

An Analysis on WSN and IOT Based Deployment in Smart Home Automation System

S. Sowmiya¹ S. Sivakumar²

¹Research Scholar ²Assistant Professor

^{1,2}Department of Computer Science

^{1,2}Thanthai Hans Roever College (Autonomous), Perambalur- 621220, India

Abstract— The real-time knowledge of the location of the personnel, assets, and portable instruments can greatly enhance home automation control efficiency. Location estimation is the process of obtaining location information of a node with respect to a set of known reference positions. The research involved in the design and deployment of WSN in home automation applications has been briefly described. WSN has been designed by using Digi wireless sensor nodes to carryout home automation task and using wireless sensor nodes to facilitate in-home healthcare function. The tasks associated with configuring WSN node, managing data acquisition, analyzing the collected data, and presenting the resultant data have were presented. Using IoT with Wireless Home Automation system is a method which control home functions and features automatically through computers or mobile devices. Study of Internet of things (IoT) has become the motivation for years with the enlargement of human-computer interaction skill and development of people's living standards. Smart home framework has drawn increasingly more consideration in IoT. This research is based on wireless sensor network and IoT for home automation which explores the architecture of home automation system with advantages. **Keywords:** WSN, Automation System, Internet of Things (IoT), Smart Home

I. INTRODUCTION

Wireless Sensor Network (WSN) is a remote system which comprises of conveyed and self-governing gadgets those utilization sensors to screen natural or physical conditions. WSN framework is planned by consolidating hubs or, independent gadgets with a gateway plus router. The nodes communicate wirelessly to a central gateway, which provides a connection to the wired world where you can collect, process, analyze, and present your measurement data. You can use routers. To gain a communication link between end nodes we can use routers and for extend distance and reliability in a wireless sensor network we can use gateway. The wireless sensor is arranged increasingly adaptable and requires almost no power. It is additionally savvy and furthermore achieved quick information procurement, solid and exact over the long haul, however costs little to buy and introduce, and requires about zero support. The Internet has completely changed human by giving whenever, anyplace network with anybody. The same number of headways in innovation has gone to the sensors, processors; transmitters, recipients, and so on are currently accessible in exceptionally shabby rate.

Hence these all things can be used in our day to day life [1]. If anyone wants to expand the services of internet then Internet of Things can be said as the expansion of internet services [2]. The present web is currently extending towards the Internet of Things (IoT). The main objective of

this paper is to design and deploy WSN for home automation system. The study presented in the thesis, enumerates the design and development of WSN hardware and software for the intended applications. It deals with monitoring and controlling ambient temperature, humidity, and other parameters by using sensors located in a domestic place to facilitate home automation.

If we apply both Internet of Things (IoT) and wireless network in the similar system, it creates the system more practical importance by winning advantages of the flexible control of IoT and the suitability and consistency of wireless network for lighting, curtain, door locker and other stationary applications [3].

II. WIRELESS SENSOR NETWORK (WSN)

A WSN consists of distributed wireless sensor nodes to monitor and manage physical or environmental conditions. A wireless sensor node is a battery driven radio microcontroller with sensors and actuators interfaced to it as shown in following figure,

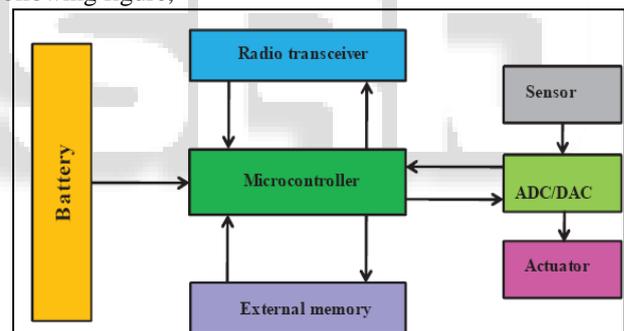


Fig. 1: Wireless sensor node

The wireless sensor node operates in three modes namely transmit/receive, process and sleep. The node consumes more power during transmission and reception. In sleep mode, it consumes minimum amount of power since it is idle. In process mode the node wakes up and processes the data acquired. In process mode the WSN node operates either in normal mode or event detection mode. In normal mode of operation the node samples the intended parameters once in a specified time interval and transmits the same to the destination. In event detection mode, the node wakes up by detecting an event. The node then senses the data and transmits the same [4]. The node transits to sleep mode when it becomes idle to extend its battery life. These nodes combine with routers and a gateway forms a typical WSN system as illustrated in below figure,

