

ZIGBEE based Public Addressing Systems

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ABSTRACT

Public Addressing System (PA) is an electronic sound and amplification distribution system with a microphone, amplifier and loudspeakers. PA systems are widely used to make announcements in public, institutional and commercial buildings and locations. In PA systems cost, quality and expansion are the major factors that affect the working and implementation of the system. The Zigbee based monitoring and controlling help us to improve the quality and performance, reduce cost, power and complexity and simplifies expansion. The proposed project is a wireless controlling, delivering and monitoring system for a public addressing system by combining embedded and Zigbee wireless network technology for low power and low cost data communication in fields where wired communication is expensive and complex. Zigbee is a secure, popular, low power, low data rate and low cost Wireless Personal Area Network. Zigbee devices are used in smart energy, medical and in home automation. This project has a server and a number of client modules. Server module remotely starts, monitors and stops client modules using Zigbee server module. Client modules connect to the server through Zigbee client module.

The system can be fully controlled from a single system (server module) through a GUI, which can be developed from any of the visual developing tools. The proposed application can be used to make low rate, low cost, secure and easily expandable systems for announcements in public, institutional and commercial buildings and locations.

General Terms

Introduction, Zigbee Protocol, Related Works, Proposed System, Software Specification, Limitations, Future Work, Conclusion, Reference

Keywords

Zigbee, PAN, IEEE 802.15.4, WLAN, Mesh Topology

1. INTRODUCTION

Embedded systems changed the nature of consumer electronics, home appliances, automobile, office automation, business equipments and security systems. An embedded system is nearly any computing system [2] other than a desktop, laptop, or mainframe computer. Computing systems are embedded within large electronic or consumer devices. Wireless based automation is a prime concern in our daily life. Zigbee is a secure, popular, low power, low data rate and low cost Wireless Local Area Network developed for wireless communication, which is more efficient than other wireless technology in terms of communication distance, cost, power consumption and end device support. It is a low rate and low power wireless personal area network which support IEEE 802.15.4 standard.

A public address system (PA system) is an electronic sound amplification and distribution system with a microphone, amplifier and loudspeakers, used to allow a person to address a large public, for example for announcements at large and noisy air and rail terminals or at a sports stadium. The term is also used for systems which may additionally have a mixing console, and amplifiers and loudspeakers suitable for music as well as speech, used to reinforce a sound source, such as recorded music or a person giving a speech or distributing the sound through a venue or building. The small PA Systems can be used in Railway Termini, Airports, International Conference, Cruise Ships, Workshops, Schools, Industrial Units, Theatres, Factories, Shopping Centers, Waiting Rooms, Restaurants etc.

Most of the existing systems have complex designs due to excessive wiring and are difficult to expand in order to meet the necessities of the customer. The Blue Tooth based PA systems suffers from noisy air, distance and line of sight communication. These systems support short distance wireless communication, with a limited number of end devices. As the number of end devices increases its performance decreases. The proposed project is a wireless controlling, delivering and monitoring system for a public addressing system by combining embedded and Zigbee wireless network technology for low power and low cost data communication.

PA Systems have mainly three components namely input sources, amplifies and one or more loud speakers. These systems can be used in places like school auditoriums, Churches, Colleges, Universities where the sound information has to be delivered to people. Microphone which is used as an input source in PA systems should give real time service by extracting sound signals and direct it to loudspeakers after amplification. Speaker delivers sound to the audience. Electrodynamical loudspeaker is a device that uses an electromagnetic coil and diaphragm to create sound. This is the most common type of speaker in the world today. PA Systems can be small Systems like used in small auditoriums and can be large systems like used in Universities.

This project combines the benefits of wireless PA systems and Zigbee protocol by embedding Zigbee modules in both server and client modules. Server is a single computer system with microphone, GUI for interaction and Zigbee server module. Client systems have wireless speakers with amplifying units and Zigbee Client module. These server and client modules communicate by means of Zigbee communication protocol.

