

# Iot Based Wireless Home Automation Systems Using Zigbee Technology

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## Abstarct

*Over the time researchers, attention is on Wireless home automation systems. Technologies like Z-Wave, Insteon, Wavenis, Bluetooth, WiFi, and ZigBee are used to implement these systems. ZigBee based systems plays a major role due to its low cost and low power consumption with high efficiency. Here ZigBee based wireless home automation systems have been addressed. There are two main parts of this paper. In the first part a brief introduction of the ZigBee technology has been presented and in the second part a survey work on the ZigBee based wireless home automation system has been presented. The performances of the ZigBee based systems have also been compared with those of other competing technologies based systems. In addition some future opportunities and challenges of the ZigBee based systems have been listed here.*

**Keywords :** Home automation, ZigBee, Z-Wave, Insteon, Waveins,PAN, voice control, energy management, assistive homes, industrial automation

## 1. INTRODUCTION

Home automation industry has drawn impressive consideration of the scientists for over 10 years [1].The fundamental thought is to consequently control and screen electrical and electronic home apparatuses. As indicated by the statistical surveying firm ABI around 4 million home automation systems were sold universally in 2013. Similar firm additionally assessed that around 90 million homes would utilize home automation systems before the finish of 2017. A few business and examination variants of home automation system have been presented and assembled. Among these solitary home security systems have become the standard of improvement exercises. Keen home systems have caught a few advancements up until this point and items have been accessible on the lookout. In spite of longer than a long term of different exercises in the business organizations neglected to make home automation as a well known innovation. The explanations for this disappointment have been exhaustively considered and recorded in [2]. A portion of these significant reasons incorporate expense, hard to utilize, merchant reliance, less usefulness, and security. In addition, master hand was needed to introduce, arrange, and keep up these systems. Consequently, the establishment and upkeep expenses of the system were high and just rich individuals with enormous houses could bear the cost of it. To defeat a portion of these constraints wireless home automation system (WHAS) has been presented and it has acquired a significant consideration in the new years.

The WHAS has diminished the activity and upkeep cost. Furthermore, it has given solace, security, wellbeing, and distant checking capacity. A normal WHAS comprises of battery worked low force wireless sensors and actuators joined with the home machines. These sensors and actuators are associated with a spine wireless organization. The accessibility of modest sensors, actuators, and wireless modules has prevailing to make WHAS famous and moderate. It has likewise decreased the hole between the extravagance and mass market divisions of home automation systems. Nonetheless, WHAS has a few impediments as well. These limits emerge because of the threatening radio channel, asset limit, and portability. Notwithstanding these constraints a few associations and organizations have created WHAS for

various enhanced applications [3]. A portion of the applications incorporate light control, Heating Ventilation and Air Conditioning (HVAC) control, savvy observation, computerized home security, machine control, shrewd water supply and water system, keen metering, energy guideline, and assistive home. The essential inspirations driving these applications incorporate energy saving, improved security, inhabitant wellbeing, agreeable, and helpful living. The auxiliary inspirations incorporate diminishing the activity and upkeep expenses of the home apparatuses, expanding life-season of the equivalent, saving common assets (i.e., diesel, oil and so on), and decreasing the ozone harming substances.

The WHAS business has changed radically since the presentation of modest PCs and workstations. In addition, progressive advancements in the product business have made the UI of the WHAS modest and easy to use [4]. Presently a-days, WHAS can be checked and controlled from a far off area whenever. There have been numerous arrangements proposed for wireless home automation industry in the previous few years. Some of them incorporate Z-wave, Insteon, Waveins, Bluetooth, WiFi, and ZigBee. Zeroed in on the ZigBee based WHAS. An extensive overview work is directed on the ZigBee based WHAS and introduced the rundown of this study work in this paper.

## **2. THE ZIGBEE TECHNOLOGY**

An extensive depiction of the ZigBee convention can be found in the writing [5], introduced just a halfway portrayal of the ZigBee convention in this part with the goal that the perusers have enough foundation to comprehend the rest substance of the paper. The ZigBee innovation was presented by the ZigBee Alliance. The ZigBee innovation has developed dependent on a normalized set of arrangements called 'layers'. These ideally planned layers have given the ZigBee interesting highlights including minimal effort, simple execution, dependability, low force, and high security.

