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Research paper

Centralized framework for elegant hospital mechanization

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Abstract

There is a massive demand for medical treatment and services throughout the globe which motivates to give an automated service for the people with less time delay and enhanced mechanization process. The framework is dedicated to the hospital administration at the operational level. This model is intended to screen the day by day living of the occupant, identify the possible inconveniences and mischance, corresponds with family, specialists and emergency services. Elegant hospital mechanization (EHM) framework utilizes sensor networks to provide automation in the hospital. The sensors are smaller, cheaper and intelligent connected with the communication network allowing them to monitor and control inside the hospital. This model is a measured methodology keeping in mind the end goal to successfully portray the activities and the exercises of the entire system. The system provides automation in the hospital and hence makes the individual comfortable.

Keywords: *Network; Sensors; Hospital Mechanization; Nodes; and Automation.*

1. Introduction

Hospital mechanization is a component of well being informatics that concentrates fundamentally on the administrative needs of healing centers. In numerous usages, healing centre automation is a complete, incorporated data framework intended to deal with every aspects of a clinic's operation, for example, administrative, medical, budgetary, and lawful issues and the corresponding handling of services. The health recovery in hospital is a distinct option for the conventional hospital to advance the early release and to help patients and elderly individuals to live self-governing. The general population life expectancy is anticipated to increment in the following decades. Consequently, it is important to enhance independence and the autonomy of old or handicapped individuals. The innovations in Healthcare at Hospital are new distinct options for the doctor's to facilitate and secure the life to elderly or weak individuals. Accordingly, scientists are at present exploring about novel methodologies that can empower the application to the healing center [1]. The hospital facility administration at the strategic level manages medium time choices concerning the dimensioning and allotting assets, for example, specialists, nurses, therapeutic facilities; obtaining approvals to deliver care. To this point we consider a smart hospital. The structure is designed to monitor the day by day living of a patient [2-3].

The research shows that advanced healthcare standards may extraordinarily lessen the dangers of conventional healthcare as well as brings down the uneasiness of caregivers, also lessening the cost at the hospitals. This framework was introduced to address the requirement for another era of pervasive medicinal services that permits early identification of deteriorating health by providing proper infrastructural facilities over time. By the incorporation of miniature, minimal cost, low-interruption sensors with the framework provides a constant monitoring and analysis which leads to prompt improved medicinal diagnosis and better patient personal satisfaction [4].

In hospitals the mechanization is a critical part but most of the hospitals are costly. The scheduling of doctors, rooms and resources plays a critical part towards accomplishing their objectives, such as: a coordinated approach in hospital mechanism and to implement strategies that provide improved patients care by allocating the doctor, also monitoring the number of patients entering, sending alarm during emergency, measures the temperature and controls the drug delivery system [5]. This in turn gives the patients' satisfaction by reducing waiting time and enhancing productivity by reducing costs.

This paper exhibits the approach and advancements utilized as a part of the mechanization process at the hospital. Specifically, an EHM model offers a few critical focal points with respect to the other discrete framework models. In segment 2 the system architecture is clarified. The proposed system is discussed in Section 3 moreover benefits of automation in Section 4 along with results and discussion and conclusion in Section 5 and 6.

2. System architecture

In this section the system architecture helps to take the real time decisions of EHM framework with sensor network. More exactly, the data from the sensors is analyzed and based on the events the message is send to the emergency services, the family and doctors this is as shown in Figure 1.

The EHM device can perform and execute certain operations such as:

- Observation
- Alarms signals can be send
- Patient interaction
- Crises calls

- Reaching family and specialist
- Establishing contact between call center and patient when he requests help physically
- Interacting with the hospital mechanization system of the patient.
- Alarming during fire outbreak

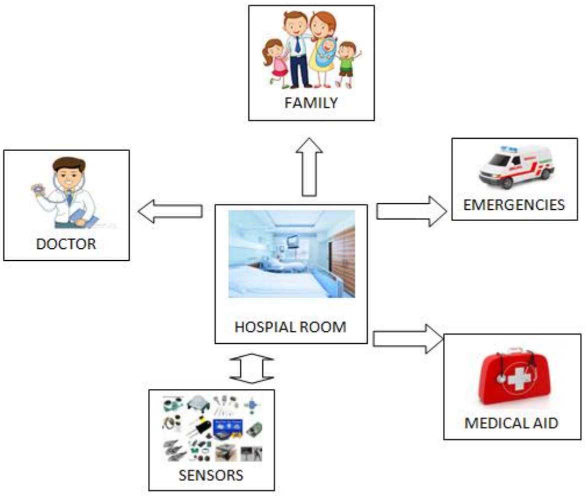

Fig. 1: System Architecture of EHM.