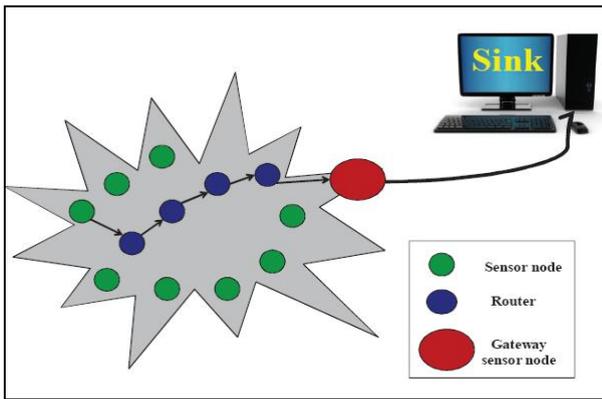


Fig. 2: Typical WSN

A. Factors that Influence WSN Design and Deployment

A WSN is influenced by many factors [5]; they are listed in following table,

S.No	Factors that Influence WSN	Description
1	Reliability	Environmental interference, sensor breakdown or depletion of batteries can cause the sensor node to fail.
2	Scalability	The number of sensor nodes deployed in sensing may be in the order of tens and increases to hundreds depending on the application.
3	Network topology	Sensor nodes are deployed either in a dense manner or sparse manner. In dense deployment the sensor nodes are disbursed from a flight whereas in sparse deployment nodes are fixed manually.
4	Power consumption	Sensor node lifetime is dependent on battery life. The wireless sensor nodes are equipped only with a limited battery power source.

B. WSN in Home Automation System

WSN has the potential for enormous impact on many aspects of home automation and in-home healthcare applications. WSN is a group of spatially distributed autonomous sensor nodes. A wireless sensor node is a battery driven radio microcontroller with sensors/actuators which uses ZigBee and IEEE 802.15.4 standards for its communication [6].

The distributed WSN nodes communicate wirelessly to a central gateway, which provides a connection to the wired world where data is collected, analyzed and presented [7]. Among all the wireless contestants WSN is more ideal for home automation and healthcare applications for the following reasons,

- The nodes transmit data intermittently in short frames
- The nodes can be easily tagged with persons that permits mobility
- The sensor nodes consume low power which enhances battery life
- The nodes can be added or removed without any reconfiguration
- The sensor nodes are cost effective

The WBAN is a subset of WSN that consists of a network of sensors placed or implanted on a person [8]. The base station collects physiological data from the biomedical sensors placed on the patient body and transmits it to the health care provider. The hospital server stores the data into the patient database for long term analysis and illness prediction. The base station can perform data analysis and detect abnormalities of physiological condition immediately.

III. CONCEPT OF INTERNET OF THINGS: IOT

The Internet of Things (IoT) is a climate in which items, creatures or individuals make accessible with unmistakable identifiers and the capacity to exchange information through a system without expecting human-to-human or human-to-PC communication. 'Web of Things' characterizes various abilities and research trains that enable the Internet to venture into this present reality of physical articles. Innovations like short-go remote interchanges, RFID, specially appointed and remote sensor systems (WSNs) which is the piece of the Internet of Things (IoT). Items will be very much designated with some correspondence capacities, which will be mistreated to deal with their activity. A typical precedent is books in a library, which having the one of a kind RFID labels, in light of the fact that each book precisely situated by a WSN framework orchestrated in the library. This information then served to search engine which is running on a computer sited within the library or even outside. This pattern can be easily prolonged to our houses or offices to acquire the physical location of objects within buildings through a WSN infrastructure connecting the physical world to the Internet domain [9].