The ZigBee was based on top of the IEEE 802.15.4 norm. The IEEE 802.15.4 standard characterizes the attributes of the physical and Medium Access Control (MAC) layers for Wireless Personal Area Network (WPAN). Accepting this norm as a "suspension" the ZigBee Alliance has characterized the upper layers in the ZigBee standard. Gadgets are the fundamental parts of the WPAN. The gadgets have been completely characterized as (a) actual sort, and (b) consistent sort. The actual kind gadgets have been additionally grouped into two sorts to be specific Full Function Device (FFD) and Reduced Function Device (RFD). Any gadget may go about as a sensor hub, control hub, and composite gadget regardless of its sort. Just the steering elements of an organization are performed by the FFDs. Contingent upon their areas in an organization the FFDs may have at least one youngster gadgets and they perform directing capacities for these kid gadgets. The RFDs don't perform directing capacities in an organization and subsequently they can't have any kid gadget.

The intelligent kind gadgets have been additionally grouped into three sorts to be specific organizer, switch, and end gadget. Among these consistent gadgets, the facilitator is the most fit gadget, which frames the foundation of the organization tree. There ought to be actually one ZigBee facilitator in an organization to start the arrangement of an organization tree. It additionally goes about as a scaffold to different organizations. The ZigBee end gadgets have restricted usefulness to speak with a facilitator or a switch no one but; it can't hand-off information for different gadgets. Because of this restricted usefulness, the end gadgets can "rest" for a lot of the time and henceforth can appreciate a long working life.

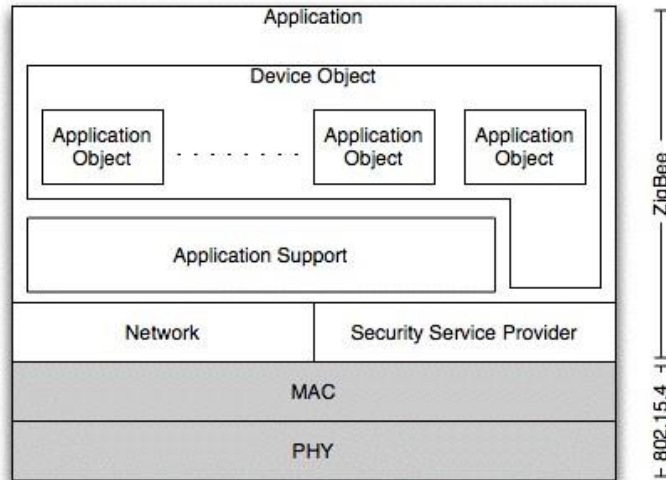


Figure 1: The ZigBee and IEEE 802.15.4

The protocol stacks defined by the ZigBee Alliance with respect to IEEE 802.15.5 standard protocol stacks are shown in Figure 1. The ZigBee architecture includes the Application Support (APS) sub-layer, ZigBee Device Object (ZDO), and user-defined application profile(s). The APS sub-layer's responsibilities include maintenance of some tables, which contain information used to enable matching and establish communication among the devices. During the discovery phase these tables are also used by a device to identify other devices that operate in the operating space. The ZDO determines the nature of the device (i.e., coordinator or FFD or RFD) in a network. It also replies to binding requests while ensuring a secured relationship between two devices. The user defined application refers to the end device that conforms to the ZigBee Standard.

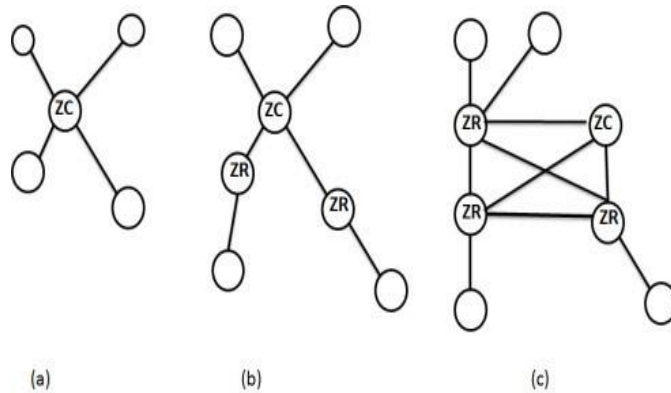


Figure 2 Network topologies of ZigBee network (a) star, (b) Tree, (c) mesh

The network layer assists the network to grow. This layer can handle a network consisting of up to 64000 nodes. The physical layer accommodates a high level of integration by using direct sequence technique. The Medium Access Control (MAC) layer permits to form several topologies without introducing complexity. The ZigBee devices have 64-bit addresses, with an option to enable shorter addresses to reduce packet size, and work in either of the two addressing modes namely star and peer-to-peer as shown in Figure 2. Some of the other technological features of the ZigBee have been listed in Table 1.