In addition, the framework interacts with all the devices and takes the input from the sensors and performs the operation like initiating the actuators, alarms and alerting the caretakers to serve the patients [6].

3. Benefits of automation

The six major benefits that can be acknowledged by applying mechanization in the hospital are:

3.1. Saving of labors

Utilizing mechanization to supplant physically concentrated assignments that are better done by machine can be a huge time saver. It doesn't need to take out workers, yet rather lift them into higher-working roles that make use of the hospital expertise for which they have been prepared for.

3.2. Enhanced consistency and quality

Automation devices are not subject to human mistake or weakness, so they can give a steady premise of care exercises. In hospitals it is found that more automation helps in maintaining records, order entry and seemed to bring about a lessening in deaths, difficulties and cost.

3.3. Waste reduction

Utilization of paper and spreadsheets and different workarounds required for an overfull workload can prompt a considerable measure of waste. For instance, rather than having a phone tag with a patient who is discharged with hospital, the automation can help to establish a connectivity more frequently thus can reduce the waste.

3.4. Expanded outcome predictability

At the point when patients take after an standardized care way supported via mechanization, it is more probable they will keep focused towards anticipated results. Furthermore, mechanization can distinguish when a patient has deviated from the suggested care plan so the care group can intervene.

3.5. Throughput is higher

The nurse supported via mechanization apparatuses can deal with a bigger population of patients at a single time. Rather than scaling all over your headcount as patient volumes develop and contract, a mechanized platform can scale flexibly to address gatherings of all sizes.

3.6. Information driven insights

Innovation used to mechanize processes can likewise convey an abundance of information in a continuous feedback loop that can be utilized for performance improvement and optimization. With each cycle, mechanization frameworks can gather information on how the process is functioning and utilize that data to enhance the program. It enhances itself after some time, turning out to be much more effective, more exact and more accommodating to the group's workload.

4. Related work

Gustavo H. P. Florentino et al [7] proposed RFID based system for hospital automation, they incorporated RFID tags to track the patients and somehow achieved the automation but the data collection about the patient status was not dealt in that work, the centralization of the data and the processing were not mentioned in the paper. The completely different approach followed by Uğur Kantekin et al in [8], they relayed on brain waves processing of the patients to send the messages to the control systems as the part of automation but the practical feasibility of their system was not included in the paper. The power automation system in the hospitals using live gesture recognition was proposed by Amit Bhat et al in [9] the depend on the comparison technique of pre existing gestures with the new gestures for hospital power automation, they focused on the limited area of scope than what we are proposing. Christoph Niemann and Torsten Eymann in [10] developed a hybrid human and computer decision support systems for scheduling in the hospitals which has the limited scope. Optimized Network topology and sensor count as the important factors of the system, as Nordio et al in [11] computed the optimal communication rate achieved by the nodes which are operated in the half duplex mode, the incorporation of the similar concept in the proposed system enhances the efficiency with respect to the network issues.

5. Proposed system

The EHM framework guarantees information precision, automation, temperature maintenance and proper allocation of resources with the help of sensor network.

5.1. Arduino microcontroller ATmega 328

The ATmega328 is a solitary chip micro-controller; it is utilized to get the physical conditions through the sensor associated with it. It controls all the operations inside the hospital like checking the temperature, sending cautions when there is a fire, helps in keeping up temperature by switching on the device so that the drugs are safe and keeping a count on number to patients entering the hospital and vice-versa, It also triggers the alarming system when there is possible fire outbreak by collecting the data from the sensors through wireless communication mode.