There are numerous points of interest of fusing IoT into our lives, which can encourage people, organizations, and society once a day. The role of IoT can also be as a tool that can protect people money within their homes. In the event that the home apparatuses are competent to impart, they can work in a vitality productive strategy. In this way, the IoT can bolster individuals with their day by day designs [10].

IV. METHODOLOGY

Here, we apply both Internet of Things (IoT) and wireless network in the single structure, it creates the system more practical importance by winning advantages of the flexible control of IoT and the suitability and consistency of wireless network for lighting, curtain, door locker and other stationary applications. The smart home frameworks have been produced to watch the wellbeing of elderly individuals living autonomously without anyone else at home. The keen home framework created is prepared to do at the same time observing the general physical exercises of an occupant and physiological and encompassing elements. It is a multi-demonstrate, inconspicuous, non-intrusive novel detecting framework sent at focal areas in the home condition. The persistent in-home observing can be accomplished with the single neighborhood home passage server PC.

The developed analysis and decision-making algorithm software modules execute in a Windows software working environment [11]. Through the web association, we can get to the health data from a remote area. The below figure shows the functional description of the wellness-based smart home monitoring,

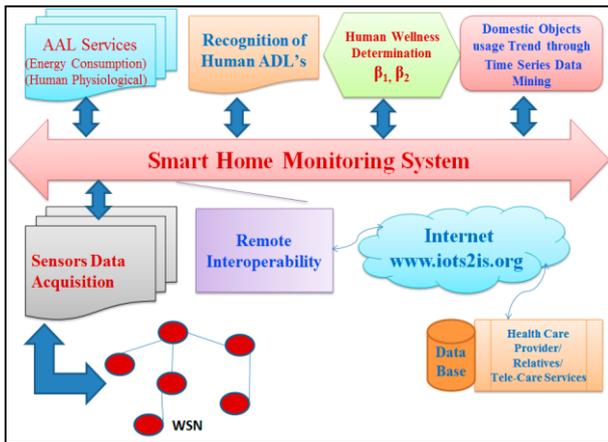


Fig. 3: WSN and IoT based smart home monitoring system

Here, Wellness functions are introduced to provide a mathematical expression and to ascertain the wellness of an individual under the ambient-assisted real-time monitoring environment. The two health capacities β_1 and β_2 characterize the wellbeing of an occupant dependent on the utilization of family unit machines.

The rationale for the wellness functions is to determine “how well” the inhabitant is using daily objects [12]. The principal function β_1 is gotten from the non-utilization and the latent length of the apparatuses. While the second function β_2 is generated from the over-usage of few specific appliances. The health record demonstrates the conduct of the individual concerning the day by day question uses continuously.

A. Proposed System Feature

The proposed framework is a conveyed home mechanization framework, comprises of server, sensors. Server controls and screens the different sensors, and can be effectively arranged to deal with more equipment interface module (sensors). The Intel Galileo improvement board, with implicit WiFi card port to which the card is embedded, goes about as web server. Mechanization Framework can be gotten to from the internet browser of any neighborhood PC in a similar LAN utilizing server IP, or remotely from any PC or portable handheld gadget associated with the web with proper internet browser through server genuine IP (web IP). WiFi innovation is chosen to be the system framework that interfaces server and the sensors. WiFi is chosen to improve system security (by using secure WiFi connection), and to increase system mobility and scalability [13]. The proposed home automation system has the capabilities to control the following components in users home and monitor the following alarms:

- Temperature and humidity
- Motion detection
- Fire and smoke detection
- Light level

The proposed home automation framework can control the accompanying apparatus:

