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Implementation of 4x4 Mimo with Zigbee

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ABSTRACT

MIMO (multiple inputs, multiple outputs) is an antenna technology for wireless communications in which multiple antennas are used at both the source (transmitter) and the destination (receiver). The antennas at each end of the communications circuit are combined to minimize errors and optimize data speed. MIMO is one of several forms of smart antenna technology, the others being MISO (multiple inputs, single output) and SIMO (single input, multiple outputs). In conventional wireless communications, a single antenna is used at the source, and another single antenna is used at the destination. In some cases, this gives rise to problems with multipath effects. In digital communications systems such as wireless Internet, it can cause a reduction in data speed and an increase in the number of errors. The use of two or more antennas, along with the transmission of multiple signals (one for each antenna) at the source and the destination, eliminates the trouble caused by multipath wave propagation, and can even take advantage of this effect.This was only the first step as system then started to utilize the multipath propagation to advantage, turning the additional signal paths effectively be considered as additional channels to carry additional data.

Keywords : Zigbee, Multiple Inputs, Single Output, Single Input, Multiple Outputs, Body Area Networks, Internet of Things, SNR, 3GPP, LTE, NR, WSN

I. INTRODUCTION

The evolution of wireless communication from analog to digital led to the enhancement of early propagation models, which provided information about power, in order to consider time delay information. Further considerations of the space domain either with space diversity or smart antennas, MIMO systems has also pushed the evolution of the faster and efficient communication.In the decades of cellular systems, they have undergone five generational transitions. Among them, the fourth generation(4G) brought about a complete adoption of packet switching as a platform for the mobile internet and the convergence of all standards worldwide into the long-term evolution (LTE) system, besides faster bit rates and lower latencies. LTE then evolved into the fifth generation (5G), augmented by another radio access interface termed new radio (NR) that allows operating on a much wider range of frequencies.

In the transitional period between 2G and 3G, as the soaring costs of spectrum collided with the pressures to increase bit rates so as to accommodate data and multimedia applications, the interest in improving the spectral and power efficiencies became acute. Hence MIMO concept have been introduced, such that it amounts to the transmission of concurrent signals, from multiple antennas at one end of the link, with multiple antennas also at the receiving end. Although MIMO is defined as the incorporation of the space domain to the communication process, this is not quite precise. The space domain is the core of the

wireless systems and it is inherent to the concept of a cellular network.

II. EXISTING SYSTEM OF COMMUNICATION

Communication networks have become an integral part of our society for faster and reliable exchange of information. Wireless Sensor Networks (WSN) is a variant of wireless communication and patient care to a smart home system etc. Sensor network technologies and research outputs are often used under different domains such as Body Area Networks (BAN), Internet of Things (IoT), Machine-to-Machine communications, Sensor Cloud Infrastructure, Cyber-Physical Systems, Real time location systems etc. In today's world of technology, MIMO technology is mostly available in smartphones which is used by most of the people. Smartphones are one of the coolest, most useful and convenient electronic devices of all time. Since all smartphones have inbuilt transreceiver with (2x2 MIMO) two inputs and two outputs, it will be easier for the user to send and receive data.

Some of the limitations of the smartphones are power consumption and type of antenna used. It mainly requires Wi-Fi devices to have multiple antennas in order to support the sending and receiving of multiple data streams. The majority of Wi-Fi devices are especially in smartphones because the additional antennas and signal processing requires more space and power in the mobile devices, which adds extra cost and requires more power from the battery.

The concept of multiple antennas can be traced back long ago. In 1960's, antenna array was applied in military radar systems for signal copying , direction finding and signal separation. These signal parameter estimations need high resolution. Many algorithms have been proposed in this field such as maximum likelihood (ML) based approach and maximum entropy(ME) based approach. The main limitations of these approaches are the bias and high sensitivity. Many schemes have been proposed in order to achieve high performance with significantly reduced complexity.

