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A Review on Wireless Smart Homes

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Abstract: ***The recent development in wireless technologies have led multi-fold development in Smart Homes. These wireless technologies are used to make a wireless node capable of collecting data and process it with the help of micro-controller then this processed data is sent to the main co-ordinator. A WSN is formed using such nodes which forms the basis of Smart Homes. With the availability of various wireless technologies, the task to choose the best option amongst them is more important rather than simply applying it. This paper reviews the current technologies that are being used and provides a guideline as to which technologies are to be used when.***
Keywords: ***Smart Home, Home Automation, Wi-Fi, Bluetooth-LE, ZigBee.***

I. INTRODUCTION

Automation is anything which involves minimum human efforts. Automation makes machines human-independent. The impact of this feature of automation in a home completely changed the traditional homes. Home automation is the term used to describe a home which self -sufficient in performing most of the day to day tasks such as opening doors, controlling the blind rollers of the windows.

Smart homes are the future of home Automation. A home which can take a decision on its own is a smart home. According to Winkler, a “smart home” is a home that is able to proactively change its environment to provide services that promote an independent lifestyle for elderly users [1]. Winker limits smart home users to the elderly.

Many new technologies are daily appended in the domain of smart homes. Earlier automation in the homes was done using wires. The Wired technology was reliable but was costly and was easy to maintain and if any new addition is to be made then whole architecture was disturbed. The solution was the use wireless technology. With the inclusion of wireless technology in Home Automation a door to a whole new era in smart homes is opened. Wireless communication can easily replace the existing wired technology and also provide security features.

There are many wireless solutions available in the market like Bluetooth, Wi-Fi, Z-wave, Insteon, Waveins and ZigBee. Each technology has its advantages and disadvantages. Wireless communication technology is used to make a self-sustained network of sensors which is also known as Wireless Sensor Network(WSN). A WSN consist of many sensors geographically separated within a house or premises but are connected to each other using recent wireless technologies like ZigBee. A WSN has a co-ordinator which sends control information to all the end -device and receives data from all the end-devices. To increase the range of the WSN routers are used which forms a bridge between the co-ordinator and end-devices. This paper reviews the main technologies that are being used nowadays. Paper reviews implementation of these technologies in Smart Homes.

The paper is organized as follows. Section II gives an overview of the important technologies viz. Bluetooth, Wi-Fi, and ZigBee. Section III reviews some of the work using the above technologies in Smart Homes.

II. TECHNOLOGIES USED IN WSN

There are mainly three technologies used in WSN

Other than the above-mentioned technologies other options are also available like Z-wave, Insteon, Waveins etc. This paper focuses on Smart Homes based on the Bluetooth , Wi-Fi and ZigBee.

A. Bluetooth

The Bluetooth wireless technology provides the means for the replacement of cables and infrared links that connect one device to another with a universal short-range radio link. this technology is used to create wireless networks[7].

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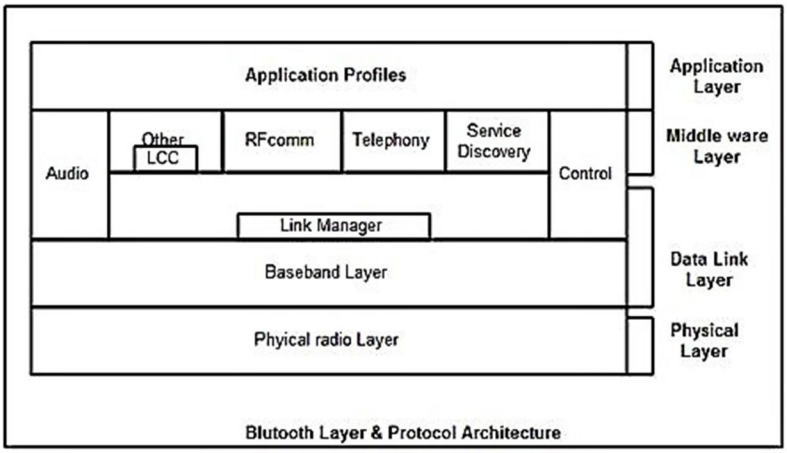
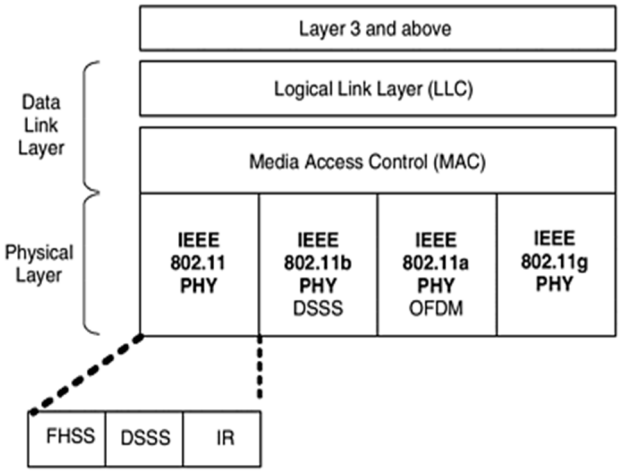


