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A Literature Survey on Wireless Sensor Network in Home Automation Based on Internet of Things

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***Abstract*—** The hustling lives in today's fast pace era has led to people undergoing stress with less time and more responsibilities. With the emergence of digitization, the above problem is approached with the solution of home automation. Home automation alludes to the controlling of home, which includes home appliances, home environment, home safety, home energy, and other domestic features, remotely or by the means of local networking, and it is gaining popularity at a very rapid rate today as it offers numerous benefits to its users such as time saving, cost saving, decreased stress, better immunity, better self-productivity and self-efficiency. Home automation can be efficiently achieved by the Internet of Things, which is a framework wherein physical objects are interconnected via the Internet to form a dynamic network infrastructure. Due to its synergistic and minimal effort nature, Wireless Sensor Network (WSN) brings noteworthy favourable circumstances over conventional communication techniques utilized as a part of the present IOT framework. This paper presents a detailed study of various smart home systems that are built on the IOT framework using Wireless Sensor Networks (WSNs) wherein the interconnected multiple devices including home appliances and various sensors such as temperature sensor, fire sensor, safety sensors etc., are monitored and controlled through a single or multiple smart device/s such as smart phone, laptop etc. either locally or remotely by the user. The heterogeneity of home automations is indicated in this survey in which various technologies that have been considered are ZigBee protocol, cloud computing, wearable sensors, and android-based and arduino-uno microcontroller based protocols.

***Keywords*—** Home Automation, Internet of Things (IOT), Wireless Sensor Networks (WSNs), Smart Home, ZigBee, Cloud, Arduino

I. INTRODUCTION

As the world grows more and more into an era of digitization, the lifestyles of people are also getting progressive at a matching rate. To cope up with the fast pace of life, the concept of Internet of Things is rapidly advancing and is being applied in various fields, out of which a very crucial one is Home Automation. Home automation is increasingly becoming popular and necessary for various needs such as home assistance, home security, home energy management and many other such aspects, all of which can adequately result in decreasing stress in life, saving time and effort due to the automation of such aforementioned tasks, and increasing self-efficiency and self-productivity by using time saved. Internet of Things can be defined as a dynamic network infrastructure of interconnected physical objects which are embedded with computing devices and the connections are established via the internet. The physical and virtual 'things' in the Internet of Things could be mechanical devices, computing devices, digital machines or even living beings like a person or an animal, which are coherently integrated into the information network and have physical attributes and unique identifiers (or an IP address) that enable them towards interaction and communication among themselves and also with the environment by the exchange of data and information 'sensed' about the surrounding environment, and subsequently reacting autonomously to the surrounding events and influencing them by running processes that trigger actions and create services with or without direct human intervention.

A. Characteristics of Internet Of Things (IOT)

An Internet of Things infrastructure has many characteristics. Some of its characteristics that make it suitable to be a base

for building a home automation system to a great extent are mentioned below.

1) High Scalability

To cope up with the growing number of smart devices being deployed on the Internet, an IOT network needs to be well equipped to handle numerous devices and objects connected to it, which includes both the devices connected directly to the Internet as well as those that are handled by the connected devices. [13] In home automation, the high scalability of IOT results in the incorporation of a large number of devices and sensors used to read and process data, which thereby, results in a large generation of data that can be used to take necessary actions. Since large amount of information facilitates better decision making, an IOT network well enables easy and continuous functioning of a home automation system.

2) Connectivity

Network connectivity is characterised by two things: *(i) Network compatibility*, which can be defined as the ability of the consumption and production of data; and *(ii) Network accessibility*, which is defined as the ability of getting on a network. An IOT network aids both network accessibility and network compatibility. [11] This enables the home automation system to monitor various things for their quality, quantity and various other measures to further take appropriate actions.

3) Heterogeneousness

An IOT infrastructure eases the use of devices that are based on different hardware platforms. [11] This is possible because devices communicate through different networks with other devices running on different service platforms, enabling diverse devices to be working together towards the collection of large, heterogeneous data which exposes much more information about the same surrounding. The resultant data can thus, be acted upon as per requirements to achieve automation on a much larger scale in the house.

4) Dynamic and self-adapting

The devices in an IOT infrastructure change states dynamically. The ever-changing surrounding contexts require the network devices to dynamically adapt and take actions based on the collected and read data, user's context, as well as pre-defined operating conditions. Such a real-time machine-to-machine interaction results in better efficiency implying that accurate results can be obtained fast. This leads to saving valuable time in a home environment.