III. PROPOSED SYSTEM OF COMMUNICATION

The wireless technology we used is a new, advanced and improved technology named ZigBee, which is an IEEE802.15.4 standard. In this system in place of 1 sensor could be used 8sensors can be used. ZigBee is far better than compared to any other wireless technology available like Bluetooth, wifi. ZigBee is designed to consume very low power which is cost-effective and provides a wide range like 100m. WiFi and ZigBee both have their positive qualities, but they obviously come with negatives. It also has a low-channel bandwidth of 1MHz.. It is restricted to wireless personal area networks (WPAN) and reaches an average 10 to 30 meters for usual applications. Maximum speed of ZigBee is just 250kbps, which is much lower than the lowest speed of WiFi offers. ZigBee's best quality is its low power-consumption rate and battery life. For 2x2 MIMO, which is mostly used in smartphones , the transmission speed becomes two times faster than the Single Input Single Output(SISO) LTE and for 4x4 MIMO, the transmission speed becomes four times faster than the SISO LTE at maximum. In this practical environment, the throughput enhancement can be lower than the maximum gain according to the channel environment. Especially when the signal-to-noise (SNR) is low, the gain is going to lower than the maximum because the rank of the MIMO channel is smaller than the maximum gain value. Zigbee provide security tools allowing its member companies to create some of the most secure wireless devices. Its security is based on symmetric-key cryptography, in which two parties must share the same keys to communicate and it also supports frequency agility, in which its network is relocated in case of a jamming attack.

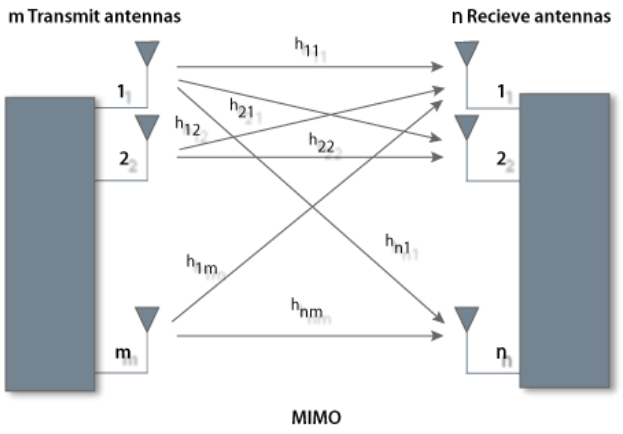

Figure 1 - Basic block diagram of MIMO

IV. FEATURES OF MIMO

Nowadays, multiple-input multiple-output(MIMO) systems have become one of the trending research topics due to the magnificent enhancement brought by multiple antenna techniques. The possibility to deploy multiple antennas at both sides of the communication link lies on the following facts.

- The developments in hardware miniaturization and advancement in antenna design make the deployment of multiple antennas at the mobile systems more feasible.
- Wireless applications like wireless local area network(WLAN) and fixed wireless access(FWA) allow large physical sized devices that can afford multiple antennas.

In contrast, MIMO can be employed to achieve both transmit and receive diversity and make the system throughput increase linearly with the minimum number of the transmit and receive antennas. However some of the modern wireless communication systems, such as the 3rd Generation Partnership Project (3GPP) and Long Term Evolution (LTE) employ transmission technologies that brought the rates of point-to-point communications close to the channel capacity.Quick popularization of data-thirsty applications supported by smartphones and computers has led to an unprecedented demand for high spectral efficiency. Some of the alternatives have been introduced to increase the system capacity are the expansion of spectrum, the sophistication of transceivers with multiple antennas, the increase of cell density and the introduction of co-ordination and co-operation among users.

Recently, the 3GPP organization introduced their work on developing a framework for the evolution of the radio-access technology toward a high data-rate and low-latency in its LTE Advanced system. It has a wide range of services from satellites that provide low bit rates,cellular systems with continental coverage to high bit rate local area networks to personal area networks with a maximum range of 10 to 100 meters. In the near future, we will expect seamless global roaming across different wireless networks and access to personalized applications via universal and user-friendly interface.