Parameter	Value
Data Rate	250 kb/s, 40 kb/s, and 20 kb/s
Topology	Star or Peer-to-Peer
Addressing	16-bit (short) or 64-bit (extend)
Multiple Access Technique	Carrier Sense Multiple Access Collision Avoidance with (CSMA/CA)
Frequency	868 (Europe) 915 MHz (North America) 2.4 GHz (Worldwide)
Range	10-20 meter
Channels	11 channels (868/915 MHz) 16 channels (2.4 GHz)

Table 1: Features of the ZigBee technology

Two modes of communication are used in a ZigBee network namely (a) beacon mode, and (b) nonbeacon mode. The beacon mode is used by a battery operated coordinator to save power. A device waits for the beacons that are periodically transmitted by the coordinator and looks for the messages addressed to it. If the message transmission is complete, the coordinator sets a schedule for the next beacon for this device. After knowing the schedule for the next schedule the device can go to sleep. On the other hand, the non-beacon mode is used by a mains-powered coordinator. All devices in a mesh network know the schedule to communicate with each other and they need to wake up at a scheduled time so that they do not miss the beacon. Hence, a quite accurate timing circuit needs to be associated with the devices. It means that there will be an increase in power consumption. The non-beacon mode communication is suitable for applications such as smoke detector and burglar alarm applications where devices 'sleep' nearly almost all the time. Till now ZigBee has found numerous applications. Some of these applications include smart energy network, home entertainment and control, monitoring and controlling industrial plant, health care, and home automation.

### 3. RELATED TECHNOLOGIES

The competing technologies of the ZigBee are Z-wave, Insteon, Waveins, Bluetooth, and WiFi. A comparison of these technologies has been presented in Table 2.

Technology	Z-Wave	Insteon	Waveins	Bluetooth	WiFi	ZigBee
Frequency	868 MHz 908MHz 2.4 GHz	904 MHz	433 MHz 868 MHz 915 MHz	2.4 GHz	2.4 GHz 5 GHz	868 MHz 915 MHz 2.4 GHz
Modulation	FSK/GFSK	FSK	GFSK/PSK	FHSS	QPSK COFDM QAM	BPSK O-QPSK

Error Control	CRC(8-bit)	CHECKSUM	BCH	CRC (16-bit)	CRC(32-bit)	CRC(16-bit)
Range	30-100m	45m	200-1000m	10m	100m	10m-100m
Network size	232	256	unknown	8	2007	64000
Power Consumption	Low power	NA	Ultra-low	Medium	High	Very Low

Table 2: Comparison of different WHAS technologies

The Z-wave is a wireless arrangement created by Sigma Design and it is advanced by the Z-wave coalition. The principle uses of the Z-wave are in a private and light business climate. The motivation behind the Z-Wave is to help dependable transmission of short messages from a control unit to at least one hubs in an organization. The Z-Wave network works in the 900 MHz ISM band. It can uphold an information rate up to 64 kbps by utilizing Binary Frequency Shift Keying (BFSK) balance.

Insteon is a home automation arrangement created by Smart Labs and advanced by the Insteon Alliance. The Insteon characterizes network geography by utilizing radio recurrence (RF) connection and electrical cable connection. The hubs can uphold either RF connections or electrical cable connections. They can likewise uphold the two kinds of correspondence. Insteon works in the 904 MHz recurrence band. It can uphold an information rate up to 38.4 kbps by utilizing Frequency Shift Keying (FSK) balance. It additionally bolsters multihop correspondence to build the inclusion territory. In any case, the most extreme number of bounces that information can make a trip is restricted to four.

Waveins is a low force wireless convention created for controlling and observing home apparatuses. It is as of now oversight and advanced by Wavenis Open Standard Alliance. This convention characterizes the physical, connection, and organization layers. Wavenis administrations can be gotten to from the upper layer through an application programming interface. Like Insteon the working frequencies of Waveins are in the ISM Band (i.e., 433 MHz, 868 MHz, and 915 MHz in Asia, Europe, and United States individually). The greatest information rate offered by Waveins is 100 kbps. Gaussian Frequency Shift Keying (GFSK) and Fast Frequency Hopping Spread Spectrum (FHSS) radio advancements are utilized in Waveins.

