

Efficient IEEE 802.15.4 Physical Layer System using Spatial Diversity

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Abstract - The IEEE 802.15.4 physical layer research is a fascinating area of research and lots of research are being carried out on it. Several researches are working on to make Zigbee technology better and better in terms of error probability or end to end performance. The end to end performance makes system reliable to save energy for which IEEE 802.15.4 standard known. In this paper spatial diversity using multiple inputs multiple output (MIMO) technology is adopted to enhance the performance of the Zigbee technology. In addition of proposed spatial diversity architecture O-QPSK is adopted which better perform with the standard than other modulation techniques. The proposed system is tested for transmitters and receiver considering 2, and 4 antenna pairs and found better results.

Keywords- IEEE 802.15.4, OQPSK, Spatial Diversity and Zigbee.

I. INTRODUCTION

ZigBee has been come from the household honeybee that uses a zigzag kind of dance to communicate vital information to other members. This communication dance is the "ZigBee Principle" which is engineers are trying to follow with this procedure a bunch of individual part and simple organisms that joins together to tackle complex tasks.

The widespread use of laptops, cell phones, PDAs, GPS receivers, RFID, and intelligent electronics in the post-PC era, represents a gigantic step towards an increasing miniaturization and ubiquity of modern embedded systems. With it, computing devices have become cheaper, more mobile, more distributed, and more pervasive in everyday life, creating an eagerness for monitoring and controlling everything, everywhere [1]. These advancements in information and communication technology (namely on memories, batteries, energy scavenging techniques and hardware design), and the necessity of large-scale communication infrastructures, triggered the birth of the

Wireless Sensor Network (WSN) paradigm. In the upcoming years, wireless communication will be embedded in everyday objects, such as clothes, gadgets, toys, home appliances, food carts to cars, bridges, roads, farm lands, buildings, animals and people. The integration of a wireless module is not just enabling a way to communicate but it is a means to make objects smarter and granting those new abilities [2]. Wireless Sensor Networks will enable a wide range of new applications and usages like building automation (e.g. security, HVAC, lighting control, access control), consumer electronics (e.g. TV/VCR/DVD/CD remote control), industrial automation (e.g. asset management, process control, environmental control, energy management) and personal health care (e.g. body sensor networks). This computing ubiquity will help improving the quality of life and change the way individuals perceive the world.

However, for this to become a reality, many new problems and challenges must be overcome in WSNs as their paradigm differs from traditional wireless networks. There is the need for low cost devices enabling large-scale networked embedded systems (as there can be hundreds or thousands of nodes scattered in large regions) and energy requirements that impose low communication rates and ranges and low duty cycles. Some of the most important challenges in WSNs are related to energy-efficiency, scalability, routing, mobility, reliability, timeliness, security, clustering, localization and synchronization.

Benefits of Multiple Antennas for Wireless Communications the enormous potential of using multiple antenna system for wireless communication system has only become clear during the last decade. The end of the 1990s, multiple-antenna methodologies were described to provide a novel means to get both higher bit rates and smaller error rates. Likewise, they constituted a significant technology for new wireless communications. In the sequel, they have been characterized in more detail.

Higher Bit Rates With Spatial Multiplexing

Spatial multiplexing techniques simultaneously transmit independent information sequences, often called layers, over multiple antennas. Using M transmit antennas, the overall bit rate compared to a single-antenna system is thus enhanced by a factor of M without requiring extra bandwidth or extra transmission power.² Channel coding is often employed, in order to guarantee a certain error performance. Since the layers are superimposed during transmission, they have to be separated at the receiver using an interference-cancellation type of algorithm (typically in conjunction with multiple receive antennas).

II. ZIGBEE NETWORKING

ZigBee can use so-called mesh networking, which may extend over a large area and contain thousands of nodes. Each FFD in the network also acts as a router to direct messages. The routing protocol optimizes the shortest and most reliable path through the network and can dynamically change, so as to take evolving conditions into account.

This enables an extremely reliable network, since the network can heal itself if one node is disabled. This is very similar to the redundancy employed in the Internet. ZigBee networks are mainly intended for small duty cycle sensor networks (<1%). A novel network node can be recognized and connected in about 30 ms.

Waking up sleeping node takes about 15 ms, as does accessing a channel or transmitting data. ZigBee uses from the capability to rapidly attach information, detach, and go to deep sleep, which outcome in low power consumption and extended battery life.