A number of researchers have pointed out the substantial capacity advantages available in wireless systems using multiple transmit/receive antennas. The use of multiple antennas has been a recent significant breakthrough in wireless technologies, as it creates a MIMO channel in which each path from one transmit antenna to one receive antenna can be viewed as one signaling branch. Thus more than one signaling branch can be formed based on the requirements and signal capacity of the systems. A simple transmit diversity scheme for two transmit antennas was first proposed by Alamouti. The scheme is mainly for the improvement in the quality of transmissions in wireless communication systems. Based on that, maximum transmission rate and significant bandwidth efficiency can be obtained.

V. SYSTEM ANALYSIS

Some of the benefits of MIMO technology that help achieve significant performance gains are array gain, spatial diversity gain, spatial multiplexing gain and interference reduction.

ARRAY GAIN - It is the increase in receive SNR that results from a coherent combining effect of the wireless signals at a receiver. It improves resistance to noise and coverage range of the wireless networks.

SPATIAL DIVERSITY GAIN - Fading of the signal level at a receiver in a wireless system can be reduced with the help of spatial diversity gain. It can be realized by multiple copies of the transmitted signal in space, frequency or time such that it improves the quality and reliability of the signal reception.

SPATIAL MULTIPLEXING GAIN - MIMO systems offer a linear increase in data rate through by transmitting multiple independent data steams within the operational bandwidth. The number of data streams that can be reliably supported by a MIMO channel which increases the capacity of a wireless network.

INTERFERENCE REDUCTION AND AVOIDANCE - It results from multiple users sharing time and frequency resources. Interference may be mitigated in MIMO systems by exploiting the spatial dimension to increase the separation between users. Thus interference reduction and avoidance improve the coverage ad range of a wireless network.

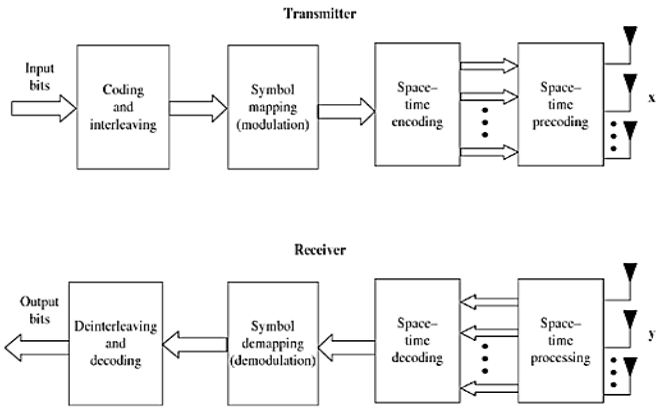

Figure 2 - Basic MIMO communication system with x and y stand for transmitted and received signal

The information bits to be transmitted are encoded and interleaved. The interleaved codeword is mapped to data symbols by symbol mapper. These data symbols are input to a space-time encoder that outputs one or more spatial data streams. The signals launched from the transmit antennas propagate through the channel and arrive at the receive antenna array. The receiver collects the signals at the output of each receive antenna element and reverses the transmitter operations in order to decode the data: receive space-time processing, followed by space-time decoding, symbol demapping, deinterleaving and decoding. Each of the building blocks overcomes significant design challenges and complexity-performance tradeoffs. It mainly addresses key concepts and challenges in designing and understanding the performance limits of a MIMO communication system.

Both of the Smart-antenna and MIMO systems are multiple antenna systems but fundamentally different in practical environment. Smart antenna technology uses beam forming technology at transmitter end (Figure 5.3.1) and receive combining technology at the receiver end (Figure 5.3.2) to enhance the traditional one dimensional wireless communication systems. In the place of antennas, we have implemented sensors for better performance of communication of data bits between two ends of the system.