Bluetooth, a standard kept up by Bluetooth Special Interest Group (SIG), fundamentally intended for short reach Personal Area Network (PAN) applications. It utilizes low force and minimal effort handset. Bluetooth utilizes an uncommon radio innovation called Frequency Hopping Spread Spectrum (FHSS), which utilizes around 79 frequencies during the jumping. Bluetooth gives an approach to interface and trade data among gadgets including cell phones, phones, PCs, PCs, advanced cameras, and computer game consoles.

WiFi was presented by WiFi Alliance. The primary objective of WiFi was to supplant the wires of the neighborhood (LAN) and consequently to diminish the organization activity and upkeep costs. Practically totally confirmed items that have a place with a wireless neighborhood might be associated with a WiFi organization. The consistently dropping expense of wireless chipsets for WiFi network has assisted this innovation with involving a mass-market division of the wireless business. The WiFi innovation is in reverse viable and it is a worldwide arrangement of standard. Subsequently, a viable gadget can be

associated with a WiFi network found anywhere on the planet. The working scope of the WiFi network is exceptionally restricted (i.e., 32 meters inside and 95 meters outside). The scope of WiFi networks is the fundamental driver of its restricted applications that incorporate stock following machines, scanner tag perusing, and retailing.

Super wideband (UWB) is additionally an expected contender for WHAS. Like the ZigBee, this innovation additionally devours low force. Initially, the UWB was presented for radar imaging. In any case, it is presently viewed as an appropriate innovation for different applications like objective sensor information assortment, accuracy finding, and following applications. It can communicate the data that is spread over a huge transfer speed (>500 MHz). The UWB can uphold an organization comprising of up to 8 gadgets.

#### **4. THE ZIGBEE BASED WIRELESS HOME AUTOMATION SYSTEMS**

In security applications, WHAS has been proposed to guarantee the security of a home. One of the early exploratory ZigBee based home security system has been proposed in [6]. This system is equipped for checking entryway and window, smoke, gas hole, and water flooding in a home from a distant area. Some straightforward control systems (i.e., working a valve and imparting signs to security organizations) have additionally been related to this application. The security disturbing system has been executed by utilizing a ZigBee chip called MC13192 and a low force utilization miniature regulator called MSP430F135. The system likewise underpins Web interface with the goal that a client can get to the system distantly to control, search, and audit record. The proposed system was designed by utilizing an LCD board.

Another comparative system has been proposed in [7]. The proposed system has been produced for programmed entryway opening and shutting, temperature observing, gas identification, and light control. Three innovations in particular RFID, ZigBee, and GSM have been utilized to actualize the system. Controlling light and fan has been actualized by utilizing GSM so these home apparatuses burn-through least force. Temperature checking system has been created by utilizing GSM innovation.

Astute home automation system (IHAM) has been introduced in [8] to guarantee security at home. The system utilizes PIC microcontroller with ZigBee wireless correspondence innovation, discourse acknowledgment method, and GSM organization. The home automation system is utilized to control all lights and electrical apparatuses in a home or office utilizing voice orders with the assistance of HM2007 chip. In this work the creators have introduced the general structure for equipment and programming to actualize the system. The proposed system has likewise coordinated a security cautioning system with it so the clients can be cautioned about the fire perils. This admonition system has been executed by utilizing a smoke sensor and GSM Module. The system can send a SMS to the client if smoke is recognized.

In observation applications WHAS has been utilized to screen the exercises at home. A portion of these systems additionally permit a client to do likewise from a far off area. One such system dependent on the ZigBee has been planned in [9]. The system sends intermittent information from an area data administration to decide the current situation of a client. The proposed system comprises of three segments in particular indoor position system (IPS-M), indoor position system-foundation (IPS-I), and indoor position system-entryway (IPS-G). The IPS-I gadget occasionally communicates dynamic reference points to an IPS-M gadget to gauge distances. The creators have asserted that the proposed system performs in a way that is better than a detached versatile system. The IPS-M gets wireless signs from an IPS-I to follow an IPS-M.

In a comparable work [10] Digital Living Network Alliance (DLNA) agreeable computerized home machines have been tended to. As per the writers DLNA agreeable gadgets will be gotten boundless soon.

Subsequently controlling these gadgets by utilizing sensors by means of certain organizations has become a significant issue now. The creators have likewise guaranteed that the ZigBee innovation can be viewed as an appropriate answer for such sort of organization. To interconnect DLNA agreeable home apparatuses with a ZigBee network a Gateway is essential. The creators have proposed the design of such Gateway. They likewise proposed an energy productive technique for controlling the sensor organization. This sort of energy productivity has been accomplished by utilizing dynamic exchanging among unicast and broadcast in the sensor information assortment strategy. The creators have demonstrated that the proposed system is power effective by estimating the force utilization in the organization.