B. Applications of Internet Of Things (IOT)

1) Pollution Monitoring:

Air and sound quality monitoring and control systems have been generated for the regulation of the amount of pollutants present in a home environment. Such a system senses presence of harmful gases/compounds in the air using air sensors and reports it, and also measures sound level and reports that as well. [16] With the increasing amounts of pollutants in the air and the increasing noise pollutions around us, pollution monitoring helps the users achieve better living standards by facilitating them from breathing in bad air and be surrounded by a noise-free environment which results in the avoidance of unnecessary stress and keeps the users away from many air-borne and other diseases as well.

2) Power management:

IOT based power management systems have been created to monitor the energy and power consumptions of various electrical appliances being used inside the house. Apart from monitoring, these systems have additional abilities of controlling the connected appliances by turning them on/off and sometimes other various simple controls as well depending on each appliance. [1,9] This ensures that none of the appliances are being overused, consume more electricity than they normally should, are running when they should remain turned off, or are creating hazardous events due to unusual power consumption. The overhead of always checking whether the electrical appliances present in the house are turned off before the user leaves the house is somewhat reduced both efficiently and reliably by the use of power management systems in homes.

3) Security and emergency systems:

Efficient home safety and security systems have been developed for the following: (i) detection of any intrusion inside the house without permission or at an unusual time and taking necessary actions like setting off an alarm or notifying the user; (ii) detection of fire in a more than usual or defined parameters and taking actions; (iii) detection of any theft of items or burglary from the house; (iv) detection of damage or breakage of items inside the house that could cause physical harm to the residents. [17] Security and safety systems gives people the freedom to know that the residents of the house are safe and sound. This IOT application diminishes to some extent certain threats to human life that may have been caused due to any of the above mishaps inside the house, and it also makes sure of the security of the properties inside the house as well. Also, by doing so the users potentially end up saving a significant amount of money as well by avoiding any damages that may have been caused to properties and human life due to the absence of such a security system thereby making economic benefit one of the advantages.

4) Health monitoring system:

Health monitoring systems, health management systems and health controlling systems have been created for closely monitoring health of any patients or residents at all times, see for any unusual data or conditions that are out of the bounds of pre-defined health parameters for the concerned person, and recording all the data including data inputted by the users for long term using database system. [18] This facilitates better decision making abilities to doctors visiting due to the provision of a decision support system. For patients of any disease, syndrome or medical condition, the requirement of doctor to visit the patients periodically is reduced, saving significant amount of time and energy. The accuracy and precision of IOT build its reliability and credibility to enable it to be applied in health monitoring systems. Such a system is one of the most important applications of IOT as it ensures the physical well-being of its users and efficiently.

5) Assisted living system:

Remote healthcare, rehabilitation and assisted living for the elderly and medically challenged humans are some applications of IOT involved in assisted living systems. It provides services to the concerned people by allowing to take preventive measures and providing immediate care in certain circumstances such as when a user falls down and needs help etc. It provides facilities of wellness detection of the user. Such systems enable the users to not be very much dependent on other human beings, gives them confidence thereby, empowering them, and it also enables a rather free movement of the people who were supporting the concerned users in the absence of such assisted living systems.

6) Management of waste:

IOT has given rise to the development of efficient waste management systems which manage the disposal of waste material, keep track of any waste material lying on the floor that needs to be disposed, keep track of the amount of waste in dustbins inside the house and dispose off the waste material in the dustbins whenever it has reached its maximum level inside the dustbin, help in separating biodegradable and recyclable waste from non-biodegradable and non-recyclable waste, and also manage food waste material. [19] Various systems are capable of performing any one or more of the aforementioned functions. Since nowadays more and more people are becoming aware of the importance of clean and green disposal of waste material and its effects towards a green environment, such waste management systems make it very easy and less cumbersome for people to carry out the needful tasks towards achieving those goals and also, it reduces the overhead of waste disposal and management for the residents or users of the system.

7) Smart lighting system:

A smart lighting system is one which, depending on the number of people present inside the house, weather conditions, power consumption and many other factors, can perform one or more functions out the following: control the brightness of lights inside the house, turn them on and off, change the colours of lights, and change the pattern of the lighting inside the house. Such a system often results in better power consumption by the lights along with a better lighting inside the house which enables the users to have a better sight by controlling how bright or dim the lights are.