5.2. Sensor

Here the sensors are disseminated in the system. It measures environmental or physical conditions, for example, temperature, radiations, light and so on and send their information to the proposed system where further processing of the information will be handled.
The sensors used in the system are:

- LM 35 temperature sensor
- PIR sensor and
- IR sensors

5.2.1. LM 35 temperature and humidity sensor

The LM 35 is an integrated circuit sensor used to gauge temperature runs from - 55 to 150 degree Celsius and the input current to the sensor is 60uA. This sensor is utilized to control the temperature in the hospital, when the temperature is more than 35̊C. Then the information is received and processed by the Arduino microcontroller (ATmega 328) which in turn makes the cooling device on to keep up the temperature.
LM 35 with Linear voltage temperature relationship, it's output Voltage

$$V_o = T\,(0.01) \quad (1)$$

Where T is the Temperature in ^oC

5.2.2. PIR sensor

A passive infrared sensor (PIR sensor) measures infrared light radiations. It is used in the doctor's room to detect whether the doctor is available or not. When the PIR sensor senses the presence of the doctor then that data is processed by the microcontroller and then the LED light will glow in order to ascertain the patients when they are in need. The detection range of PIR sensor is 6 meters.

5.2.3. IR sensor

The sensor sends the infra red light through IR-LEDs, which is then reflected by the general population entering the hospital and is sensed by the sensor. Then the reflected IR light is used to find the count of the number of people who had entered/left the hospital in a stipulated interval. This activity will be useful for the hospital management to track and restrict the number of visitors in case of highly infected patient.

5.2.4. Blood pressure sensor

This sensor is required for the critical patients were sensing of the Blood pressure at continuous intervals helps them to recover soon based on the treatment given, considering those factors the system was incorporated with this sensor, the sensor works through the mathematical analysis by calculating Mean arterial pressure (MAP), it is the average over the cardiac cycle and is determined by the Cardiac output (CO), System Vascular resistance (SVR) and Central Venous pressure (CVP) [13].

$$\text{MAP} = (\text{CO}.\text{SVR}) + \text{CVP} \quad (2)$$

Ignoring CVP in practical scenarios

$$\text{MAP} = \text{CO}.\text{SVR} \quad (3)$$

MAP can be identified by Systolic Pressure (P_{sys}) and Diastolic Pressure (P_{dias})

$$\text{MAP} \cong \text{Pdias} + 1/3(\text{Psys} - \text{Pdias}) \quad (4)$$

The total pulse pressure measured as $\text{Ppulse} = (\text{Psys} - \text{Pdias})$ (5)

5.3. Buzzer

Buzzer is used only when the amount of temperature is high and is detected by the temperature sensor and the data is processed by the microcontroller which in turn triggers the Alarm system in the hospital. This feature will alert the hospital authorities in many emergency cases like patient severe condition, fire outbreak etc.

5.4. Block diagram

The centralized module as the proposing system for hospital mechanization which covers and monitors various aspects like temperature range of the room, the availability of doctor, and the number of people visiting the hospital. The module is built with the help of temperature sensor, PIR sensor, IR sensor and it also alerts during emergencies with a SMS using the message gateway with the help of the GSM module. The Elegant hospital mechanization framework block diagram is as shown in the above Figure 2. The controller based system determined as the node which is interfaced with several sensors and actuators serving our purpose of automation, the sensors establish communication with the node using advanced wireless communication protocols, and every node performs multi user processing for better vicinity of its operations. Large amount of similar nodes will be required for the execution in bigger hospitals, and each node will be communicating with others through wireless means for the purpose data centralization and tracking. In this paper the optimistic approach of Network design using the nodes was discussed and the performance analysis was measured to ascertain the efficient count of nodes required for a certain area of the hospital. Apart from these set of nodes a centralized hub as the primary component of this system receives the emergency alerts and takes action accordingly in the case of emergencies. Every node covers certain area and receives the parameter information from the limited patients through the sensors installed.