Another home organization entryway dependent on the ZigBee innovation has been proposed in [11]. The system has understood the association of low rate wireless home organization and Internet. A client can handle the home apparatuses through the proposed home organization entryway. This was perhaps the soonest work to portray that the home apparatuses could be controlled from a distant area by means of Internet. The equipment and programming used to plan the home door and gadget hubs have additionally been introduced in a similar work.

Another comparable wireless distant checking for home security has been proposed in [12]. In this work a constant observation of the home security was created dependent on assortment of sensors, the ZigBee innovation, and GSM/GPRS organization. The proposed system can send strange pictures and cautioning messages through MMS and SMS. The system can likewise get distant guidance to screen and control the family machines. The dependability of the proposed system has been tried and the creators have asserted that the proposed system can effectively ensure home security for a distant client. The exploratory outcome shows that the system has far off observation capacity to guarantee home security with high accessibility and unwavering quality.

A ZigBee wireless sensor organizations of star geography has been proposed for wireless smart home system in [13]. The proposed system is appropriate for an average little home organization. The system can be distantly checked and constrained by utilizing GSM module. The system is made out of the accompanying three primary segments: (I) home worker with GSM module, (ii) savvy climate identification sensor modules, and (iii) shrewd home apparatuses. The ideas and the structures of the proposed system have been examined in similar work. The system has been tried to guarantee its distant disturbing and control capacity.

Another wireless home automation system dependent on the Internet of Things and the ZigBee wireless sensor network innovation has been proposed in [14]. The creators have actualized the system by utilizing Texas Instruments MCU gadget LM3S9B96, which depends on the ARM Cortex-M3 based regulator. The whole system can run on the  $\mu$ C/OS-II inserted continuously performing various tasks working system. Clients can get to this system by utilizing a unique website page of LwIP TCP/IP convention stack or GSM SMS. By utilizing this system a client can screen and control the natural boundaries, for example, temperature, moistness, meter readings, and light of a home. The system is additionally ready to screen and control the home machines like light, forced air system, and warmer.

In energy the board applications WHAS has been utilized to save energy devoured in a home. This energy saving is accomplished by controlling the electrical and electronic home apparatuses. One such ZigBee based force checking system (PMS) has been accounted for in [15]. Notwithstanding ZigBee wireless correspondence the PMS additionally uses Digital Signal Processing (DSP), and Web administrations. This work has the oddity of coordinating ZigBee, DSP, and Web Services advancements together. The DSP has been utilized for the calculation of continuous force boundaries. The Web Services are utilized for the correspondence foundation among dispersed systems across an organization. The proposed system has been built, tried, and approved for the force the executives of a grounds. The test

outcomes show that the elements of the proposed PMS follow the planned targets. The proposed system additionally shows great exhibitions indirect burden control and in the transmission of caution message.

A portion of the ZigBee based energy effective system has been focused to control the force of power plugs for saving energy. One such work has been proposed in [16]. The proposed system can likewise gauge the flows drawn by power plugs. The system has been executed by utilizing an installed board and the ZigBee innovation. This proposed system has two fundamental segments in particular ZigBee control module and the worker module. The ZigBee control module comprises of a few controllable outlets, a current estimation circuit, a ZigBee transmitter, a ZigBee recipient, and a miniature control unit. The estimation circuit gauges the flow drawn by the plugs and it imparts a sign to the worker module through the ZigBee transmitter. The information of the current and voltage are put away in an implanted board. The proposed system can distinguish any over-burden and can make an impression on the electrical switch to securely kill the force. Visual Basic has been utilized to plan the UI with the goal that a client can without much of a stretch work the system.

To beat the building impediments of wireless sensor networks a ZigBee-based insightful self-changing sensor (ZiSAS) has been presented in [17]. Because of the design requirements of wireless sensor networks there is a compromise between the presentation and cost. Once in a while, a wireless sensor-based home automation system can't be successfully executed in home conditions. To defeat this limit, ZiSAS has been proposed. The ZiSAS utilizes a circumstance based self-changing plan. Henceforth, ZiSAS is an occasion driven self-changing sensor network actualized by utilizing equipment and middleware. The proposed system has been tried in a genuine proving ground. The trial results show that the proposed system lessens energy utilization in a home.