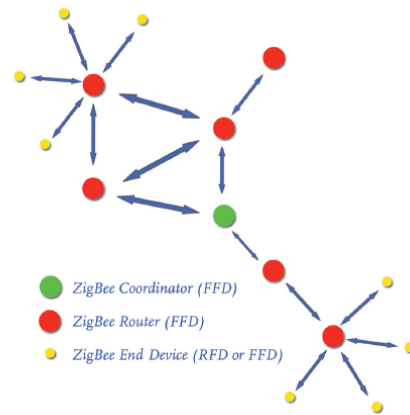


Figure 1.1: Mesh network

III. PROPOSED APPROACH

The IEEE 802.15.4 standard is meant for the low energy consumption data transmission and the end to end performance play key role to save energy. The frequent packet loss or frame destruction need again same energy to retransmit the frame thus consume lots of energy. If the system is encountered with less error probability the network live longer as it made for.

The proposed system is given in the figure below. The Zigbee technology works better with the Offset-Quadrature Shift Keying (O-QPSK) thus the existing system is implemented with the spatial diversity technology to enhance the performance.



Fig. 2.1 Block diagram of the proposed IEEE 802.15.4 (Zigbee) with spatial diversity

The major blocks of the systems is to convert symbols into chips and then modulate data followed by initialization of the MIMO AWGN channel to transmit data over. During transmission channel introduces noises in to the signal and signal become noisy and difficult to recover useful information. In such situations the spatial diversity has an added advantage by utilizing the space to reduce the error probability. Now at the receiver side the signal is detected and the demodulation process is performed and the chip

sequence is then converted into symbols and finally got the data at the output.

The above explained proposed IEEE 802.15.4 with spatial diversity system is implemented on the simulation tool and the implemented algorithm is explained with the help of flow chart given in the Fig. 2.2.

The algorithm execution steps are as follows:

- a. Start of simulation
- b. Create simulation environment using variables
- c. Generate data frame for transmission over network
- d. Convert data symbols into chip sequence
- e. Modulate the chip sequence with Offset-Quadrature Phase Shift Keying
- f. Initialize MIMO-AWGN channel for better error probability (Spatial Diversity)
- g. Generate noises which is being added during transmission through channel
- h. Transmit signal through channel and add generated noise

- j. Convert chip sequence into data symbols
- k. Calculate BER and the display results for various parameters
- l. End of simulation

IV. SIMULATION RESULTS

The Zigbee known for its low power data transmission network and this performance can be better if the error probability is reduced. To achieve the same a spatial diversity based system is proposed in this paper and the system with the implemented algorithm is explained in the previous section. The simulation results of the spatial diversity are shown in the figures below.

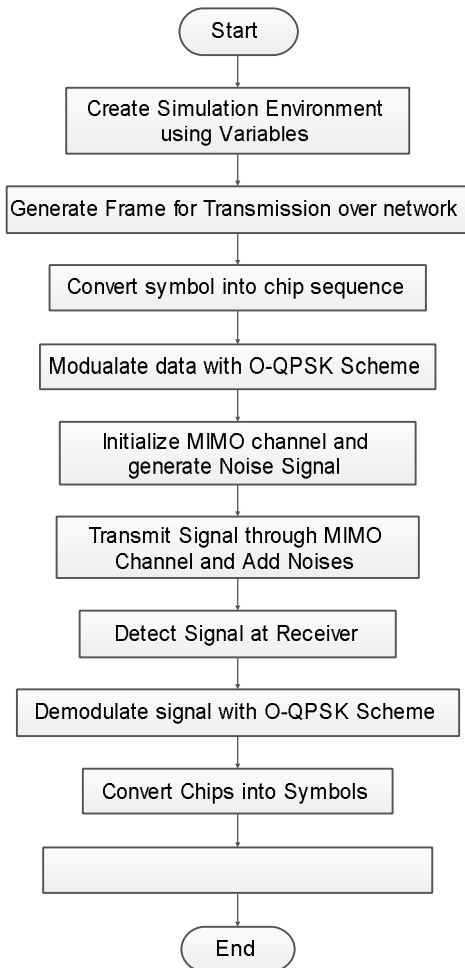


Fig. 2.2 Flow chart of the proposed IEEE 802.15.4 (Zigbee) with spatial diversity

- i. Detect signal at receiver and the received signal is demodulated with Offset-Quadrature Phase Shift Keying