2. ZIGBEE PROTOCOL

Zigbee is a low power, low rate wireless communication standard for Personal Area Network based on IEEE 802.15.4 standard. Zigbee networks are also called Personal area Networks or PANS. Zigbee used in home automation, medical and energy saving environments. Zigbee supports mesh

topology to support mesh routing. In home, automation of electronic devices can be performed with Zigbee. In health field a large number of health monitoring devices can be connected and controlled. Zigbee is a low cost, low data rate and low power network which operates on two bands. The 868/915 band support 20-40 kb/s and 240 MHz band provides 250 kb/s data rate. Zigbee can support 10 to 100 meter wireless distance depending on the capability of transmitter, power, frequency, antenna etc. Zigbee client devices have a sleep mode of operation which reduces the power consumption in client modules.

Zigbee mesh topology has 3 components [3]. 1. Zigbee Coordinator 2. Zigbee Router and 3. Zigbee End Devices. The Coordinator should install first to start a new PAN. It then starts router and router starts other routers and end devices. It is the duty of the coordinator to assign pan ID to itself and to other devices and has to select appropriate radio channel for communication. Coordinator and router always receive power from AC and it does not go to sleep mode. End devices get power from battery and it can operate in sleep mode. Mesh and star topologies can be used in end devices. Maximum of 254 devices can be attached to a network. The working of these components is specified in the layers of the protocol suite.

Fig 1 shows the layers in Zigbee protocol Stack. The MAC and Physical Layer are designed as per the specifications of IEEE 802.15.4 and the remaining layers are as per Zigbee alliance [3] specification. The router and end devices join the network using either MAC or Network Layer. Mac layer used to connect between Coordinator and Router/end devices or Router and end devices or Router and other Routers.

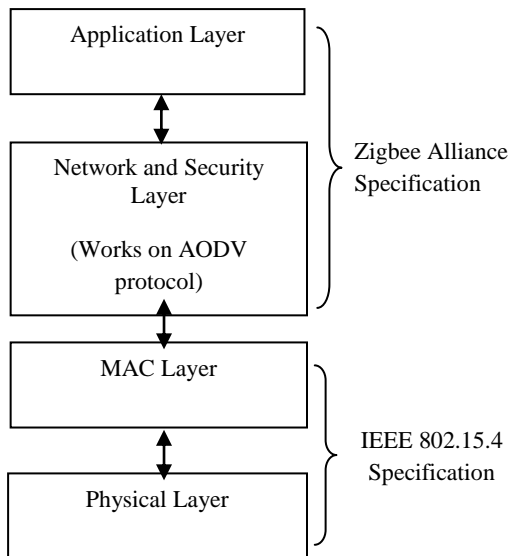


Fig 1: Zigbee Protocol Stack

The upper two layers specified by Zigbee Alliance provides Services like

1. Extra Encryption services (application and network keys implement extra 128b AES encryption)
2. Association and authentication (only valid nodes can join to the network).
3. Routing protocol: AODV, a reactive ad hoc protocol has been implemented to perform the data routing and forwarding process to any node in the network.

4. Application Services: An abstract concept called "**cluster**" is introduced.

The Table 1 shows the frequency table of Zigbee networks. The number of channels supported by each frequency is also specified along with its data rate. It shows that a maximum of 27 channels are available in Zigbee. Different geographic regions have different frequencies. Whenever a Zigbee server module starts, it selects one available channel and all end devices and routers in the networks form a PAN network by assigning PAN ids and they communicate through this frequency.

Table 1: Zigbee Frequency Table

Geographical Regions	Europe	America	World Wide
Frequency	868.0-868.6 (MHz)	902.0-928.0 (MHz)	2.4 - 2.48 GHz
No. of Channels	1	10	16
Data Rate(Kb/s)	20/100/250	40/250	250

3. RELATED WORKS

A number of the cost effective and energy saving systems developed using Zigbee networks. The systems used in smart energy, medical and home automation which has mesh topology can be developed effectively using Zigbee.

