COOPERATIVE BEAMFORMING FOR WIRELESS SENSOR NETWORK

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Special dedication to my beloved father and mom, my entire sibling and my kind hearted Mr. Mohd.Riduan B. Ahmad, and all my dearest friends.

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ABSTRACT

Wireless sensor network are being employed in variety application ranging from medical to military and many application. The principle that been used in this research is a collaborative Beamforming for wireless sensor network. The multiple inputs multiple output (MIMO) Beamforming is introduce to maximize the signal to noise ratio based on the weight vector at the transmitter and receiver. Collaborative Beamforming has already demonstrated and many researchers have been done to prove its potential of significant power saving in distributed sensor network. In collaborative Beamforming, the antennas of the sensor nodes form a distributed antenna array in an effort to direct the radiated energy to the desired direction and thus increase the overall power efficiency of the network.

In these research will focus on the energy consumption and the delay introduce by the collaborative Beamforming. This done based on the wireless communication systems; the transmitted signal is distorted by fading and interference. Because of these distortions, the recovery of the transmitted data is difficult. However, by applying collaborative Beamforming will improve the bandwidth efficiency and reliability of the system. Moreover, the diversity techniques are well known techniques to improve reliability of the wireless transmission system. Hence, energy and the delay introduce by these technique is analyze and see the performance of these technique.

ABSTRAK

Jaringan pengesan tanpa wayar telah banyak digunakan di dalam pelbagai aplikasi dari kesihatan, ketenteraan dan sebagainya. Prinsip yang digunakan di dalam kajian ini adalah Beamforming teknik di dalam jaringan pengesan tanpa wayar. Beamforming menggunakan pemberat pada transmitter yang dapat memaksimumkan nisbah signal kepada bisingan. Kerjasama Beamforming telah didemonstrasikan oleh ramai pengkaji dan telah membuktikan bahawa teknik Beamforming berpotensi untuk menjimatkan tenaga di dalam taburan jaringan pengesan wayar. Di dalam kerjasama Beamforming antenna pada jaringan pengesan tanpa wayar dapat menumpukan radiasi tenaga kepada tempat yang di tuju. Secara tidak langsung dapat meningkatkan bekerkesanan tenaga di dalam sistem.

Kajian ini akan focus kepada penggunaan tenaga dan masa tundaan oleh teknik Beamforming. Tenaga dan masa tundaan akan dianalisis dan keupaayan teknik ini akan dibincangkn.

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ADC	Analog to digital converter
BF	Beamforming
BPSK	Binary Phase Shift Keying
BER	Bit error rate
DAC	Digital to analog converter
PER	Packet Error Rate
PT	Transmit power
SM	Spatial multiplexing
SNR	Signal to noise ratio
STBC	Space time block coding
WSN	Wireless Sensor Network
MIMO	Multiple Input Multiple Output
SISO	Single input single output

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CHAPTER 1

INTRODUCTION

1.1 Project Background

A sensor network is an infrastructure comprised of sensing (measuring), computing, and communication elements that gives an administrator the ability to instrument, observe, and react to events and phenomena in a specified environment. The administrator typically is a civil, governmental, commercial, or industrial entity. The environment can be the physical world, a biological system, or an information technology (IT) framework. Network sensor systems are seen by observers as an important technology that will experience major deployment in the next few years for a plethora of applications, not the least being national security. Typical applications include, but are not limited to, data collection, monitoring, surveillance, and medical telemetry. In addition to sensing, one is often also interested in control and activation. The sensors are constrained devices because periodical recharge or replacement of batteries is not practical. Because of the characteristic of the sensor network, the sensor should be design cheap, simple, and highly energy efficiency. One way to improve, the sensor network performance is to integrate the Beamforming capability in all sensors.

Integration of Beamforming to sensor network is very beneficial for a reduction of transmission power consumption and for improvement to the overall

system performance. This project focuses on the designing and development of cooperative Beamforming coding for wireless sensor network in Matlab Simulink. The result will be analyzed and compared with existing technique of non-cooperative technique in terms of bit error rate, energy consumption and delay. Moreover, this project aims to study the performance of this technique on certain parameter and compared to other transmission technique in wireless network for example Spatial multiplexing technique.

The objectives of this project are:

- To design and simulate the digital Beamforming coding in Matlab Software and do observation of performance in term of energy consumption and delay.

- To compare the performance of digital Beamforming with non-cooperative system in term of energy consumption and delay.

1.2 Scope of Works

The work scopes of this project are to do research on the performance of the digital Beamforming technique for wireless sensor network in terms of bit error rate energy consumption and delay. This research is divided into three phase.

- The first phase involves, designing the digital Beamforming coding for wireless sensor network in Matlab software.

- Next, the simulation process will take place for the coding of the digital Beamforming in the Matlab.

- Finally the data is analyzed and monitored in the form of graphs. The bit error rate, energy and delay characteristic is monitored and analyzed from the graph plotted.

1.3.1 Problems Statement

The non-cooperative system in wireless sensor network can be describes as two nodes are transmitted and receive through a channel or link. If the channel fails, the transmitted packet can be lost or dropped. In the other word there are no back up nodes to do the transmission and reception. By improving the system, the cooperative system is introduced to transmit and receive the data in the cooperative way which is mean the transmission and receiving process are done through several channels in the same time. This will give the better performance for the wireless sensor network in terms of the energy consumption and delay.