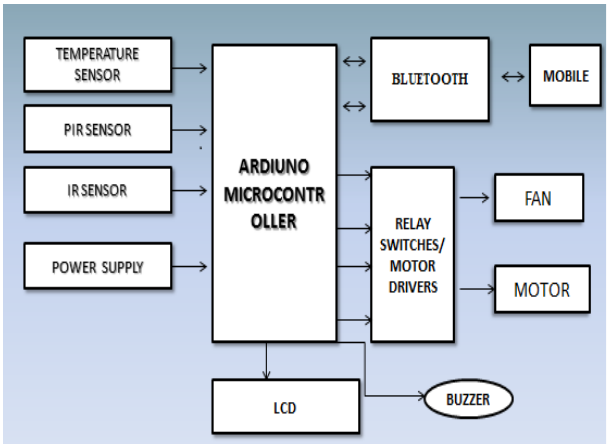

Fig. 2: Block Diagram of EHM.

5.5. Flow chart

The flow chart shown in Figure 3 explains how the elegant hospital mechanization framework works with the help of sensor network and micro-controller inside the hospital. The flow chart explains only the case of measuring ambience temperature and IR sensing within a room ambience in the hospital. Room parameters like moisture, temperature, availability of the doctor and so on were measured in this system along with patient's parameters as the part of hospital automation. The data from the individual sensors were received at regular intervals based on the threshold conditions, for example when the measured room temperature crosses 35 ^{o} C the proposed system triggers a fan through initiating its actuators. The doctor's availability in the cabin will be ascertained through PIR sensor based on the infrared mechanism, the system notifies the doctor's availability using LED blinking from the data collected by the PIR sensor. Similarly the IR sensor leads to count the number visitors, though the sensors were propagating their data to the nodes through wireless means the complete automation and actuator initiation was performed by the code executing within the controller. The controller is capable to handle certain number of tasks like data processing, actuator initiation and alerting the hospital authorities during emergencies.

5.6. Programming the controller

Boot loading as the primary step to setup the system, which establishes the communication between Arduino board and the microcontroller, fixing of all the necessary components according to the requirement followed by Aurduino board connection with the computer for further programming. With the aid of C language all the functionalities according to the requirement were framed and executed, even python and java can serve our purpose of programming the controller. Several aspects of controller like number of inputs, outputs, PWM pins, interrupts, timers, clock frequency, USB ports, serial communication and memory aspects were also considering while programming the controller. The sample radio link establishment code as the part of the proposal shown below which initiates communication between two nodes through "NRF24L01" components, discussion on "NRF24L01" will be viewed in the later chapters.

```
void setup(){ radio.begin();
radio.openWriting Pipe(address);
radio.setPALevel(RF24_PA_MIN);
radio.stopListening();
}
```

5.7. Motor involved

The DC servo motor for the various actuator applications is the choice of execution for achieving high speed, the interfacing of the Microcontroller with the Motor to be implemented by considering the various specifications of the Motor. The DC servomotor actuates the necessary components like fire extinguishers and fans in the case of emergency as the part of the project which is interfaced with controller and initiated through the set of instructions like "#include <Servo.h>", figure 4 shows the schematic of the DC servo motor which is incorporated with armature circuit and mechanical load, the complete technical details of the Servo will be out of this box.

Even the regular DC motors are interfaced to the controller via H-bridge which drives the motor in both the directions, the pulse width modulated signal with varying duty cycles controls the speed of the motor, the handling of these tasks were performed by instructions like pinMode(pwm, OUTPUT) and digitalWrite(),the schematic of the regular DC interface with controller depicted in figure 5.

The motor rotation based on the sensed data from a temperature sensor or from moisture sensor initiates fire extinguisher when the sensed value reaches a threshold especially to protect from the fire, this representing as one the safety mechanism in the proposed system.

5.8. Network

The node to node communication as the important factor of the system through wireless means was achieved by NRF24L01 transceiver module, it uses 2.4 GHz band and operates from 250 kbps to 2 Mbps covers at the range up to 100 meters when operated in lower baud rates, the module use 125 channels and each channel with 6 addresses means one unit can communicate with six at the same time, the channel distribution was shown in the figure 6.

The paper also aims to deal with the achieving of the high performance based on the number of sensors deployed and the number of this type of nodes deployed over a certain area for optimum communication which ultimately satisfies the objective of effective hospital mechanization.