The system which controls the working of DC motor remotely [1] using Zigbee can control the working through a PC. The PC with a GUI form designed with VB can monitor the activities of the motor and the database associated with the PC stores the working details. The motor has a set of sensors [10] which monitor power, speed and voltage of the motor. These sensors are connected to an AVR microcontroller which supports Zigbee protocol. The sensors [4] measurements displayed in the microcontrollers LCD display will be transmitted to PC. Receiving and transmitting takes place between PC and AVR. The implementation has a Receiver part and transmitting part. Remote Health Monitoring System [5] is a system which uses biological sensors to monitor the health condition of patients remotely. It has a patient module and manager module. The pressure, heart beat and temperature read by biological sensors sent to a remote PC continuously with a Zigbee enabled microcontroller. The Manager can be informed with health measurements through GSM with the support of internet.

Remote Water Meter Reader [6] controls water supply in metropolitan cities using Zigbee enabled water meter reader [7]. The System has a server PC, set of base stations and water meters corresponds to each consumer. Each meter has a ARM microprocessor, which monitor the flow of water and records the usage temporarily for a period of 30 days. The recorded reading, which is in digital format, will be transmitted to a base station. From base station, GSM/GPRS services transmit it to the server PC. This system effectively control and monitor the water usage in the city with minimum man power and minimum cost. Zigbee based theft monitoring [8] system trying to supplement another model for ordinary GSM theft monitoring by considering range in mobiles. This system

keeps the time of theft in its temporary storage if the mobile is not in range. The time information and the video details together speed up the recovery operations. It is mainly used for car automation, consumer electronics etc.

Two modules namely client and server are common to Zigbee based system. Some systems needs intermediate modules. All client modules have sensors to read values, microcontroller for storing temporary data and interfacing the sensors and Zigbee module. It is the duty of Zigbee module to communicate or to respond server modules. The server module requires PC, GUI and communication modules to client. Zigbee based and GSM based server communication module can be used depending on the nature of the system. The client, server and intermediate modules work together to provide faster, flexible and less expensive systems with low data rate protocol.

4. PROPOSED SYSTEM

Based on the above studies, a new system for public addressing can be developed with a single server and number of client modules. Fig 2 shows the overall system model

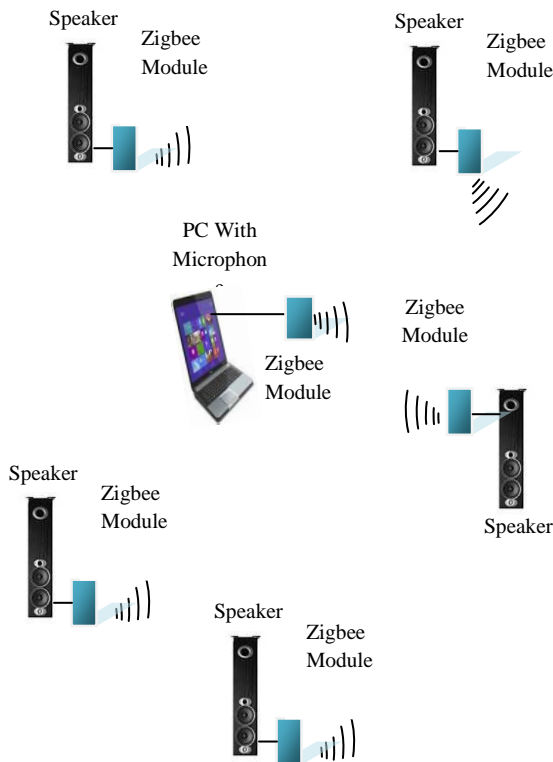


Fig 2: Zigbee based PA systems

This system focuses on the development of low cost, low power, easily expandable and effective PA Systems using Zigbee. It has two modules namely server module and client module. The Server is responsible for controlling, delivering and monitoring of data and client modules responsible for receiving and delivering of data through speakers. The system has a single server. The block diagram of entire system is shown in Fig 3.