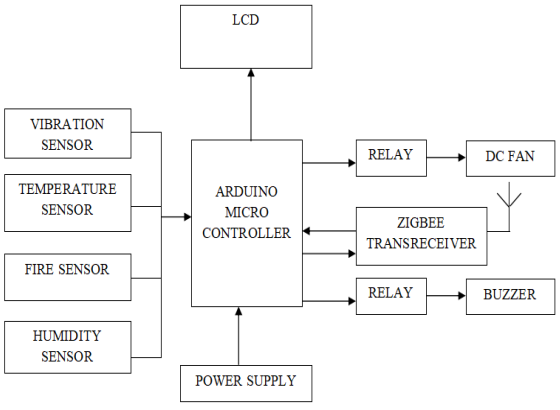

Figure 3 - Transmission section of MIMO

It consists of all the advantages of MIMO systems with many fold increased data throughput. It is a low cost and low power communication system. Multiple

antenna systems combined with multi-carrier systems gives tremendous performance for a wireless communication system. MIMO-OFDM using different kind of FFT algorithms is practically very much useful in 4G communication systems. With improved features of conventional OFDM systems integrated with large scale MIMO named as Massive MIMO-OFDM is one of the most capable techniques for wireless communication systems of future generation (like 5G).

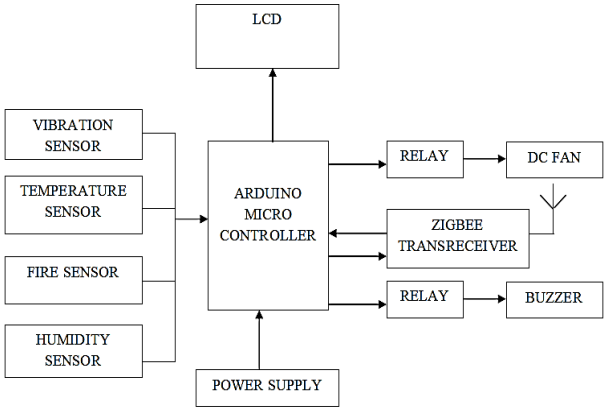

Figure 4 - Reception section of MIMO

VI. WORKING

The sensors are connected to the controller and each node as four sensors to indicate as multi input and four outputs to indicate as multi outputs.The temperature sensor is used for the identification of temperature and based on that the DC fan will be ON in the other node. The Humidity and vibration sensor values are transferred to the other node and it is displayed in the LCD of the other node.The fire alarm detects the fire and based on that the buzzer is intimated in the other node. These operations are done in vice versa manner for representing MIMO and all these are done in one antenna. For transfer of data, the ZigBee transreceiver are used for data transmission and reception.The multiple signals arrive at the receivers at different times in different phases, depending on the different paths they take. Some signals will be direct, others via multiple different paths.Higher throughput performance can be achieved with a high SNR while low data rate with low SNR. The low data rate will prolong the transmission period of packets, which reduces the throughput and wastes energy. The advantage of this system is good for High traffic load in advance control application that need high data rate, flexibilities, and robust.

VII. CONCLUSION

With modern smartphones, we nowadays have access to almost every place on the planet and beyond. This project elaborates the information theoretical background for MIMO wireless communication systems. The MIMO capacity is simply explained, which showed the dramatically increased capacity and reliability as compared with conventional single - input single-output systems (SISO). With the growing data rates that can be delivered and the possibilities for new applications came along with the demand of faster connection. This is mainly due to higher data rates encourage a more excessive usage of more high-bandwidth applications. It is expected that this type of communication (4x4 MIMO) will play an important role in the future. With the evolution of the mobile telecommunication standards from the first (analog) and second (digital) generation to the third and fourth generation (3G and 4G). Future network of the fifth generation (5G) and beyond will have to deal with the improvement of existing technologies by providing data rates that are higher than today's systems and also have to guarantee high reliability and extensive coverage.

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