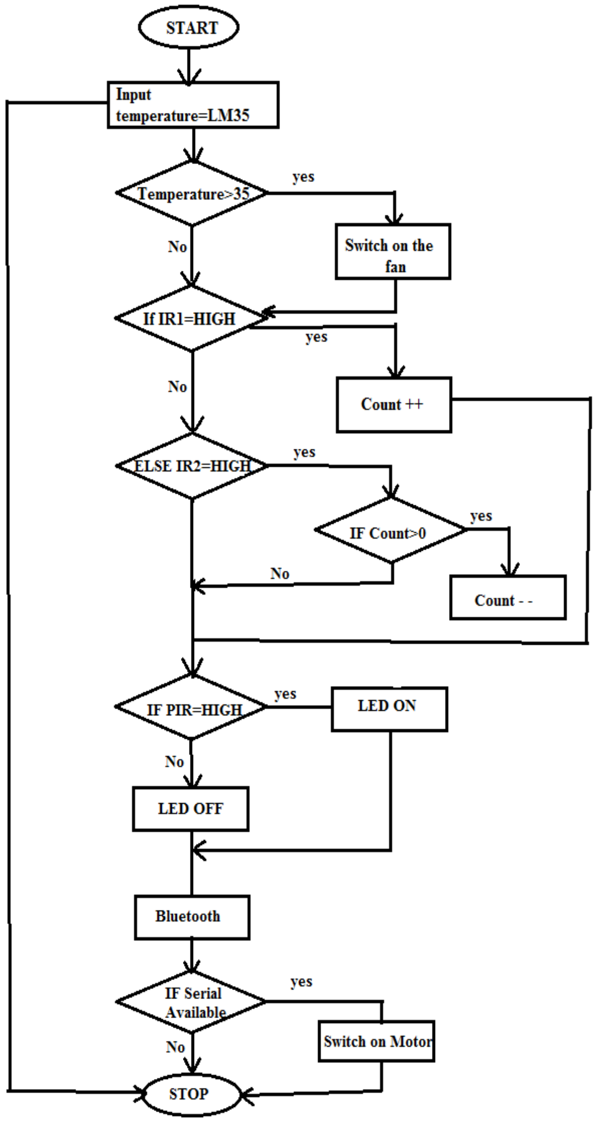

Fig. 3: Flow Chart for the Hospital Mechanization.

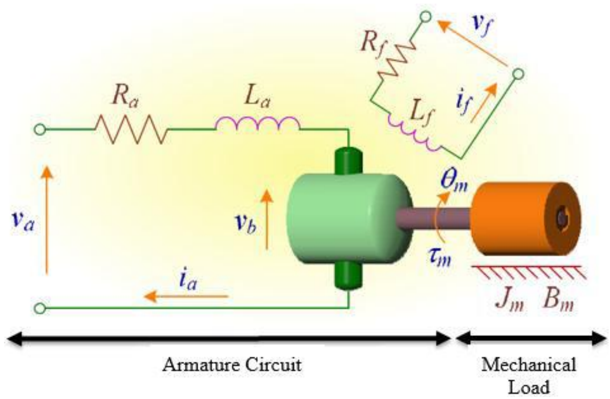

Fig. 4: DC Servo Motor Interfacing [11].

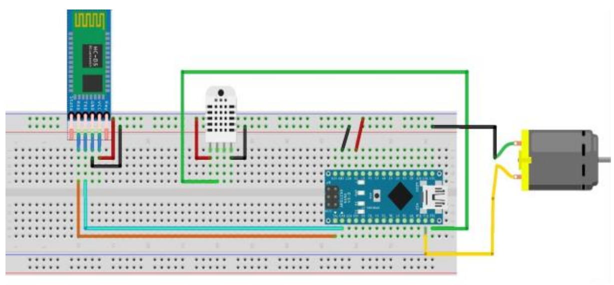

Fig. 5: Schematic.

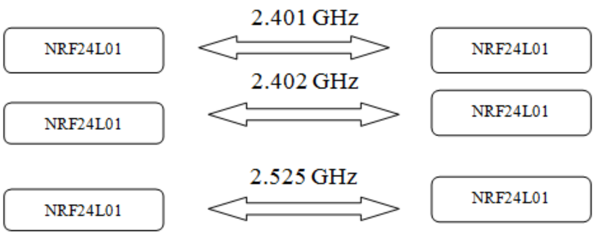

Fig. 6: Channel Distribution.