The radio layer is a physical layer of IP model. Bluetooth devices are low-power and have a range of 10 m. Bluetooth uses a 2.4-GHz ISM band divided into 79 channels of 1 MHz each. Bluetooth uses the frequency-hopping spread spectrum (FHSS) method in the physical layer to avoid interference from other devices or other networks. Bluetooth hops 1600 times per second, which means that each device changes its modulation frequency 1600 times per second. A device uses a frequency for only 625 µs (1/1600 s) before it hops to another frequency; the dwell time is 625 µs. It uses GFSK modulation. The baseband layer is roughly equivalent to the MAC sublayer in LANs. The access method is TDMA. The Logical Link Control and Adaptation Protocol, or L2CAP (L2 here means LL), is roughly equivalent to the LLC sublayer in LANs. It is used for data exchange on an
ACL link; SCQ channels do not use L2CAP.

B. Wi-Fi

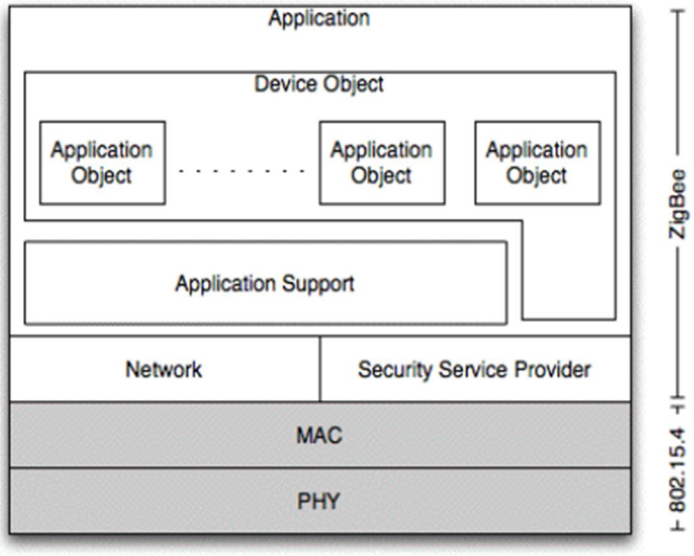
IEEE has defined the specifications for a wireless LAN, called IEEE 802.11, which covers the physical and data link layers. It defines two kinds of services that are BSS (Basic service set) and ESS (extended service set)[7]. The BSS is the basic building block of W-LAN. In BSS stations, can be mobile or stationary but connected each other. There can be an Access Point(AP) or a BSS can be without an AP. The ESS on other is formed by more than one BSS with an AP's.