In numerous mechanical applications, the expense of a wireless sensor network is anything but a significant factor. It is more imperative to convey the organization in quickly changing application conditions and plan prerequisites. In such manner, two significant issues are (a) to quickly build application programming for various plan necessities, and (b) to work the system easily. One such quickly deployable system has been accounted for in [18]. A naturally inserted programming age system has been proposed in this work that can quickly make and advance ZigBee applications. The structure comprises of a few significant modules specifically (a) design extraction, (b) code age, and (c) engineering planning. The writers have given an inserted programming improvement structure that coordinates the heterogeneous perusers and sensors interfaces with an ideal energy control model to upgrade the nature of computerized home living conditions. The proposed structure permits fast arrangement of the supporting programming for a set-up of energy control and detecting gadgets pointing at energy saving as well as permitting singular inhabitants to screen their energy utilization whenever. The creators have asserted that the proposed device has effectively finished the objective to control the solace level at home with least measure of energy utilization.

In [19] the creators have recommended the prerequisites for a proper innovation for automation system. They have asserted that determination of a proper innovation for home and modern automation systems ought to be founded on minimal effort, simple position and establishment, simple augmentation, comfort advantages, and cell phone availability. An energy mindful home automation system fulfilling every one of these necessities have been proposed in [19]. The proposed system can handle load and henceforth can save energy. This ZigBee based system is utilized for far off controlling and checking of different home burdens/apparatuses. A definitive goal is productive force usage through constant force level marker with the assistance of a PC-based GUI application. The creators have explored different execution boundaries, for example, dormancy, gotten signal strength marker (RSSI) esteem, and full circle defer time (RTD). They additionally have contrasted the proposed ZigBee based system and that of a Bluetooth based system. The outcomes show that the ZigBee based system can save more energy contrasted with its



Bluetooth partner. A similar investigation of various wireless conventions, for example, ZigBee (over IEEE 802.15.4) and Bluetooth (over IEEE 802.15.1) has been researched in a similar work. The target of this work is to examine the appropriateness of various advancements and select the best one for home automation. The home automation system introduced in this work depends on ZigBee has been proposed for distant controlling and observing of different burdens/apparatuses. A definitive target is to guarantee proficient force use through continuous force level pointer with the assistance of a PC-based GUI application. The creators have asserted that the ZigBee based system performs better contrasted with its Bluetooth partner regarding inactivity, RSSI worth, and RTD.

In assistive applications, WHAS has been proposed to help elderly individuals and individuals with handicaps. One such ZigBee based assistive WHAS has been introduced in [20]. The proposed system depends on a voice control system. The system has incorporated a voice acknowledgment module with a ZigBee based organization. The perceived messages sent by the module are directed to electronic gadgets situated in the home. In this work SI-ASR (Speaker-Independent Automatic Speech Recognition) has been utilized. The proposed system doesn't need any preparation and recording of the words. This discourse acknowledgment system has been utilized to actualize the human PC communication to understand different menu choice capacities. A tale discourse acknowledgment technique has been utilized for requesting melodies put away in a SD memory card. To improve the precision of the system three control techniques have been proposed in particular discourse acknowledgment control, button trigger mode, voice secret phrase trigger mode, and circle acknowledgment mode. A client can pick a mode relying upon the condition. A model of discourse acknowledgment module has likewise been introduced in a similar work. The creators have given some exploratory outcomes to approve the essential elements of the proposed system. It has been indicated that the system is simple and adaptable for individuals, particularly the elderly folks individuals and individuals with incapacities.

A low force voice control system for home automation system has been proposed in [21]. The inspiration driving this work is to give supporting systems to the old and the handicapped individuals. The system depends on the acknowledgment of voice orders and it utilizes low-power RF ZigBee wireless correspondence module. The home automation system is expected to control all lights and electrical apparatuses in a home and office utilizing voice orders. The ZigBee innovation has been utilized to get the voice order and send the voice information to an ARM9 regulator. The regulator at that point changes over the voice into a necessary organization and sends the information through a ZigBee organization to another ZigBee module and miniature regulator connected with the gadgets. In view of the got message the system can either kill ON or the gadgets. The proposed system has been stretched out to incorporate a mixed media streaming, in which Differential Pulse Code Modulation (DPCM) pressure calculation has been utilized to pack the discourse information significantly.

Another idiot proof answer for control the home machines through voice orders for truly tested individuals has been proposed in [22]. In the proposed system the voice order is sent wirelessly to a PC. A shortcoming recognizable proof system has been fused in the proposed system to screen the specific status of the home apparatuses. By utilizing this flaw recognition system a client can guarantee that the home machines had gone precisely ON or OFF or gone through issue. The creators guaranteed that the proposed system has a few points of interest since it gets status data from the heap end. Be that as it may, the other recently proposed systems get the status from the client end. This end client information may give a bogus sign when force supply isn't free for a specific burden or when burden get open circuited because of wire irregularity or open wire condition.