The analysis in the NS2 Simulator provides the better outcomes to design effective Network topology both in sensor and Node level. For the optimized system of Hospital mechanization the number of nodes required were analyzed using the Network Simulator, the experiment was done considering two cases, in the case one 20 nodes of similar type were deployed and in the case two 10 nodes were deployed, several parameters like packet delay and Through put were measured.

The results were showing that the network with less nodes is highly efficient than with more number nodes, but the limited amount of nodes in the network will not satisfy the requirement of mechanization and automation to much extent if the area to be coverage is more.

Considering these factors our system was design for better quality of service with optimum throughput and less delay. So the analysis was made considering the hospital of area of 2000sqft and deployed around 20 nodes as shown in the figure 7, the parameters like throughput and delay were measured for this case.

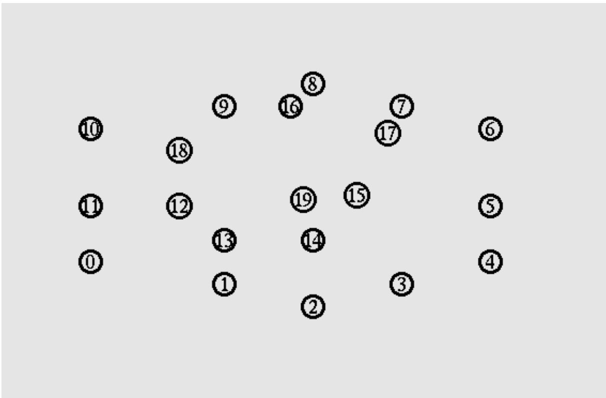

Fig. 7: Deployment of 20 Nodes.

In the case two we deployed only 8 nodes to check and compare the performance of the system within the stipulated area of 2000sqft. All these nodes are communicating each other to perform the action of automation in the hospital, usually there will be many sensors associated to a patient and 'n' number of sensor will be associated to our system to measure and monitor different types of parameters like temperature, pulse, humidity and etc., continuously from the patients. All these systems (nodes) were communicated each other to serve the entire hospital, as the part finding the optimized solution for the network design we made this analysis, the below figure 8 shows the deployment of 8 nodes for efficient communication.

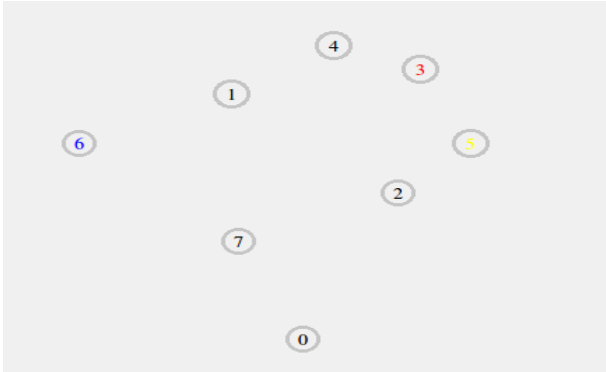

Fig. 8: Deployment of 8 Nodes.

All these simulations were done using Network Simulator (NS 2) and the parameter comparison discussed in the results chapter. In the above diagrams each node represents the system which we are proposing, they were deployed over certain area to measure the performance. Based on the values collected the deployment of 8 nodes will be optimistic in terms performance rather than deploying 20 nodes within the same stipulated area.

6. Results and discussion

The hardware part of the mechanization framework is shown in figure 9, which consist of various sensors, LCD, microcontroller ATmega328, Bluetooth, Alarm etc.