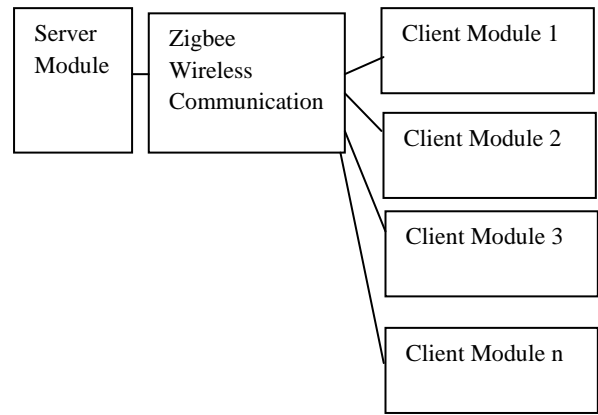


Fig 3: Block Diagram of Entire System Module

4.1 Server Module

The server module effectively control, deliver and monitor all system modules. The module can be a lap top or a personal computer with microphone, GUI and server Zigbee module. The GUI form has options for controlling each client modules, recording delivered speech, and amplitude and voltage monitoring. Controlling of client modules means power control, assigning PAN ids and status monitoring. The start button in the GUI form starts the entire networks by installing coordinator and selecting channel for communication. The coordinator connects other devices and routers in the communication. The GUI has an option to enable powering of client devices. The necessary clients can be powered and others can be unplugged easily by automating power supply of client devices through Zigbee. Once coordinator, end devices and routers (if needed) are ready the recorded or live audio data can be effectively transmitted to client devices with the help of Zigbee server module. The block diagram of server module is given in Fig 4.

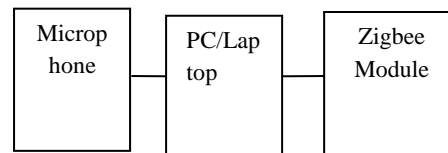


Fig 4: Block Diagram of Server Module

The low data rate of Zigbee is enough to sent audio data to client devices. The Zigbee module ensures secure delivery of data. Unlike the Blue tooth technology (which requires line of sight communication) this system place client modules anywhere within the communication distance. This make Zigbee based PA system more powerful over Blue tooth based PA Systems.

4.2 Client Module

The client modules in the system act as receiving modules. Since Zigbee supports two way communication, client transmit status information to the server. The number of client modules in a PA system can specified according to the need of the consumer. A maximum of 254 devices can be attached to a server. Each client module has a client Zigbee module and a Speaker. This Zigbee module receives wireless audio data transmitted from the server and directs it to respective speakers after amplification. Speakers are responsible for delivering of data to the audience. All the client modules receive the same signals and give a live streaming of speech to the audience. To reduce power consumption Zigbee provides sleep mode operation to the client modules. The

clients go to sleep mode, if server not transmitting data. On receiving signals it wake up from sleep mode to active mode.

The speakers can be powered either through analog power or through batteries. The speakers used for communication can be multi driver supporting or single driver supporting. If it is multi driver supporting, different volume levels can be achieved with respect to appropriate driver. Depending on size, shape, volume, and furnishings the Speaker systems may vary. The quality of sound reaching listener's ears depend not only speaker system, but also environmental factors. The block diagram of client module is given in Fig 5.

The wireless distance supported by Zigbee protocol is 10 to 100 meters. Intermediate routers can be placed to support and to improve the quality in long distance communication.

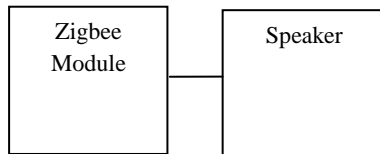


Fig 5: Block Diagram of Client Module

4.3 Software Modules of the System

Flow chart organization of both server and client modules are given below. Fig 6 shows the software organization of server module. It commonly acts as transmitting module. Fig 7 Shows the software organization of client module. It usually a receiving module.

