sensor nodes are set with a power unit, a sensing unit, a process unit, and a communication unit and every node is capable to perform sensing, processing, information gathering, and communicating with alternative connected nodes. Generally, the sensing unit senses the surroundings, the process unit calculates the restrained permutations of the detected information, and therefore the communication unit performs the swap over of processed data among 3 nearby detector nodes [5]. Wireless Sensor Network is by many little, affordable nodes that are fitted with limitations in memory, energy, and process capability. Recent advances in wireless communications and electronics have enabled the rollout of affordable, low power and multi-functional sensors that are small in dimensions and communicate in certain distances. Economical, sensible sensors networked through wireless links and deployed in large quantities, offers incomparable opportunities for observance and controlling homes, cities, alongside with the surroundings [8]. Moreover, the location estimation may enable many applications for instance inventory management, transport, intrusion detection, road traffic observance, health observance, intelligence activity and surveillance [10, 11].

## II. LITERATURE REVIEW

Through wireless medical sensors, **Mohammed Baqer *et al.* (2013)** proposed a remote patient monitoring and tracking system to observe the patient's significant symbols. The medical sensor transmits the data to an Android based mobile device that in turn periodically sends the patient health status data to the server storage. Their proposed system allows the patients to modify their position freely and it tracks them using the gathered GPS data as inputs from the mobile device and directs them to the medical care team at any health emergency case with the information. In addition, the server informs the patient's doctor about his patient's status and position. With no direct access between the beneficiaries, dedicated simple compression methods are used to reduce the GPS data size, which is periodically gathered and their developed system components communicate with each other through a third party. The Peer 2 Peer key using Advanced Encrypting Standard encrypts the transmitted data and the doctors can do inquiry about their patients using a devoted Android based application and they can inquiry using an conventional web server easily. A set of needful tests is conducted on the patient's application based on the condition and parameters; their results shows that in case of using slow and single core processor, the application takes 0.8% of the processor time, so that the patient's application can work alongside other running applications without causing considerable deprivation in the performance of the device [2].

**Audace Manirabona *et al.* (2016)** proposed a scheduling approach for Wireless Body Area Network based Health Monitoring System called Priority-Weighted Round Robin (PWRR). The Priority-Weighted Round Robin as a combination of a priority scheduling and a weighted round robin utilize the user priorities of physiological data within the Wireless Body Area Network to determine how to schedule and send them off through the Wireless Body Area Network. The developed scheduling approach brings good results in terms of plummeting the delay of emergency and medical data. The results shows that the PWRR strategy offers many improvements in terms of delay of emergency and medical data flows at the coordinator compared to the First In First Out approach. Simulation results for peer-networks involved in a Wireless Body Area Network based Health Monitoring System show that, if Priority-Weighted Round Robin is set, the behavior of WIFI, WIMAX, and LTE networks remains the same in keeping all flows as per their priorities by justifying the end-to-end delay. Moreover, it was shown that the increase in the arrival rate of emergency flows increases the delay of this latter too whereas the emergency flows have low arrival rate though in reality [7].

## III. METHODOLOGY

The methodology is defined as a systematic and theoretical analysis of the different methods, which are applied to study a field. It also comprises the theoretical analysis of the structure of methods and different principles associated with the branch of the knowledge domain. The methodology of the proposed framework is named as Continuous Health Care Monitoring System for Critical Patients. The proposed model contains two modes of operations, and they are as follows; [11]

- Hospital Monitoring Mode
- In-House Monitoring Mode

Figure 1 illustrates the proposed methodology working structure and it explains about how those four parts are integrated together to make as a functioning full model.