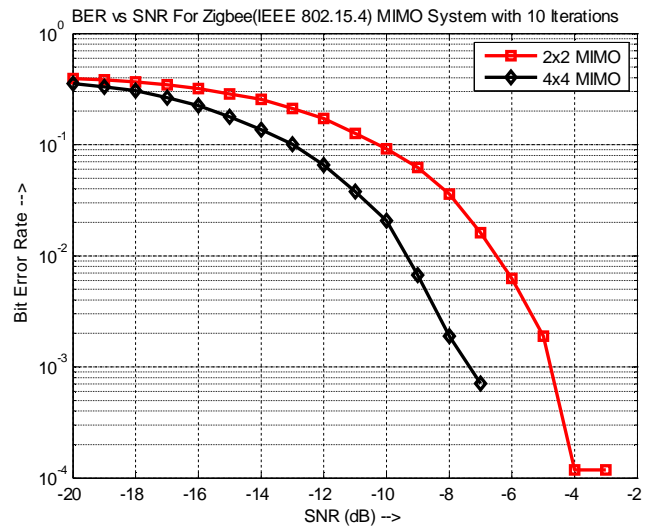


Fig. 3.1 BER vs SNR Curve of IEEE 802.15.4 (Zigbee) for 10 Iterations

In Fig. 3.1 the IEEE 802.15.4 system is simulated with the two transmitter antennas and four receiver antennas with 10 iterations and found that bit error rate of 10^{-4} range is achieved at -7dB which is low power as expected.

In Fig. 3.2 the IEEE 802.15.4 system is simulated with the two transmitter antennas and four receiver antennas with 20 iterations and found that bit error rate of $10^{-3.5}$ range is achieved at -5dB which is low power as expected.

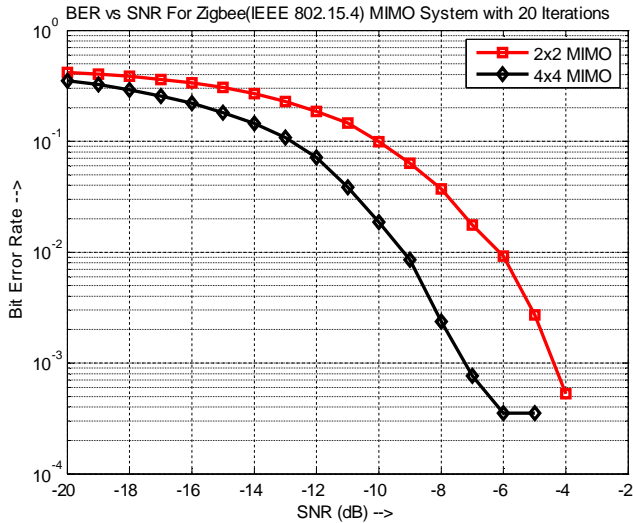


Fig. 3.2 BER vs SNR Curve of IEEE 802.15.4 (Zigbee) for 20 Iterations

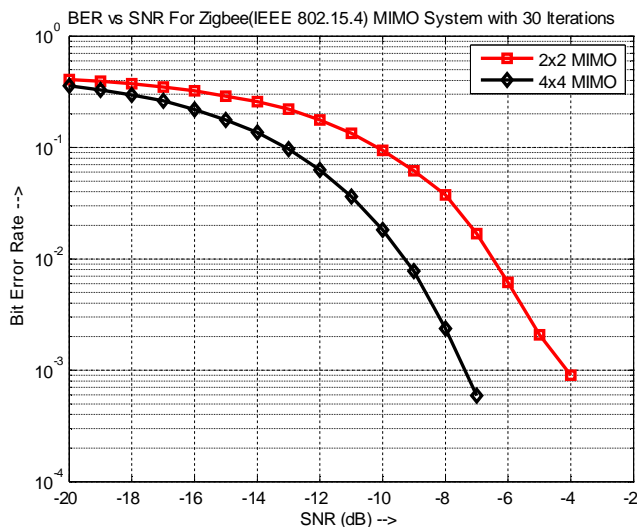


Fig. 3.3 BER vs SNR Curve of IEEE 802.15.4 (Zigbee) for 30 Iterations

In Fig. 3.3 the IEEE 802.15.4 system is simulated with the two transmitter antennas and four receiver antennas with 30 iterations and found that bit error rate of $10^{-3.5}$ range is achieved at -7dB which is low power as expected.

V. CONCLUSION AND FUTURE SCOPE

The proposed Zigbee system with spatial diversity is simulated and the performance calculated in terms of BER for 0 to 20dB signal to noise ratio (SNR). From the results the lowest BER is achieved is 10^{-4} at -7dBs and this is lower power requirements for Zigbee standard. Now we

can say that with the spatial diversity technique using two transmitter two receivers and with 4 transmitters and 4 receivers gives better performance with IEEE 802.15.4. The compared performance of the 2x2 and 4x4 configurations is found better with four antenna configuration. In the future technologies better modulation techniques makes system better with the filter implementations at the receiver reduce the errors to achieve optimum low power operations.

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