C. Enabling Technology: Wireless Sensor Networks (WSNs)

Numerous domains of various systems such as home automation systems, assisted living monitoring system and health monitoring systems require them to have self-configuring and self-adapting capabilities. To develop such distributed networks with said capabilities, several kinds of sensors are connected wirelessly through standard and interoperable communication protocols. A standout amongst the most crucial advancements used in home automation is Wireless Sensor Networks (WSN). A wireless sensor network is a wireless bi-directionally connected network of spatially distributed autonomous devices that consist of sensors, each connected to one or several other sensors that monitor and measure various physical or environmental parameters such as temperature, pressure, humidity, speed, motion, sound, vibration, or pollutants at centralised locations, and then pass the collected data on to the processing subsystem. [14,15. WSN falls in the category of WPAN in wireless networks. Tiny size, limited power supply, specific application and other various constraints make Wireless Sensor Network different from general wireless networks. Characteristics of WSN include minimum power consumption, high resilience, i.e. high ability to cope with node failures, heterogeneity of nodes, mobility of nodes, reduced likelihood of communication failure, scalable to large scale deployment or as required, commendable ability to withstand in unfavourable environmental conditions, cross-layer design, and unparalleled ease of usage. [2,3,7,8,9,10] Such characteristics make it highly favourable for wireless sensor network to be adapted as the device managing network in vast and heterogeneous smart home automation systems.

Figure 1 shows a basic layout of the architecture of a wireless sensor network using Internet of Things in a home automation system. As shown in the figure, there are several sensors that work as a sensing unit of the system, some of which that are used in a home automation system are Passive Infrared Motion sensor or PIR sensor, climate control and temperature sensor or smart thermostats, smoke detector, leak/moisture detector, video doorbell, window/door open and close sensor, security cameras, UV sensors, wearable

sensors such as heart rate monitor, health monitoring gadget, fitness monitoring sensor, force sensor etc. The feeds from the sensors present in a home environment are stored in the memory of the processing unit of the network. Each sensor node consists of one or more sensors working in synergy to sense physical parameters and output processed information about the surrounding using a microcontroller and a transceiver. The feeds from the sensors are continuously monitored for conditions and updates that may or may not invoke a predefined action to take place. The microprocessors and microcontrollers present in the processing unit of the network process the information stored in the memory to check for occurrences of any valid condition, and when it occurs, the microprocessor and/or microcontroller takes an appropriate pre-defined action programmed into it. The updates about the home environment are sent in a timely manner to the intended smart devices over the Internet. The users of the home automation system can monitor and control their home environment by giving commands through applications installed in their smartphone, tablet, laptop or any other smart device.

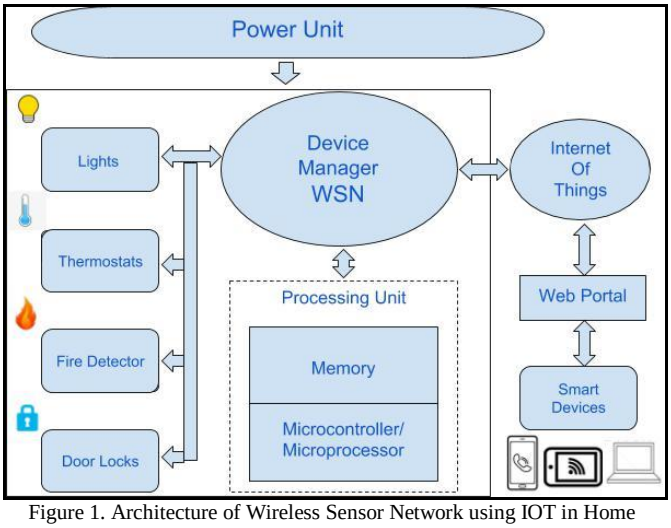

Figure 1. Architecture of Wireless Sensor Network using IOT in Home Automation

II. LITERATURE SURVEY

In this paper, Joshi and Khan (2017), current and voltage are sensed at the electrical load by placing the current and voltage sensors respectively. The sensor modules are interfaced with the Zigbee transmitter. The sensed electrical parameters are collected and transmitted by the Zigbee transmitter to the Zigbee receiver wirelessly under the Zigbee module. The Ethernet Shield installed collects the transmitted data by the means of its Serial port through which the Zigbee receiver has been interfaced. The data collected from the Ethernet shield is sent to LAN by using a Wi-Fi router. There have been given three means to control home appliances- they can be controlled automatically using a given smart software, or by manual control, or they can be remotely controlled by the user using smart phone or personal computer. In this way the user can monitor the home appliances and control them by switching them on/off. [1]