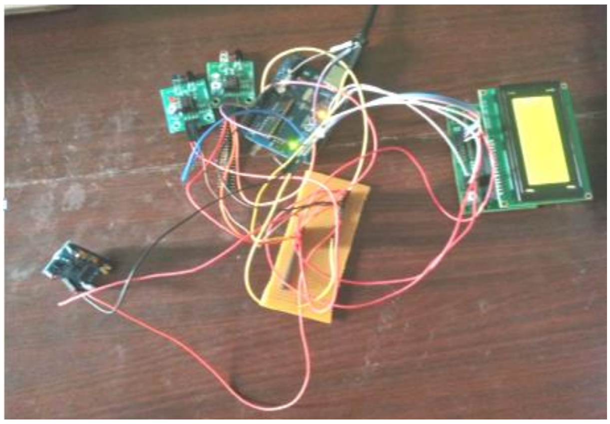

Fig. 9: The Complete Mechanization Framework.

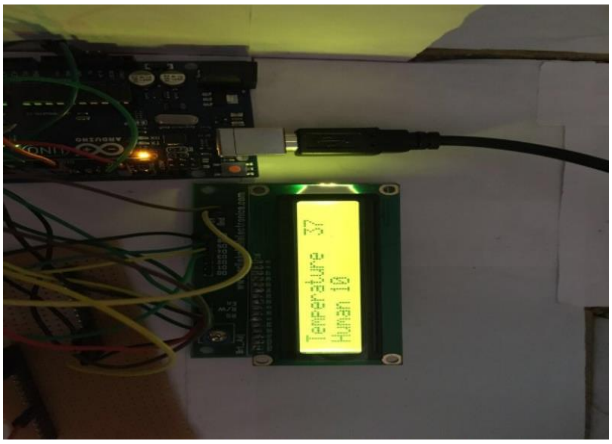

Fig. 10: Temperature Measured by LM 35.

Temperature measured by the LM 35 and number of patient present in hospital is measured by IR sensor this information are processed by the Arduino microcontroller (ATmega 328) is displayed on LCD as shown in Figure 10. When the temperature is more than 35 ^{o}C then that information is processed which in turn makes the cooling device on to keep down the temperature.

The working model along with the parameter analysis presented for the proposed system, few parameters like Temperature and Humidity were continuously monitored for a patient, and their readings were projected through mobile application blynk console as shown in figure 11.

Fig. 11: Blynk Console which Displays Humidity and Temperature Values.

The parameters always limited to a threshold value, once any parameter is crossing threshold for any patient or for the room ambience, immediately the system will trigger an alarming situation by activating all the necessary actuators to alert the hospital staff or safety equipments, the safety system active status indicated through LED on alert as shown in figure 12–a, otherwise the alert system will be off as shown in 12-b

Fig. 12: Safety System Active Indication (A-On, B-Off).

The system is also giving the provision for fire safety mechanism to aid the patients during the fire with the deployment of moisture sensors. Moisture sensors were deployed in the hospital rooms as the part of mechanization, these sensors are reading the moisture levels of the room at regular intervals of the time, when the moisture levels drop than the threshold point it indicates the threat for possible fire break which eventually triggers the safety system and alerts the Hospital staff. The moisture measurement console in the figure 13 depicts the values from two sensors collected simultaneously

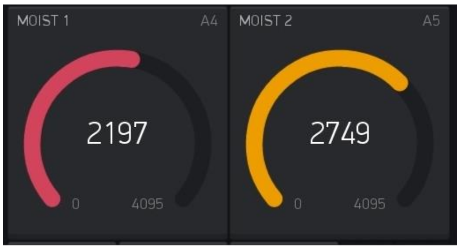

Fig. 13: Moisture Values.

The other feature of the system includes measuring of the patient's body temperature at regular intervals of time as shown in the figure 14. The readings indicate the body temperature of a patient at every second, which will be compared with the threshold value at every possible time interval by the system.

Fig. 14: Patient's Temperature Measurement.

The entire hospital mechanization which is deployed with many sensors like Temperature, Pulse, Humidity and Moisture interfaced with motors and Actuators through the controller is the primary gist of the paper, the entire working model results were drawn using Mobile application console, and the data corresponding to the every measured value were analyzed and stored to trigger the safety mechanism especially during the catastrophic conditions. The consolidated data analysis of all the parameters which are to be tested were measured with respect to time and compared with the individual threshold values.

