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A low Power Wireless Interaction System using IFDMA in ZigBee Communication

D.Allin Joe[1*], Karthikumar R[2], P.Pavithra[3]

[1*] Department of Electronics and Communication Engineering, Kumaraguru College of Technology, Coimbatore, India
[2] Department of Electronics and Communication Engineering, Kumaraguru College of Technology, Coimbatore, India
[3] Department of Electronics and Communication Engineering, Kumaraguru College of Technology, Coimbatore, India

[*]*Corresponding Author: allinjoe.d.ece@kct.ac.in, Tel.: +91-94865-03001*

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***Abstract*—** In this paper, a new display technology which is more power efficient and provides less interference along with interaction between users is designed. It displays the data entered in touch screen to the connected nodes and vice versa. The input data is entered in touch screen by touching the screen or using a stylus. The touch screen system has a built in data buffer that enables the user to enter data without waiting for the touch screen to be refreshed. When touch screen is refreshed, data from data buffer is sent to a computer and processed. The computer stores the data which is received from the data buffer and transmits the data to connected nodes through ZigBee transceiver. A maximum of 65,536 nodes can receive the data that is transmitted from the ZigBee transceiver within a range of 100 meters. A node can be added or removed easily from the computer by using their IP address which also decreases the interference between nodes of adjacent networks. ZigBee networks are more power efficient and can determine the pending data available in it. Data is received in the connected nodes via ZigBee transceiver attached in them. The nodes also have the capability to transmit messages by their ZigBee transceiver which is displayed in a segment of the screen. Hence an interaction between the users is enabled. If data in a node gets lost, it can be retrieved from the personal computer (PC) itself. This technology can augment the active interaction between the users in classroom and video conferencing. Embedded C and JAVA programming languages are used for the implementation.

***Keywords*—** Touch screen, ZigBee, SC-FDMA, MATLAB, IFDMA, and PAPR

I. INTRODUCTION

Interaction technology is the vital component in all the new age technologies. Human computer interaction involves interaction between users and computers [1]. ZigBee is used for the short range and low power interaction technologies. Li-Chien Huang, Hong Chan Chang, Cheng Chung Chen and Cheng Chien Kuob have proposed a ZigBee based monitoring and protection system. In their work, they proposed that ZigBee could form large networks which will be an efficient interaction technology for monitoring and protection system [2]. A ZigBee network can connect over 65,000 nodes in a time. Fabio Leccese analyzed ZigBee-based wireless devices which enable more efficient street lamp-system management [3]. The information between lamps and control system is transferred point by point using ZigBee transmitters and receivers. The control system is the intelligent management of the lamp posts by sending data to a central station by using a ZigBee wireless communication. The system maintenance is easy. He concluded that ZigBee system is more energy effective, highly efficient, reliable and avoids interference. G.Song, F.Ding, W.Zhang and A.Song have proposed a wireless power outlet system for smart homes [4]. In their work, they used ZigBee to enhance the energy efficiency. In ZigBee, based on the transmission power the successful transmission distance between nodes is determined. At present, the transmission distance of ZigBee is about 100m under an obstruction free situation. ZigBee can maintain the network structure as tree or mesh which effectively overcome the issues of transmission along long distance. Peizhong Yi, Abiodun Iwayemi, and Chi Zhou had developed a ZigBee Deployment Guideline under WiFi Interference for Smart Grid Applications [5]. They thoroughly evaluated ZigBee performance under WiFi interference for smart grid applications and they found that ZigBee may be severely interfered by WiFi and that a “Safe Distance” and “Safe Offset Frequency” can be identified to guide ZigBee deployment. It is shown that 8 m between ZigBee and WiFi is a “safe” distance which can guarantee the reliable ZigBee performance while 8 MHz is a “safe” offset frequency even when the distance is just 2 m. Hua Qin and Wensheng Zhang proposed a ZigBee-Assisted Power Saving Management for Mobile Devices [6]. ZigBee transceiver was the optimal solution on the issues of wireless communication.

The organization of this paper is as follows. The next section represents the proposed system model and involves in the explanation of each blocks in system model. The performance of the proposed system with a discussion of the issues that needs to be addressed for describing the power efficiency and less interference of the design is noted in Section III. Section IV summarizes the main conclusions of this paper. The final section provides the future directions of investigation of this paper.