IEEE 802.11 FHSS uses the frequency-hopping spread spectrum (FHSS) method. FHSS uses the 2.4-GHz ISM band. The band is divided into 79 sub-bands of 1 MHz (and some guard bands). A pseudorandom number generator selects the hopping sequence. The modulation technique in this specification is either two-level FSK or four-level FSK with 1 or 2 bits which result in a data rate of 1 or 2 Mbps, DSSS uses the 2.4-GHz ISM band. The modulation technique in this specification is PSK at 1 Mbaud/s. The system allows 1 or 2 bit (BPSK or QPSK), which results in a data rate of 1 or 2 Mbps, OFDM using the 2.4-GHz
ISM band. The modulation technique achieves a 22- or 54-Mbps data rate. It is backward compatible with 802.11b, but the modulation technique is OFDM.

C. ZigBee

The ZigBee was built on top of IEEE 802.15.4 standard[9]. The IEEE 802.15.4 standard defines the characteristics of the physical and Medium Access Control (MAC) layers for Wireless Personal Area Network (WPAN). Taking this standard as a "chassis" the ZigBee Alliance has defined the upper layers in the ZigBee standard. Devices are the main components of the WPAN. The devices have been categorically defined as (a) physical type, and (b) logical type. The physical type devices have been further classified into two types namely Full Function Device (FFD) and Reduced Function Device (RFD). Any device may act as a sensor node, control node, and composite device irrespective of its type. Only the routing functions of a network are performed by the FFDs.



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.

III. A REVIEW OF PREVIOUS PAPERS

A. Bluetooth Based

Mario Collotta in [1] has proposed an energy management approach for smart homes that combines a Bluetooth Low Energy Wireless Sensor Home Automation Network (WSHAN), for the communication among home appliances, with a Home Energy Management (HEM) scheme. Simulation results have clearly shown that Bluetooth Home Energy Management Scheme (BluHEMS) is quite efficient in terms of reducing the peak load demand and electricity consumption charges and allows to achieve a concrete monetary cost reduction. Moreover, the proposed scheme contributes to the comfort level of the consumer by putting a limit on the delay factor of an appliance.

Mario Collotta and Giovanni Pau in [2] has proposed a mechanism to forecast the energy consumption conditions, i.e., to predict the home energy requirements at different times of the day or on different days of the week. proposed mechanism is able to forecast the energy consumption conditions, i.e., to predict the home energy requirements at different times of the day or on different days of the week. In the proposed work help of Artificial Neural Networks is used. In home automation scenarios, where the behaviour of consumers can be many times repetitive and almost never unpredictable, it is possible to formulate an appropriate ANN model able to learn (as it is easy to obtain a large number of data on which to perform the training) and then to predict the behaviour of consumers. This means that the ANN can be a useful tool for the evaluation and the management of energy consumption. There are some features that make useful the application of ANNs, such as they can handle large amount of data sets; they have the ability to implicitly detect complex nonlinear relationships between dependent and independent variables; they have the ability to detect all

possible interactions between predictor variables; they are a powerful data-driven, self-adaptive, flexible computational tool having the capability of capturing nonlinear and complex underlying characteristics of any physical process with a high degree of accuracy.

B. Wi-Fi Based

Jin Yeong Tan, Pin Jern Ker and Azlina Abdullah in [3] proposed a Wi-Fi based smart home. In addition, an Android GUI application was developed to interact with the proposed Wi-Fi integrated smart home system. This Wi-Fi integrated smart home system used a PIC® microcontroller and a Wi-Fi module for integration purposes. An Android app is also built to remotely control and monitor the devices.

Tong Xin, Bin Guo, Zhu Wang, Mingyang Li, Zhiwen Yu and Xingshe Zhou in [4] proposed a novel approach for human identification, which leverages Wi-Fi signals to enable non-intrusive human identification in domestic environments. Every human has a distinct influence on Wi-Fi signals. The influence can be captured by the Channel State Information (CSI) time series of Wi-Fi. Specifically, a combination of Principal Component Analysis (PCA), Discrete Wavelet Transform (DWT) and Dynamic Time Warping (DTW) techniques is used for CSI waveform-based human identification. Experimental results indicate that the identification accuracy is about 88.9% to 94.5% when the candidate user set changes from 6 to 2, showing that the proposed human identification method is effective in domestic environments.