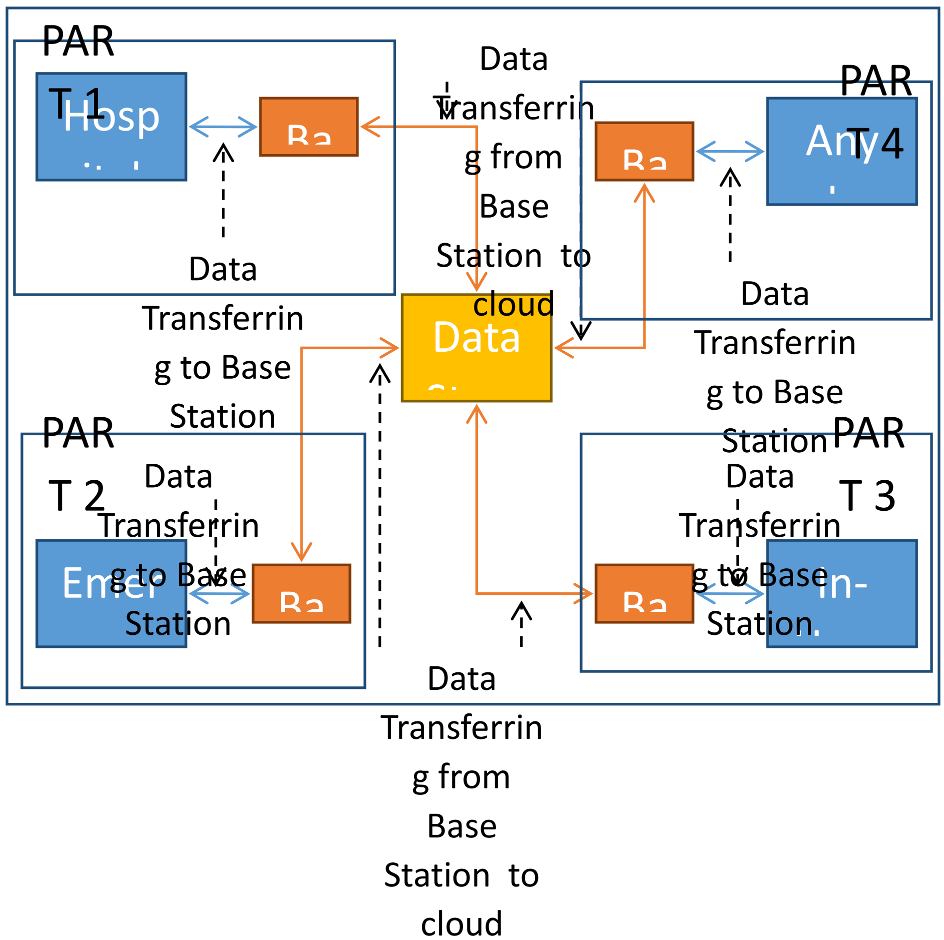


**Figure 1: Framework of Proposed Methodology [11]**

**(A) HOSPITAL MONITORING MODE**

This is the first place where the patient is brought under continuous monitoring system. The patient related information will be made as a record and all the health care information of that patient will be updated in the patient's record [15]. While the patient revisiting the hospital for a periodic check-up or further treatment, that time the stored record will be used. These records will be made as a digital record and that will be stored at cloud storage, so it is convenient to view the patient health records at anywhere and at any time by hospital team, by a patient or by a doctor. The monitoring mode is used to monitor the patients both in inpatients and outpatients.

Nevertheless, when coming record storage part, both patients records need to be taken into consideration about data easy handling and data security. Each and every patient data need to be stored within their specific files and also in the meantime, no malfunctions were not to be entertained by hospital management. Those things were considered in this design and it tries to bring out a better solution than the existing models. Figure 2 elaborates about the block design of the hospital monitoring mode [13].