II. METHODOLOGY

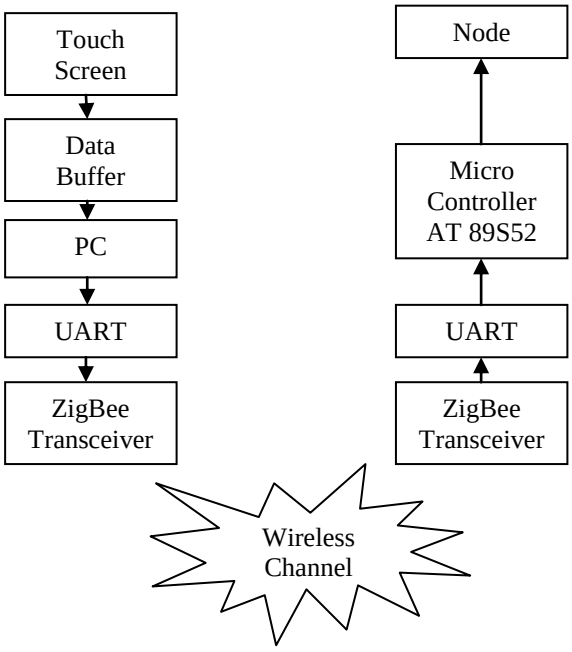

Figure 1. System Model of the Proposed System

The proposed system model of an improved power efficient, less interference interaction technology using ZigBee is shown in Figure 1. It's transmitter section is shown in the left side of the system model and its receiver section is shown in the right side of the system model. The input data is given through a touch screen. A touch screen is an electronic visual display that can spot the existence and position of a touch within the display area. It refers touching the display of touch screen using finger or hand. Touch screens can also intellect the passive objects, such as a stylus [8]. It enables the user to interact directly with the display screen [9]. The graphs, images and text can be entered through the touch screen.

Data buffer stores data entered in touch screen and sends it to PC for processing. It controls the transfer of data from touch screen to PC. It is used to store the data from the touch screen for a particular time instant. The data buffer must have the maximum capacity to store the entered data until it is processed and hence the loss of data will be avoided [10]. The data buffer gets refreshed for each millisecond which improves the accuracy of the system. Thus, for every millisecond the data is passed from the data buffer to the computer for processing. Personal Computer (PC) is used for the assignment of nodes. It has memory storage for the retrieval of data in future. The nodes are assigned based on their IP address. By opening the JAVA application in the PC, we need to enter the IP address of the node which is required to configure the system. After entering the IP address of the node, the respective node will be connected to PC. This enhances the security of the system. The nodes can be removed by selecting the nodes and click "Delete" in the application. Serial transmission of digital information is more cost efficient than parallel transmission. The universal asynchronous receiver/transmitter (UART) is used to interface the peripheral devices in the system which will provide the intermediate data transmission. It converts the transmitted digital data between its serial and parallel form as required by the user [11]. The conversion between serial and parallel forms of data is done in UART by using a shift register. It will switch over the data between the serial and parallel transmissions whenever required.

A built-in buffer is used in UART to function faster. This buffer allows UART to store the data coming in from the system bus. At the same time, it processes the data that is going out to the serial port. By using Enhanced Serial Port (ESP) and Super Enhanced Serial Port (Super ESP) data transfer rates of the system can be enhanced. The transfer rates of different UART devices are shown in Table 1.

Table 1. Transfer rates of different UART devices

Device	Transfer Rate(kbps)
UART	115
ESP	300
Super ESP	465

A. ZigBee Transceiver

ZigBee module forms the heart of the proposed system. The multiple access scheme used by ZigBee needs half the power required for ZigBee module. Hence a more power efficient multiple access scheme should be used to reduce the power consumption. ZigBee specification is suitable to create personal area networks and higher level protocols. ZigBee devices require low power but it can be able to transmit the data over longer distances by creating a mesh network. Since it does not require any central node for the control of communication, it requires less power [12]. ZigBee transceiver is used in secure networking applications that require low data rate and long battery life. It has a distinct rate of 250 kbit/s, best suited for a single signal transmission from a sensor or input device. It is simpler and less expensive. ZigBee networks are secured by a 128 bit encryption key [13]. ZigBee uses Direct Sequence Spread

Spectrum (DSSS) to reduce the interference while propagation. In addition, it uses Carrier Sense Multiple Access Collision Avoidance/Channel Access mechanism (CSMA/CA), dynamic frequency selection and transmission power control to avoid channel collision [14]. OFDMA and SC–FDMA multiple access schemes are used in ZigBee. SC-FDMA is more energy efficient than OFDMA in higher data rates [15].