Another comparative ZigBee based voice controlled WHAS has been proposed in [23]. The system depends on acknowledgment of voice orders and it utilizes low-power RF ZigBee wireless correspondence modules. The home automation system is expected to control all lights and electrical apparatuses in homes

and workplaces utilizing voice orders. The confirmation tests incorporate voice acknowledgment reaction test, indoor ZigBee correspondence test, and the pressure and decompression trial of DPCM discourse signals. The tests included a blend of 35 male and female exposed to various English articulations. 35 distinctive voice orders were sent by every individual. Hence the test included sending a sum of 1225 orders and 79.8% of these orders were perceived accurately.

In another new work [24] a voice controlled ZigBee based made sure about home automation system has been proposed for individuals who are living alone and who are living with handicap. In the proposed system a voice acknowledgment chip HM 2007 has been utilized. The chip can perceive 20 words and each word has term of 1.92 second. The 8051 microcontroller (AT89S51) has been utilized to execute the system. The creators likewise guaranteed that the proposed system is itself a made sure about one as a result of the voice acknowledgment system.

Another comparable work has been introduced in [25].The proposed system in [25] permits controlling of gadgets utilizing voice orders and diminishes client communication with system straightforwardly. This System utilizes SAPI (Speech Application Programming Interface), which is a Microsoft Application to empower voice acknowledgment. This system contains three fundamental segments: (I) clever home worker with ZigBee module, (ii) shrewd climate recognition sensor modules, and (iii) voice order controlling module. The different highlights of the system incorporate turning any home apparatuses or gadgets, playing media applications, downloading RSS channels, and sending letters. The creators additionally proposed some design to associate the system with the web so any gadget ultimately can be utilized to control and screen the gadgets.

A voice order and contact screen based home automation system has been proposed in [26]. The system has been tried and confirmed. The check tests incorporate voice acknowledgment reaction test, contact screen reaction test, and indoor ZigBee correspondence test. A hint of image on screen can handle the home apparatuses utilizing the ZigBee innovation. The home gadgets can be worked distantly. It tends to be utilized at home, industry, inns, shopping centers, and cycle control systems. This system is mostly executed for multi-debilitated individuals utilizing voice acknowledgment and contact screen innovation. Programmed Speech Recognition (ASR) motors through Microsoft discourse APIs has been utilized in this system. The system is actualized by utilizing TFT contact screen.

A comparable system has been fabricated and actualized in [27]. The proposed system can perceive voice orders and it utilizes low-power RF ZigBee wireless correspondence modules to control the lights and electrical machines in a home and office utilizing voice orders. The system has been tried and confirmed. The tests included a blend of ten male and female subjects with various dialects. Seven diverse voice orders were sent by every individual. The test outcomes included sending an aggregate of 70 orders and 80.05% of these orders were perceived effectively.

## **5. THE CHALLENGES OF ZIGBEE BASED HOME AUTOMATION SYSTEMS**

Although the ZigBee technology is considered as the most popular technology for WHAS, it has some challenges too. Some of the challenges are as follows:

- Resource Constraint: The sensors (or nodes) used in WHAS have limited resources (i.e., limited processing power, low memory, and limited battery).
- Limited Range: The ZigBee has limited transmission range and multihop communication is required to increase the range of a ZigBee network.

- Technological Limitation: The ZigBee technology depends on the physical layer and medium access control layer of IEEE 802.15.4 standard.
- Interferences: The WHAS has to co-exist with other systems operating in the same free band called Industrial Scientific and Medical (ISM) bands. Hence the communication of WHAS can be interfered by other systems (i.e., Bluetooth, WiFi, cordless phone, and microwave oven) operating in the same frequency band.
- Internet Connectivity: For remote monitoring the WHAS may need to have internet connectivity.