- Lights on/off/dim
- Fan on/off
- On/off different appliance

As the uses of IoT are expanding quickly it is hard to deal with every one of the applications in IoT condition. It turns out issues that how to oversee and control these

different expanding applications. The entire framework couldn't be progressively agreeable, secure if these expanding applications not controlled effectively and helpfully. Security is less on the server side as no exceptional technique for verification is utilized. This could prompt a shaky framework. An aggressor can gain admittance to unfortunate casualties home and he would break the entire Smart home framework. Availability is additionally the issue could happen [14]. It also comes into challenge that how to achieve connectivity at any place any time [14]. Many key challenges have been discussed in the following table,

S.No	Challenges	Description
1	Standards	This is very essential for IoT environment as it is expanding globally. Challenges are comes related which standard should be used, which will provide secure medium, how it will make system more reliable.
2	Identification	Identification is required for each device so that each device can identify uniquely
3	Privacy	The user's data should be confidential. Connection should be done with providing privacy.
4	Authentication	It is must to secure Smart Home system from an attacker. Server has to give access only authentic users.
5	Security	The system should able to take appropriate actions on security threats. And system should be able to reconfigure by itself after attacks.
6	Integration	The main challenge with IoT is to integrate applications in IoT environment.
7	Coordination	Coordination is required between the globally connected objects, humans, programs, process, etc.
8	Data Storage	As applications of IoT are increasing, the amount of data getting collected is huge. The challenge is where to store the huge data.
9	Network Self-Organization	Network structure should be created in such a way that every device connected to it could self-organize them. Actually it is network which should be able to self-organize [15].

Table 2: Key challenges in Home automation system

In smart home system, many sensing unit is utilized. They are listed as follows:

1) Electronics Appliance Monitoring Unit

This power utilization observing and control unit contains transformer and other circuit segments. The transformer block comprises of voltage and current transformers [16].

2) Force Sensing Unit

The sensor is kept under the objects to sleep and sit upon. It displays the deployment of this unit to measure force. This force measurement is linked and analyzed to identify the occupancy pattern. When any pressure is given to the sensor, the resistance of the sensor decreases. As a result, the output voltage increases. The range of resistance varies in the force sensor found in different types of sensors. The pressure is ideally given in the central circular part of the sensor on both sides [17].

3) Contact Sensing Unit for Domestic Objects

For the purpose of domestic objects usage monitoring such as self-grooming table and office desk, it fabricated with wireless contact sensing systems. The fabricated contact sensing unit connected to a grooming table to identify the frequency of usage, and these objects usage are monitored at local home gateway server by ON/OFF values.

4) Temperature Monitoring Unit

To plan temperature detecting unit the LM35 IC is associated with molding circuit for encompassing temperature observing. This scheme utilized to identifies the outdoor and indoor temperature monitoring.

5) Movement Monitoring Unit

The passive infra-red (PIR) movement monitoring unit is designed to detect the motion within the coverage range of the sensing system. This PIR detecting unit is conservative,

control effective, adaptable and strong. These detecting units are otherwise called "IR movement finder". This unit fabricated with movement monitoring unit deployed in the smart home at the door [18].

V. RESULT AND DISCUSSION

The RSSI measurement analysis has been done for ZigBee nodes to know the distance coverage in a home automation application. RSSI value specifies the signal power at receiving end. AT DB command returns the RSSI value of the last received packet. In Digi XBee nodes, RSSI is a negative value in decibel milli watt (dBm) and it is represented by an 8-bit number. The RSSI values between the coordinator and two types of DigiXBee nodes are measured. The plot of RSSI values vs. distance is shown in following figure,