B. Subcarrier Mapping

The scalable bandwidth used in the ZigBee standard is about 2.405-2.480 GHZ. In ZigBee, 16 channels are used for data transmission.

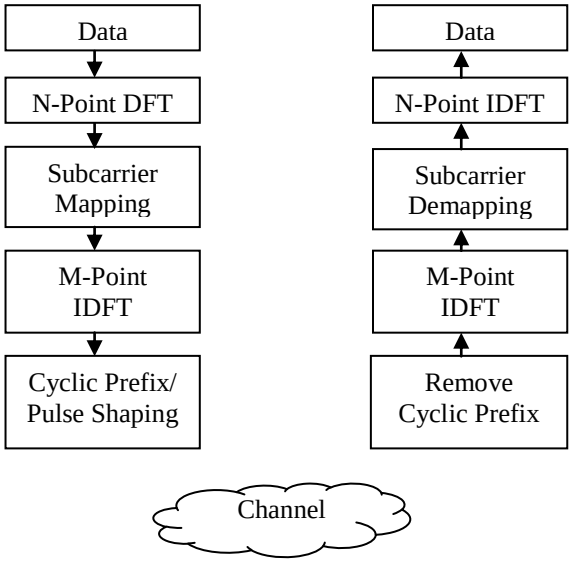

Figure 2. SC–FDMA Architecture

The data symbols from the N point DFT output are mapped into M number of subcarriers (M>N) after serial to parallel data conversion. Without this subcarrier mapping, there will be no oversampling in the signal. If there is no oversampling, aliasing effect is introduced in the signal and distorts the signal. In SC–FDMA, the symbols are mapped to subcarriers, which mean that the power is spread along the subcarriers. The subcarrier mapping allocates N point DFT output complex values as the amplitude of some of the selected subcarriers based on the type of subcarrier mapping to increase the N length block to M length block. The SC-FDMA architecture is shown in Figure 2. There are three types of subcarrier mapping used in SC–FDMA.

The DFT output complex values are mapped to a subset of successive subcarriers thereby confining them to a fraction of the system bandwidth i.e. localized either at the beginning or middle or end of the bandwidth and allocating the other sub carriers as zero.

1) Distributed Mapping (DFDMA)

The DFT output complex values are mapped to the entire system bandwidth in an uneven manner. The length of the zeros added between each DFT output complex value is not equal. Hence a complex pulse shaping filter is required. Using distributed mapping, the power of the system is distributed to the subcarriers.

2) Interleaved Mapping (IFDMA)

IFDMA is considered as a special class of DFDMA. The DFT output complex values are mapped to the entire system bandwidth in a similarly spaced manner. The length of the zeros added between each DFT output complex value is equal. This scheme combines the advantages of spread–spectrum and multicarrier transmission. It has high performance in wireless mobile communication. It proves to be more energy efficient scheme since it requires very less power for its operation [16]. Power efficiency is essential for ZigBee transceivers since they have very few energy resources. They have very low latency.

After subcarrier mapping, cyclic prefix is appended at the transmitter to prevent Inter Symbol Interference (ISI). It uses a frequency domain equalization and IDFT at the receiver [17]. Data detection is performed in the time domain after IDFT operation [18]. Microcontroller AT89S52 is used for automatically controlling the transmission and reception in nodes. It is a low power, high performance CMOS 8-bit microcontroller with 8 Kilobytes of programmable flash memory [19]. It controls the duplex transmission in nodes [20].

III. RESULTS AND DISCUSSION

The proposed architecture is implemented in hardware with the help of JAVA software. The system is powered up and the data "HAI" is entered in touch screen as shown in Figure 3.