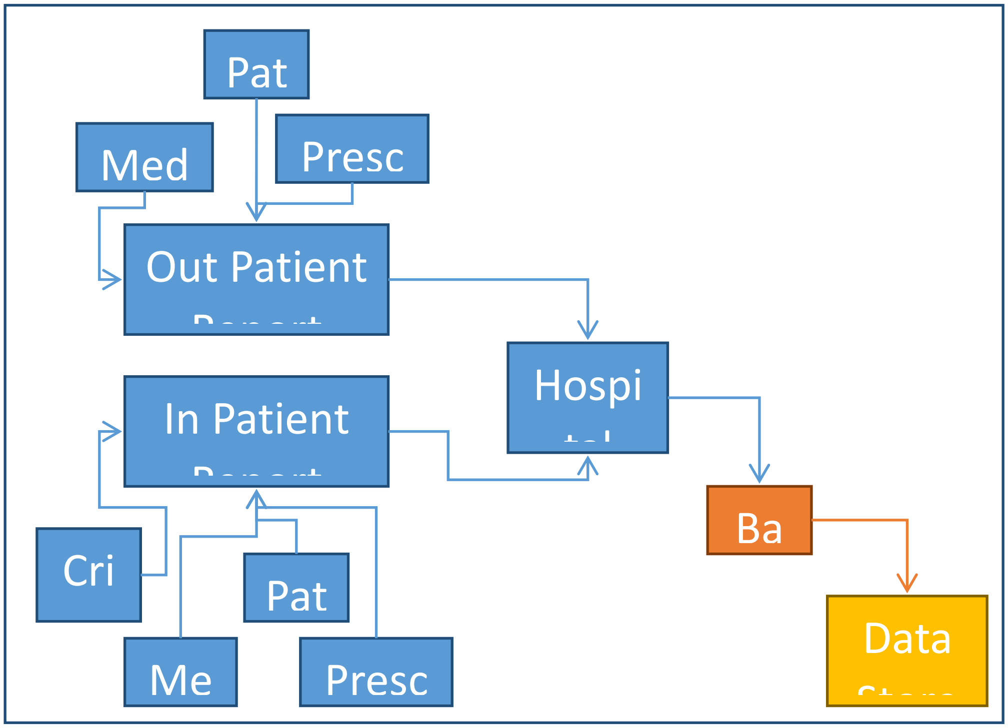


**Figure 2: Hospital Monitoring Mode Block Design**

**Pseudo Code for the Hospital Monitoring Mode:**

**Start** the Process
**Get** the patient details from request person
**Validate** the requesting person
    **If** the requesting person passes the validation **then**
    Process the request to next level
    **Else**
    Send the validation failure to that request person
**Verify** whether the patient is inpatient or outpatient
    **If** the patient identified as inpatient **then**
    Connect to the inpatient sector and provide the inpatient details only
        **Else if** the patient identified as an outpatient **then**
        Connect to the outpatient sector and provide the outpatient details only
        **Else**
        Send the error message as that the requested patient information is not available due to wrong patient details.
**Stop** the process.

**(B) IN-HOUSE MONITORING MODE**

The In-House Monitoring Mode is used to monitor the patient's health condition continuously. Some patient needs hospital assistance at any time due to their major treatment. So this mode is used to monitor and provide the health assistance to that patient under an on-demand structure. The figure 3-block diagram illustrates the In-House Monitoring Mode [10].

**Pseudo Code for the In-House Monitoring Mode:**

**Start** the process
**Start** the Continuous Monitoring Status
**While** the patient in In-House Monitoring Mode provides the full permission to the patients

**If** the patient requests to view the history of his own **then**
**Validate** the patient
**If** the patient satisfies the validation **then**
**Permit** him to view the requested details
**Else**
Send the error message as a validation failure
**If** the patient requests to view the prescription of his own **then**
**Validate** the patient
**If** the patient satisfies the validation **then**
**Permit** him to view the requested details
**Else**
Send the error message as a validation failure
**If** the patient requests to view the medical reports of his own **then**
**Validate** the patient
**If** the patient satisfies the validation **then**
**Permit** him to view the requested details
**Else**
Send the error message as a validation failure
**If** the patient requests to raise the queries to the doctor **then**
**Validate** the patient
**If** the patient satisfies the validation **then**
**Permit** him to raise his or her queries to the doctor
**Else**
Send the error message as a validation failure
**If** the doctor answer her or his queries **then**
**Forward** that answers to that patient
**If** the patient feels some difference in his health **then**
That information needs to send automatically to the hospital to take the further step and also immediate action need to be advised to the patient as first aid.
**Stop** the process