The conjunction of the ZigBee based WHAS with other system is likewise an issue. This issue has been tended to by the specialists in a few works. One such sort of examination has been accounted for in [28]. In that work the creators have contended that WHAS works in a microwave radio band, which might be shared by a few home machines in a home. For instance, PCs, wireless switches, cordless telephones, and microwaves possess the 2.4 GHz band that is situated in a similar working band of WHAS. Henceforth, the interoperability of these home machines with the WHAS presents a critical test for the home automation system planner. The creators have played out a few lab examinations to consider the conjunction of WHAS with wireless card prepared PC and microwave. The system execution has been assessed dependent on the estimation of Packet Delivery Ratio (PDR) metric. The outcomes show that the presence of the home apparatuses fundamentally influences the presentation of WHAS. An answer for this issue has been accounted for in [29]. In that examination a ZigBee based home automation system and a WiFi based organization have been incorporated through a typical home door. The home door gives network interoperability, a straightforward and adaptable UI, and far off admittance to the system. A similar work has demonstrated that a fruitful conjunction and interoperability of Wi-Fi and ZigBee in a genuine home automation system is conceivable if the system is deliberately planned.

To associate the ZigBee based WHAS with the web a reasonable entryway is an absolute necessity. A few explores have been conveyed to plan such doors. Two-level engineering of home control system (HCS) in view of ZigBee multi-bounce network has been introduced in [30]. In this work the essential information procurement, preparing capacities, and the engineering of the proposed passage have been planned and created. The proposed passage underpins three interfaces specifically (a) ZigBee based wireless access interface, (b) Bluetooth based nearby interface, and (c) GPRS based far off interface. The equipment design and convention programming just as the correspondence control strategy have been proposed for this passage. The proposed passage's exhibitions have been tried under a built test climate. The exhibition results show that the proposed passage is helpful for WHAS.

A comparative work has been introduced in [31], which is a ZigBee based inserted controller system. The system likewise runs on an implanted board instead of on a PC. The paper portrays the running and design strategies of the system on the implanted board. Since the inserted Web Server utilizes basic passage interface (CGI) to speak with different modules in the system, the CGI program is additionally utilized in this work. The product plan of the ZigBee depends on TI's Z-stack, and the ZigBee modules are actualized by TI's CC2430. The testing system can be utilized from any distant spots through an Internet interface and a program. The control modules can be imparted through wireless mode. Thusly, the proposed system can be considered as a promising possibility for home automation applications, distant modern control territories, and far off patient observing system.

Another passage has been proposed in [32] where an automation system has been intended to turn ON, OFF and become acquainted with the status of home machines by utilizing ZigBee from a distant area. The home apparatuses are associated with the ports of a microcontroller board and their status are passed to the home worker. The mix of NetBeans and Embedded C is utilized for observing and controlling

programming. The home apparatuses can be observed and gotten to distantly by a client by means of SMS or EMAIL.

Notwithstanding the previously mentioned imperatives the ZigBee based WHAS has some different issues as well. Vagrant hub is one of them. This issue emerges in light of the tending to conspire utilized in the ZigBee innovation. In ZigBee, a gadget (with a lasting 64-cycle MAC address) is said to join an organization when it can effectively get a 16-bit network address from a parent gadget. Parent gadgets figure addresses for their youngster gadgets by a dispersed tending to task conspire. This task is not difficult to actualize, yet it confines the quantity of offspring of a gadget and the profundity of an organization. The ZigBee address task strategy is excessively moderate and in this manner ordinarily making the usage of the location pool poor. Those gadgets that can't get network tends to will be secluded from the organize and become vagrant hubs. An answer for this issue has been proposed in [33].

A few examinations have just demonstrated this case. For instance, one significant preferred position of the ZigBee is that it tends to be effectively interfaced with various kinds of microcontroller. In this work distinctive microcontrollers have been utilized in a ZigBee based WHAS. Four mainstream microcontrollers were utilized to explore memory necessities and force utilization, for example, ARM, x51, HCS08, and Coldfire. The creators have asserted that the ZigBee innovation is interoperable with these microcontrollers and this is a fundamental element of WHAS. A system comprises of various transfers, ZigBee module CC2520, and microcontroller AT89S52. The creators additionally explored the information rate and inclusion territory in indoor and outside applications. They additionally have analyzed the exhibitions of the proposed system with that of another system executed by Bluetooth.

## 6. CONCLUSIONS

Here presented technical concepts of ZigBee technology. Numerous applications are there on ZigBee, which limits this effort only to its application in WHAS. Comparison is done between the performances of the ZigBee based WHAS with other technologies like Z-Wave, Insteon, Waveins, WiFi, and Bluetooth. It has been shown that the ZigBee based WHAS outperforms other technology based WHAS. Here presented a complete survey work on the ZigBee based WHAS. Challenges and Some limitations of the ZigBee based WHAS have also been listed. Still there are some challenges of ZigBee based WHAS that are still under investigations.

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