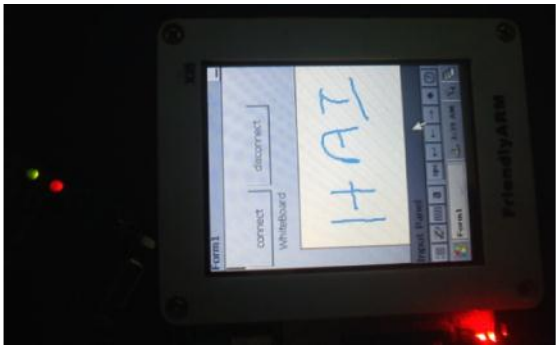

Figure 3. Input Data in Proposed System

The entered data is then stored in data buffer and then processed in PC. The node assignment is done using JAVA programmed software in PC. Using PC the nodes are assigned by using their IP address and only the assigned nodes can be able to access the system. All the unassigned nodes are unable to access the system which improves the security of the system and also avoids the interference from the adjacent systems. The system is made secure by using a 128 bit key for the encryption of data. The data is then transmitted to the receiver using a ZigBee transceiver. The subcarrier mapping schemes used in ZigBee standard are compared to find the more energy efficient subcarrier mapping scheme. The ZigBee module is made energy efficient by using IFDMA subcarrier mapping in SC–FDMA. The power consumption of various subcarrier mapping schemes used in the ZigBee module is shown in Table 2 and it is inferred that using IFDMA subcarrier mapping scheme will improve the energy efficiency of the system.

Table 2. Power Consumption of Subcarrier Mapping schemes

Distance (m)	Latency (ms)
10	9
50	12
100	16

Using ZigBee transceiver the data can be transmitted to a range of 100 meters. Hence it is used for short range applications. The latency of ZigBee transmission with respect to distance is measured and shown in Table 3.

Table 3. Zigbee Latency

Subcarrier Mapping	Power (mA)
DFDMA	42
LFDMA	39
IFDMA	35

The nodes can transmit the data that is entered in the node and this is controlled by the usage of microcontroller. The transmitted data from nodes is displayed as shown in Figure 4 in nodes and stored in PC.

Figure 4. Output Data in Proposed System

It is useful for the applications that require both display and storage. The total latency of the system for data transfer is about 29ms in a classroom environment. The whole data transfer is stored in PC for the retrieval of data in future.

IV. CONCLUSION AND FUTURE SCOPE

In this research paper, an improved energy efficient and less interference interaction technology is implemented using IFDMA subcarrier mapping scheme in ZigBee module. It is inferred from the proposed system that IFDMA subcarrier mapping is more energy efficient with less power consumption of 35 mA when compared to DFDMA of 42 mA but it doesn't improve the reliability. The reliability of the system can be improved by using interleaving process which provides more secure environment in ZigBee module. This process requires more memory which is a challenge and will be considered for further enhancement of the work.

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Authors Profile

Mr. D. Allin Joe was born in Kanyakumari, Tamilnadu, India, on May, 1990. His research interests include Antenna Design and Wireless Communication. He has published 7 research papers in International and National journals. He was awarded Amateur Wireless Station License, Grade-RESTRICTED issued by Ministry of Communications and IT, Government of INDIA, 2015. BEC Vantage certificate was awarded to him by University of Cambridge, United Kingdom. He was awarded Young Achiever Award 2016 by Institute for Exploring Advances in Science & Engineering.

Mr. R.Karthi Kumar was born in Paramakudi, Tamilnadu, India, on June, 1990. His research interests include Digital VLSI Circuit Design. He has published 7 research papers in International and National Conferences. He was awarded Amateur Wireless Station License, Grade-RESTRICTED issued by Ministry of Communications and IT, Government of INDIA, 2015. BEC Vantage certificate was awarded to him by University of Cambridge, United Kingdom.

Ms. P. Pavithra was born in Tamilnadu, India, on June, 1988. Her research interests include RF, Microwave and Dispersion Compensation in fiber optic communication. She has published 8 research papers in International and National journals. She received Young Investigator Award from Interscience Research Network in 2013 and Best Paper Award from Anna University in 2013 for her contribution towards dispersion compensation using delay line filter in fiber optic communication.