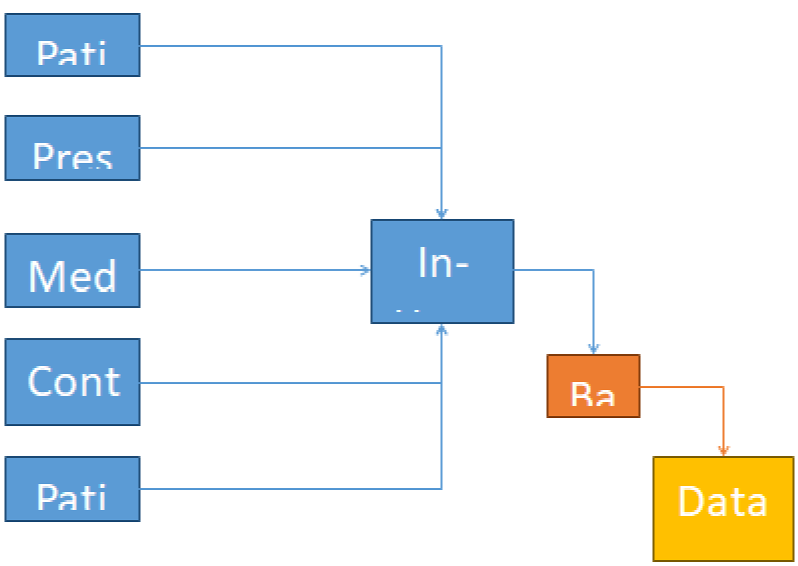


**Figure 3: In-House Monitoring Mode Block Design**

## IV. RESULTS & DISCUSSION

Each and every parameter metrics were simulated and tested for twenty times to validate the proposed methodologies efficiency and performance. Two types of parameters are taken for consideration. They are:

- Latency
- Throughput

**LATENCY**

Latency is a measure of delay, which is used as one of the parameter here. For example, in a network, latency measures the time for some data that travels to get to its destination across the preferred network. It is usually measured as a round trip delay that the time taken for information to get to its target and return back.

$$\textbf{FST} = \frac{S}{R}\text{----------------------}\textbf{Eq.1}$$

FST = Frame Serialization Time, S = Packet size (bits) and R = Transmission Rate Packet size (bits per second). Table 1 and Figure 4 illustrates that the proposed methodology's average transmission performs well and better than the two existing methodologies in the Latency comparison matrices.

**Table 1: Average Latency Comparison between Proposed and Existing Methodologies**

| **Parameters** | | **Latency (in a sec)** | |
|---|---|---|---|
| **File Size** | **Existing 1** | **Existing 2** | **Proposed** |
| **1 MB** | 8.25 | 8 | 9 |
| **3 MB** | 26 | 25 | 24 |
| **6 MB** | 55 | 51 | 48 |
| **10 MB** | 98 | 95 | 89 |
| **20 MB** | 192 | 182 | 171 |

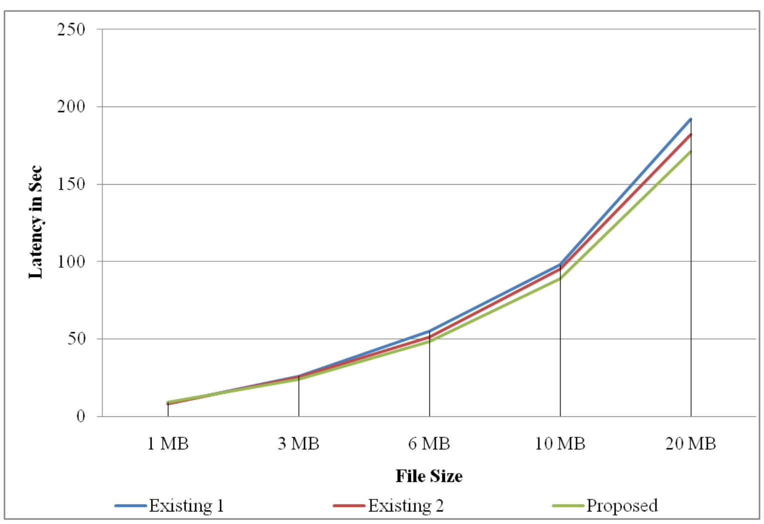


**Figure 4: Average Latency Comparison between Proposed and Existing Methodologies**

In the latency parameter, the existing 1 methodology has reached latency in 75.85 seconds, the existing 2 methodology has reached latency in 72.8 seconds and the proposed methodology has reached latency in 68.2 seconds. When comparing the latency of the proposed methodology with the existing two methods, the proposed methodology is better. In percentage, the proposed methodology is 10 percent better than existing 1 methodology and 4 percent better than existing 2 methodology.