C. ZigBee Based

Jinsoo Han, Chang-Sic Choi, Wan-Ki Park, Ilwoo Lee, and Sang-Ha Kim in [5] proposed a smart HEMS architecture that considers both consumption and generation. In the energy consumption, the EMCUs (Energy Management and Communication Unit) are installed in outlets and lights to measure the energy usages of home appliances and lights based on ZigBee; they transfer the gathered data to the home server. The home server then perceives the energy consumption of the house. The solar panels are installed with devices to monitor its status. The REG (renewable energy gateway) gathers the status data of the solar panels based on PLC and the generation data from inverters based on RS-485; it transfers the gathered data to the home server. This PLC monitoring technology can monitor each solar panel for maintenance. The home server then computes the amount of energy that can be generated based on the weather and can administer and control the energy usage. Users can access the home energy information through smart devices. The REMS (Remote energy management server) provides the comparison and analysis of each home energy usage. By considering both consumption and generation, the proposed architecture is expected to enhance home energy management and to save the energy cost.

Jinsung Byun, Boungju Jeon, Junyoung Noh, Youngil Kim, and Sehyun Park in [6] proposed ZiSAS, a situation based self-adjusting scheme, and an event-based self-adjusting sensor network in order to make consumer devices more energy efficient and smart. ZiSAS is based on a 16-bit microcontroller and consists of a ZigBee (IEEE 802.15.4 standard) transceiver, various environment monitoring sensor modules, an LED driver, a system interface, and a power regulator. The ZiSASs collect the temperature/humidity and movement information periodically. The power management system controls the devices using ZiSASs. Because the ZiSAS has the resident's preferred temperature/humidity information, the home environmental condition can be automatically adjusted according to the resident's preference. In the same manner, the intensity of illumination and user movement information is collected by the ZiSASs periodically. The results show that compared to periodic sensing and transmission, situation based control without the SMA and situation based control with the SMA is approximately 3- 12% and 8-34% reduction of energy consumption respectively, depending on the number of the ZiSASs. The ZiSAS also gradually decreases the slope of the total energy consumption according to a new routing protocol based on cooperation between the SAS and the SMA, whereas not cooperating with the SMA when routing rapidly increases the total energy consumption due to the frequent packet collision and packet loss.

IV. DISCUSSION AND CONCLUSION

TABLE 1. COMPARISON OF DIFFERENT TECHNOLOGIES

Technology	Bluetooth	Wi-Fi	Zigbee
Frequency	2.4GHz	2.4GHz	868MHz,915MHz,2.4GHz
Range	10m	100m	10-100m
Network Size	8	2007	64000
Power Consumption	Medium	High	Very Low

A. Power Consumption

Bluetooth is an old technology generally used to for data communication between few devices but the recent development in this technology with the use of Low Energy revived this development. The Bluetooth LE is still a new technology although it mainly focusses on making a WSN energy efficient but its transmission energy is higher when compared with other 2.4GHz systems [8]. ZigBee has low E_{packet} when compared to Bluetooth. Low transmission energy means longer battery life. . Wi-Fi, on the other hand, has highest power consumption amongst the three.

B. Frequency Bands and Range

ZigBee is available in two bands 868MHz in Europe and 2.4GHz worldwide whereas Bluetooth is available in 2.4GHz only. Due the larger bandwidth Wi-Fi is used mostly at the gateway of a smart home to connect to the internet. Range Wi-Fi is more than ZigBee and BluetoothLE. Although the Wi-Fi has high data rate but BluetoothLE and Zigbee provide sufficient data rate for domestic purposes. Wi-Fi should be as a gateway to connect to the internet and require high data rate or can be used to collectively send data to the control station

C. Network Size

In Bluetooth with one coordinator, seven devices can be connected. In wi-fi with a single router 2007 devices can be connected. On the other hand, ZigBee has largest size of network. With one ZigBee coordinator near about 64000 devices can be connected.