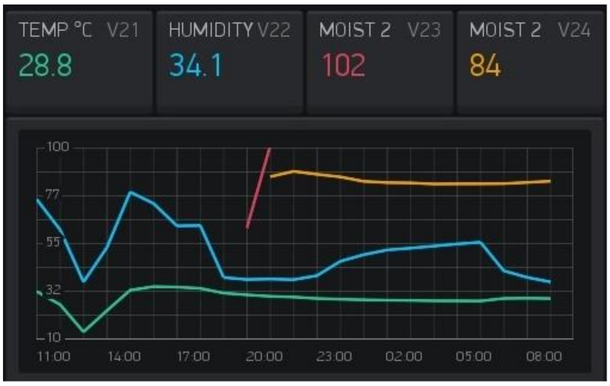

Fig. 15: Parameters from Various Sensors.

The figure 15 depicts the measuring of different parameters from different sensors as the part of Hospital mechanization, these readings were noted over the period of time to ensure the installation of autonomous nature for hospital mechanization through the proposed technology system.

6.1. Performance analysis

The network performance is also major concern, so the following conclusions were made based on the simulations made. Analysis was made to ascertain the Throughput and delay. Throughput defines how a single node can able to communicate effectively with more number of nodes, this parameter influences the complete system performance as the part of data integrity and the Delay always relates to the speed of the system, both these parameters plays vital role in the system performance, the following results were made by measuring the delay and throughput for the network with 20 nodes and 8 nodes.

It is observed from the figure 16 that the Network with 8 nodes has throughput value is around 73 kbps and for the 20 nodes Network the value is around 71.8 kbps, this show the finest value of the Throughput can be achieved by using Network of 8 nodes, still the lesser node network of five is projecting better values but the coverage issues will be there, so the network with 8 nodes was chosen for better implementation.

Next comes the delay between the nodes regarding the data transfer, even the delay will be more if they are more number of nodes in a Network than Network with less nodes, as shown in the figure 17.

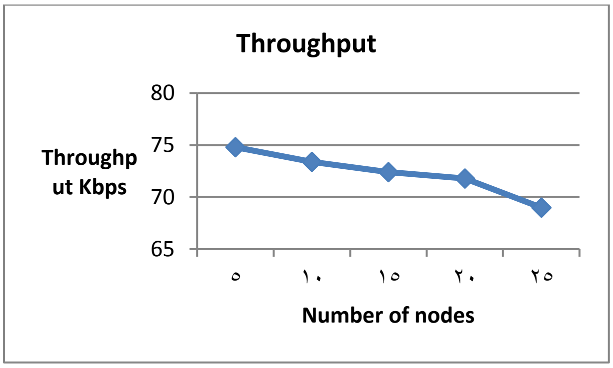

Fig. 16: Throughput Comparison.

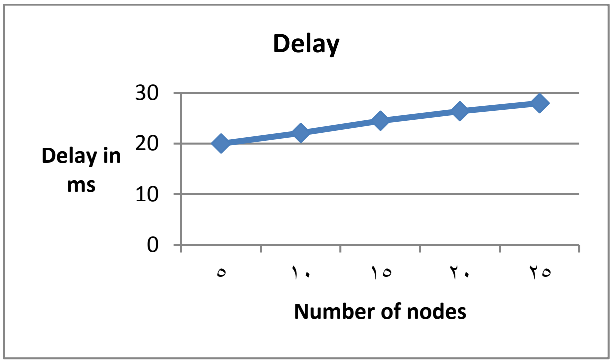

Fig. 17: Delay Comparison.

It is observed from the above graph that the delay to send the data between the nodes increased with 20 node network and decreased with 8 node network. The delay value for 8 nodes network measured as 22 ms and 25ms for the 20 node network.

7. Conclusion

This paper shows the mechanization of the hospital with various sensors and communication setup to build a completely standalone framework in the hospital. Elegant hospital mechanization (EHM) is a smart hospital which monitors and controls the mechanism inside the hospital. It is a cost and time effective technique to give enhanced patient care. It additionally helps in convenient delivery of recommended medications to the specific patients. Since the framework is made user friendly hence enhance the quality of life for the individuals. Future works can be to monitor and record the patient's information and transfer the data with security to the end user using cloud interfacing.

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