Vikram.N, Harish K.S, M.S, Umesh, Aashik, Kumar (2017) propose to build a Wi-Fi based Wireless Sensor Network (WSN) that monitors and controls environmental safety and electrical parameters of a smart interconnected home. This is done by exploiting the ability of home appliances to be interlinked, wherein each microcontroller communicates with other microcontrollers using the RF module provided to them, wherein one of the microcontrollers that has been configured as the 'Hub' and the others that are configured as sensor nodes work and communicate with each other in a tree network topology. The data is transferred and received from the server through the Wi-Fi module. [2]

Pirbhulal, Zhang, Alahi,Ghayvat, Mukhopadhyay, Zhang, Wu (2017) propose a system using sensor hubs, intended to gather information by utilizing Wireless Fidelity technology as a remote medium, save and store the information detected on the server (i.e. ThingSpeak server), which is later transmitted to the goal hub after appropriate verification. Before sending the detected information to server, the information is scrambled utilizing Triangle Based Security Algorithm (TBSA) that is proposed here which depends on non-right edge triangle key age technique that creates confirmation key (K) used to give one of a kind verification to information transmission between both the hubs, i.e. source and destination. Utilizing TBSA, the ciphertext which was produced from the source hub is communicated to the server just if there is coordinate between source hub ID and server ID, to keep the potential aggressors away. [3]

Pawar, Ramchandran, Singh and Wagh (2016) have proposed a Home Automation System prototype consisting of microprocessor Arduino ATmega328, Wi-Fi module and relays. The central device is the microprocessor that connects to the Wi-Fi module and receives orders to monitor and control the appliances. The communication between the application and microprocessor is handled by the server, thus managing the users and the appliances. The software communication module uses an Android application as the frontend, which serves as an interface to the user to communicate with the microprocessor. The proposed system consists of a server, client and a communication medium, all of which are managed by the means of socket programming. [4]

Choudhary, Parab, Bhapkar, Jha and Kulkarni (2016) have proposed a mobile and internet based home automation system using Wi-Fi technology to interconnect its distributed sensors to home automation server. In this paper, Arduino

Uno R3 has been used as the microcontroller and 8 channel Relay module to control various appliances and other equipment with large current. Various sensors used in the proposed system include PIR sensor, wherein PIR-based motion detectors are used to sense movement of people, animals or other objects, temperature sensor etc. for monitoring temperature and humidity, motion detection, video monitoring etc. [5]

This paper by Cicirelli, Fortino, Giordano, Guerrieri, Spezzano and Vinci (2016) focuses majorly on activity recognition inside a house or a living area and proposes a framework based on the Cloud-assisted Agent-based Smart home Environment (CASE) architecture. For activity recognition, the authors have proposed to use two kinds of sensors: environmental sensors, which are installed in fixed positions inside the house, and mobile sensors, which are in this case, wearable sensors worn by humans, and give dynamic changes with the changing positions of the people around the house. Activity recognition is done in four phases: data acquisition through the sensors, feature extraction by filtering the extracted data, activity discovery by using the data from the previous phase along with the previously available data and producing new classifiers, and activity recognition by using these classifiers to recognise high-level activities in real-time. CASE architecture lets these sensors along with the actuators to be integrated with a distributed multi-agent system and a cloud infrastructure. The tasks that this framework proposes to do are the detection of presence/activity, environmental measures, power usage, any emergencies, and in case of humans wearing the wearable devices, the detection of their movements, their directions, body posture, vital parameters, and their wellness. [6]

Ghavyat, Mukhopadhyay, Gui and Suryadevara (2015) have proposed a wellbeing identification framework for smart homes in light of consolidated deviation after some time that endeavours to isolate common routine information from startling information which may represent a hazard to the occupant's wellbeing and riches. In this paper, RF module, which in this case is the Digi Xbee 2nd series based on ZigBee, is used to form a network in Mesh topology. This paper deals with the various aspects of extending their proposed technology towards smart building. It lays down various issues being faced in doing so, including less accuracy due to physical obstructions, and attenuation loss, and presents their potential solutions. [7]

Sagar and Kusuma (2015) propose to build a distributed home automation system using Intel Galileo development board which has a built-in Wi-Fi card port, apart from the hardware interface modules (sensors) used. So the Galileo development acts like a web server which enables the access of the automation system from the web browsers of either any local PC in the same LAN using server IP or from any PC or mobile device remotely using Internet IP. The network infrastructure used in this paper is WiFi technology. The functions of the proposed system include temperature and humidity, motion detection, fire and smoke detection, light level, on/off control for various appliances. [8]