Amongst the three, ZigBee is best suited for Domestic application with lowest power consumption, medium and easy to extend range and largest network size. Much of the work is done in the field energy efficiencies, future work can comprise of finding ways to use these technologies simultaneously in a home environment without any interference.

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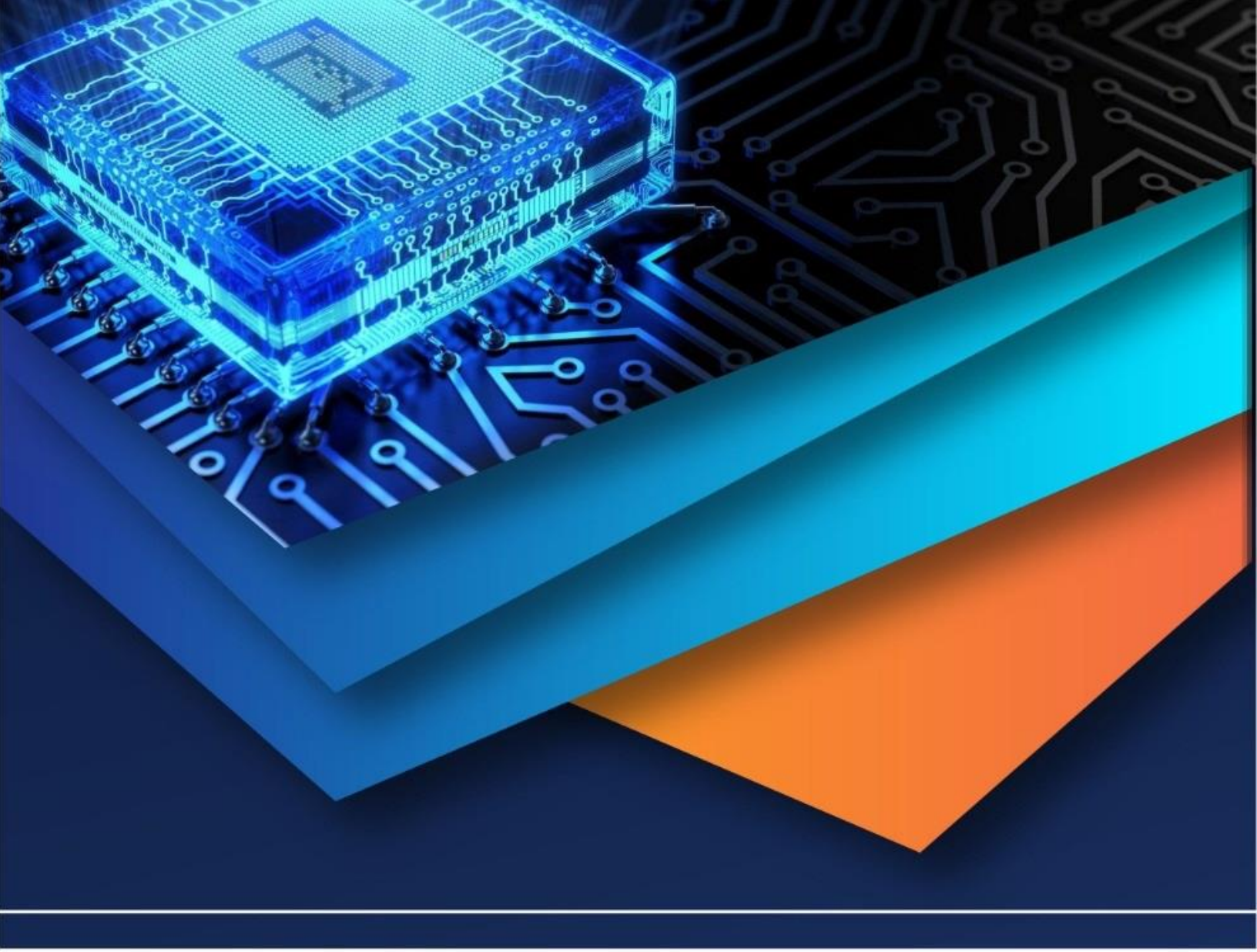

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