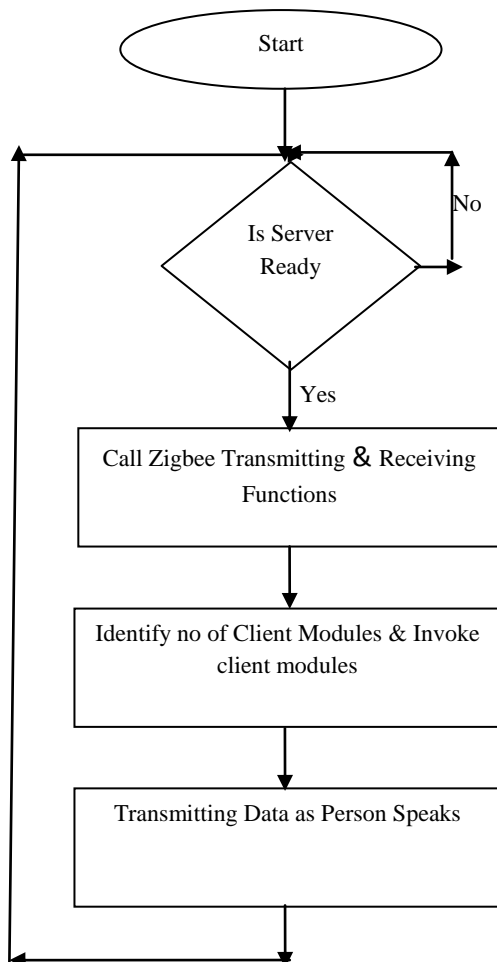


Fig 6: Flow Chart Organization of Server Module

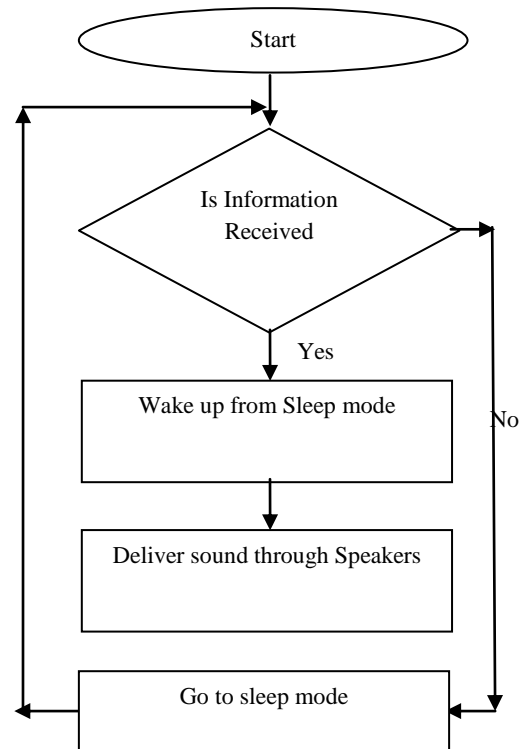


Fig 7: Flow Chart Organization of Client Module

4.4 Advantages

1. Wireless technology
2. Radio signal
3. Easily Expandable
4. Low Power Consumption
5. Low Cost

4.5 Disadvantages

1. Range Limitations
2. Cost high if few number of end devices

4.6 Limitations

The PA Systems using Zigbee is a low rate, low energy, low cost system but its hardware implementations are under research. The full hardware and software design has to be developed.

4.7 Future Work

Full working systems with essential hardware's and software's have to be developed. The experimental analysis of data rate, accuracy and efficiency has to be performed.

5. CONCLUSION

PA Systems are used for public communication in many places. The commonly used systems are wired. Heavy wiring has to perform to implement a PA system. The expansion is complex and time consuming. Wireless PA Systems based on Blue-tooth etc are not efficient in terms of communication distance, number of end devices and quality. But more efficient, low cost, low energy systems can be developed with the proposed project. In future it can catch the market.

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