**THROUGHPUT**

The Throughput in network refers to the average data rate of thriving data or message delivery over exact communications link and the Network throughput is measured in bits per second (bps).

$$\textbf{Throughput} = \frac{\text{TCP Maximum Receive Window Size}}{\text{RTT}} \text{------}\textbf{Eq. 2}$$

TCP = Transmission Control Protocol, RTT = Round Trip Time. When the transmission is completed without packet loss, this calculation is considered. Table 2 and Figure 5 illustrates that the proposed methodology's average different nodes based transmission performs well and better than the two existing methodologies in the Throughput comparison matrices.

**Table 2: Average Throughput Comparison between Proposed and Existing Methodologies**

| **Parameters** | | **Throughput (Kbit/s)** | |
|---|---|---|---|
| **Number of Nodes** | **Existing 1** | **Existing 2** | **Proposed** |
| **10 Nodes** | 124.1212 | 128 | 113.7778 |
| **15 Nodes** | 118.1538 | 122.88 | 128 |
| **20 Nodes** | 111.7091 | 120.4706 | 128 |
| **30 Nodes** | 104.4898 | 107.7895 | 115.0562 |
| **50 Nodes** | 106.6667 | 112.5275 | 119.7661 |

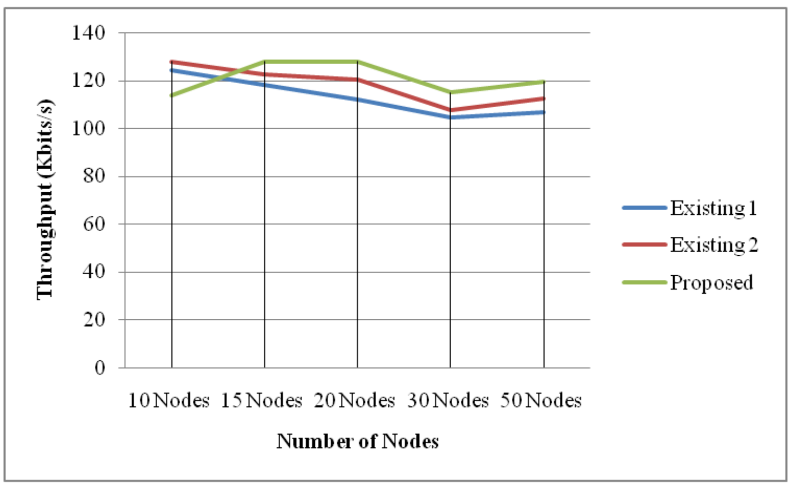


**Figure 5: Average Throughput Comparison between Proposed and Existing Methodologies**

In throughput parameter, the existing 1 methodology has reached throughput as 113.02 kilobits per second, the existing 2 methodology has reached latency in 118.33 kilobits per second and the proposed methodology has reached latency in 120.92 Kilobit per seconds. When comparing the throughput of the proposed methodology with the existing two methods, the proposed methodology is better. In percentage, the proposed methodology is 6.5 percent better than existing 1 methodology and 2 percent better than existing 2 methodology.

**Features Comparison**

The proposed methodologies features are also compared and shown in the table 3 with the two existing methodologies that were already explained in the beginning of this paper.

**Table: 3 Feature Comparison between MP-HMS and Existing Methodologies**

| **Sl. No.** | **Features** | **E-HMS** | **RWHMS** | **MP-HMS** |
|---|---|---|---|---|
| **01** | Storing Record in Cloud | *Not Available* | *Not Available* | *Available* |
| **02** | Continuous Monitoring | *Not Available* | *Available* | *Available* |

| | | | | |
|---|---|---|---|---|
| 03 | Using Digital Record | *Not Available* | *Available* | *Available* |
| 04 | In-Transit Monitoring | *Not Available* | *Not Available* | *Available* |
| 05 | Data Security for Medical Record | *Not Available* | *Available* | *Available* |
| 06 | Accessing Medical Data from Outside | *Not Available* | *Not Available* | *Available* |

## V. CONCLUSION

Wireless Sensor Network is evolving each day and many different applications are started to adopt and use it. The applications purposes may be different but the ultimate goal to use the WSN will be the same. Based on the user's requirements, needs and wants, WSN will change its usage with the same concepts in different styles. It shows that the WSN can able to adopt and use in different fields and sectors. As per the tested scenario outputs, the developed method is performed improved than the existing two methods. The objective of the research work also achieved by framing the framework model for health care monitoring system and that framework was designed and tested in the NS2 to verify the possibility and efficiency of the proposed framework.

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