Table 1: Comparative analysis of Wireless Sensor Networks in home automation using IOT

Year	**Authors**	**Problem addressed**	**Technique / protocols used**	**Merits**	**Future scope**
June 2017	Pallavi Ravindra Joshi, Prof. M S khan	Controlling and monitoring of home appliances for electrical power consumption	Zigbee module, Wi-Fi, Ethernet shield	Flexible, cheap, efficient, low power consumption	The system can be extended to a large scale for monitoring a large institute, schools, colleges, companies etc.
July 2017	Vikram. N, Harish K.S, Nihaal M.S, Raksha Umesh, Shetty Aashik, Ashok Kuma	To build a low cost Home Autoation System using Wireless Fidelity under USD 100	Wireless Fidelity, Android platform	Simple design, ease of implementation, cost effective	The future scope of this work is to develop an iOS application and a web portal. It can prove helpful in old age homes and orphanages.
March 2017	Sandeep Pirbhulal ,Heye Zhang,Md Eshrat E Alahi, Hemant Ghayvat, Subhas Chandra Mukhopadhyay, Yuan-Ting Zhang, Wanqing Wu	Building a secure and energy saving Home automation system based on IOT using Wireless Sensor Networks (WSNs)	Key generation algorithm based Triangle Based Security Algorithm, Wireless Fidelity	Consumes less processing time, supports and covers a greater range of large number of sensor nodes, low power consumption	Healthcare monitoring and crisis reaction, horticulturand farming, energy resource management, industrial computerization and automation

April 2016	Pooja N.Pawar, Shruti Ramachandran, Nisha P.Singh, Varsha V.Wagh	To develop a Home Automation System prototype which mainly focuses on monitoring and controlling household appliances through the Internet	Arduino Uno, Wi-Fi technology, client-server socket programming	Flexible, easily available, affordable	Potential improvement to a greater extent by combining technologies like cloud computing, big data, robotics etc
Feb 2016	Vinod Choudhary, Aniket Parab, Satyajeet Bhapkar, Neetesh Jha, Ms. Medha Kulkarni	Mobile and internet based smart home system	Wi-Fi technology, Arduino	Auto-configurable, increased ability of upgrading, less deployment cost, scalable	Control advance features of infrared enabled devices by using infrared transmitter
Feb 2016	Franco Cicirelli, Giancarlo Fortino, Andrea Giordano, Antonio Guerrieri, Giandomenico Spezzano, Andrea Vinci	To propose a framework for the design and implementation of activity recognition in home environment	Cloud computing, wearable wireless body sensor networks, Multi-agent paradigm/ system	Faster reactivity to generated events, better exploitation of communication bandwidth, increased reliability, scalable	Improvement of the CASE platform and extending the work to energy optimization as well
May 2015	Hemant Ghayvat, Subhas Mukhopadhyay, Xiang Gui and Nagender Suryadevara	To screen the movement of an inhabiting person for health location by breaking down the person's conduct from the past information, ongoing as of late got information and criticism got information	XBee series-2, ZigBee protocol, pattern detection through pipeline processing	Flexible, low installation cost, high scalability, affordable, reduced complexity	Extended to smart buildings with related issues addressed and their possible solutions.
June 2015	Vinay Sagar K N, Kusuma S M	To provide the user with remote control of various lights, fans, and appliances within their home and with sensors-based auto-changes to the system	Wi-Fi technology, Intel Galileo microprocessor, Cloud storage and cloud computing	System scalability, increased mobility, easy extension, reduced installation costs	Energy monitoring, weather stations, in hospitals for disable people, environmental monitoring, added home security features

III. CONCLUSION

The survey of various home automation systems based on Internet of Things using Wireless Sensor Networks (WSNs) proposed in different papers reveals that different kinds of techniques and protocols are used for implementation of this type of system. The comparison of many proposed systems has been performed and presented in this paper along with the merits of each system. The different home automation systems whose explanations as well have been given in this review, use various technologies of Wireless Fidelity, cloud storage and cloud computing, ZigBee protocol module, wearable sensors, various platforms like android app platform, and Arduino microcontroller. Due to their advantageous factors such as high scalability, portability, economical costing, high flexibility, and efficient performance, home automation systems based on IOT using Wireless Sensor Network are increasingly being applied and adopted by the global market, rapidly paving its way towards the automation of majority of each and every home.

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