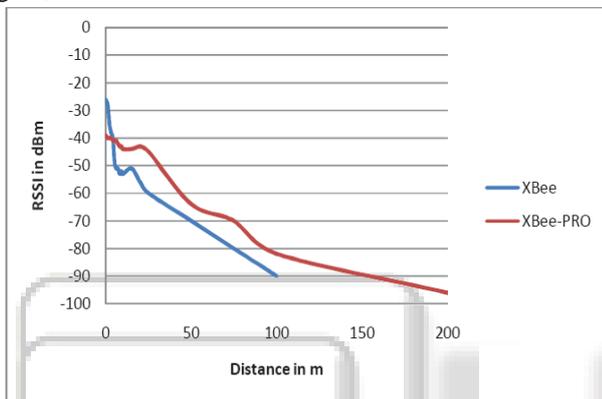


Fig. 4: RSSI values vs Distance

The plot reveals that the Digi XBee RF node effectively transmits and receives up to 100 m whereas the Digi XBee-PRO RF node communicates effectively up to 200 m outdoor. This coverage limit is preferably sufficient for a home automation application. Routers can be added to increase further distance coverage. Digi XBee nodes are relatively cheaper and easily available when compared with Iris motes and Mica motes. Also configuring the DigiXBee node appears very simple. The study depicts that WSN based home automation application is flexible and scalable. With simple modification and less complexity, the application can be extended to monitor and control other parameters like smoke, humidity etc. The system developed is found suitable for home users who wish to monitor as well as control the home ambience either from inside the home or from a remote place.

The RSSI measurement values stored in the file are used to compute the displacement error in order to realize the inaccuracy during estimation of measured coordinates as given in below equation,

$$Error = \sqrt{(X_a - X_m)^2 + (Y_a - Y_m)^2}$$

Where X_a , Y_a are actual coordinates and X_m , Y_m are measured coordinates. The RSSI readings for the present work are tabulated with minimum square error, estimated coordinate and displacement error of iterative trilateration in below Table,

Actual Coordinates		RSSI Values			Minimum Square Error	Estimated Coordinates		Absolute Displacement Error
X_a	Y_a	FN1	FN2	FN3		X_e	Y_e	
0	0	39.0	42.4	44.0	9.44	0	0	0.0
0	1	40.0	42.4	44.2	12.48	0	0	1.0
0	2	40.8	44.6	41.0	13.12	0	3	1.0
0	3	41.0	44.6	40.6	13.80	0	3	0.0
0	4	42.6	45.6	41.4	16.36	0	4	0.0
1	0	40.0	41.8	44.6	15.52	1	0	0.0
1	1	40.6	41.6	44.2	13.84	1	0	1.0
1	2	41.2	42.0	42.6	6.80	1	1	1.0
1	3	42.6	43.4	41.8	9.76	0	2	1.4
1	4	42.6	44.2	41.0	7.0	0	3	1.4

The minimum displacement error value resulted from the analysis is 0 m and the maximum displacement error value is 4.2 m. The program results in average displacement error value around 2.5 m during the measurements. The program execution takes approximately one second time which is acceptable for position tracking applications. Increasing the RSSI measurement more number of times may reduce the error rate at the cost of increasing execution time.

The application developed can be used to determine the physical location of objects/persons at any given time if a WSN node is tagged with them. The real-time knowledge of the location of personnel, assets, and portable instruments can increase home management efficiency. The learning of the area of the hubs is valuable in giving area subordinate administrations and validation process. The same location estimation concept can be extended to three-dimensional space as well at the cost of increase in computation.

VI. CONCLUSION

WSN has been designed by using Digi wireless sensor nodes to carryout home automation task. The tasks associated with configuring WSN node, managing data acquisition, analyzing the collected data, and presenting the resultant data have been discussed. WSN performance is evaluated through simulation for two different network topological scenarios. OPNET modeler 14.5 is used to carry out WSN simulation work. Low cost Digi sensor nodes (XBee and XBee-PRO) have been used in forming WSN for performing simple home automations tasks like ambient parameters measurement and location monitoring. In ambient parameters measurement, the application program has been developed using Digi device object methods in python language. Two different types of algorithms have been devised to monitor and control the ambient parameters inside a home. The home automation using Internet of Things and wireless sensor network work satisfactorily by connecting simple appliances to it and the appliances were successfully controlled remotely through internet. This research describes the concept of WSN, IoT and architecture of Home Automation.

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