Moreover, a major design requirement of WSN is to reduce the total energy consumption of the sensor node. This is because the sensor itself depends totally on the battery for it energy supply which cannot sustain for a long period. Thus, the energy efficient is must in order to minimize the energy and power consumption. Hence, the power consumption can be reduced by using Beamforming technique. Cooperative Beamforming is one of MIMO which have multiple sensors cooperatively transmit the data and allowing the sensor to share the transmission power while providing a directivity gain and the energy can be reduced.

1.4 Thesis Organization

This thesis is divided into 5 chapters. Chapter 1 is introduction which contains the project background, objective, scopes or work and problem statement. Next, chapter 2 is literature review. In the literature review, would study the wireless sensor network, multiple input multiple output (MIMO), Beamforming technique and the briefly explanation on the analysis parts. The third chapter explained the method or approaches which are used in order to the analysis. Result and discussion of this project will be explained in the fourth chapter. The result is analyzed in term of Bit Error Rate (BER), Delay and energy consumption. Last chapter of this thesis is the conclusion for overall project done.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter will discuss on the wireless sensor network, Multiple input multiple output (MIMO) and the Beamforming technique in wireless sensor network.

Recent advances in process technologies and the shrinking sizes of radio telecommunication devices and sensor allowed researchers to combine the three operations which is sensing, communicating and computing into tiny devices called wireless sensor networks (WSN). Today, there are a vast number of application scenarios involving WSN in business, military, medical and science.

However, to get the best performance in term of energy consumption and delay, the MIMO system is introduce in the WSN. Multiple sensor nodes can be used to transmit and receive cooperatively and such a configuration is known as cooperative Multiple Input Multiple output (MIMO) system. Cooperative MIMO systems have been proved to reduce both transmission energy and latency in WSN. One of the three major cooperative MIMO systems is Beamforming, Spatial Multiplexer and Space Time Block Coding [1].

Collaborative Beamforming are one of the MIMO techniques which introduce the low power wireless sensor network and present its energy saving potential. This is happened when the diversity occur in Beamforming technique allows power to be save which is distributed over the network. On the other word the energy is equally distributed to each sensor.

2.1 Wireless Sensor Network

Wireless communication is the transfer of information over a distance without the use of electrical conductors or "wires". A wireless sensor network (WSN) is a wireless network consisting several sensor device to do a monitoring of the physical or environment condition. Normally the sensor device can detect the changes of temperature, sound around the sensor surrounding, the vibration and motion in a certain range. The development of wireless sensor networks was originally motivated by military applications such as battlefield surveillance. However, wireless sensor networks are now used in many industrial and civilian application areas, including industrial process monitoring and control, machine health monitoring, environment and habitat monitoring, healthcare applications, home automation, and traffic control [2].

The figure 2.1 shows the complexity of wireless sensor networks, which generally consist of a data collected network and a data distribution network, monitored and controlled by a management center.

A communication network is composed of nodes, each of which has computing power and can transmit and receive messages over communication links, wireless or cabled. The basic network topologies [3] are shown in the Figure 2.2 and include fully connected, mesh, star, ring, tree, bus. A single network may consist of several interconnected subnets of different topologies.

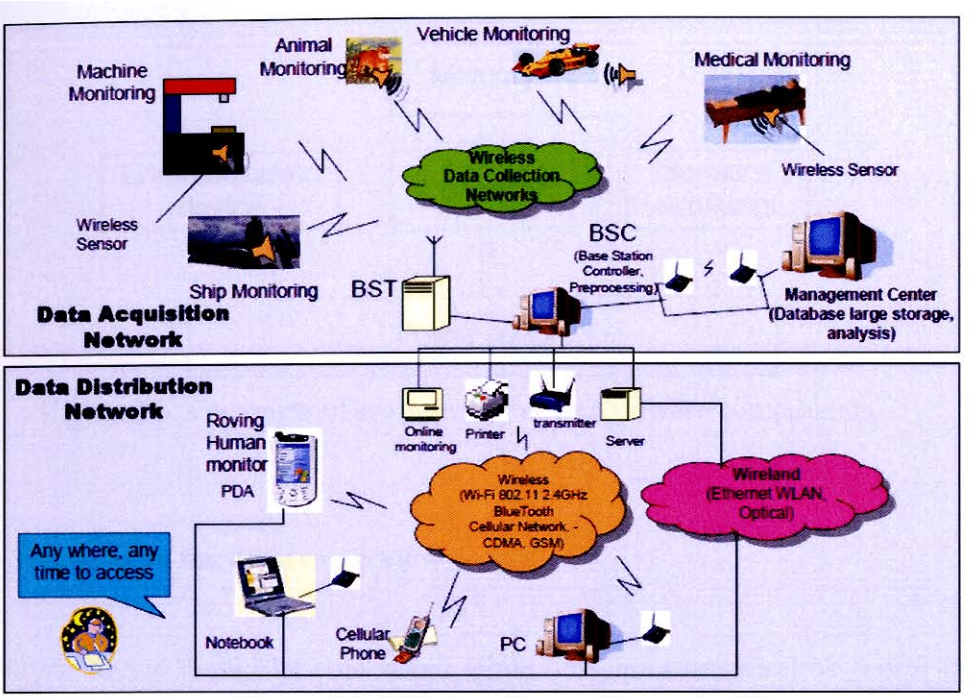

Figure 2.1: Wireless Sensor Networks [2]

2.1.1 Network Topology

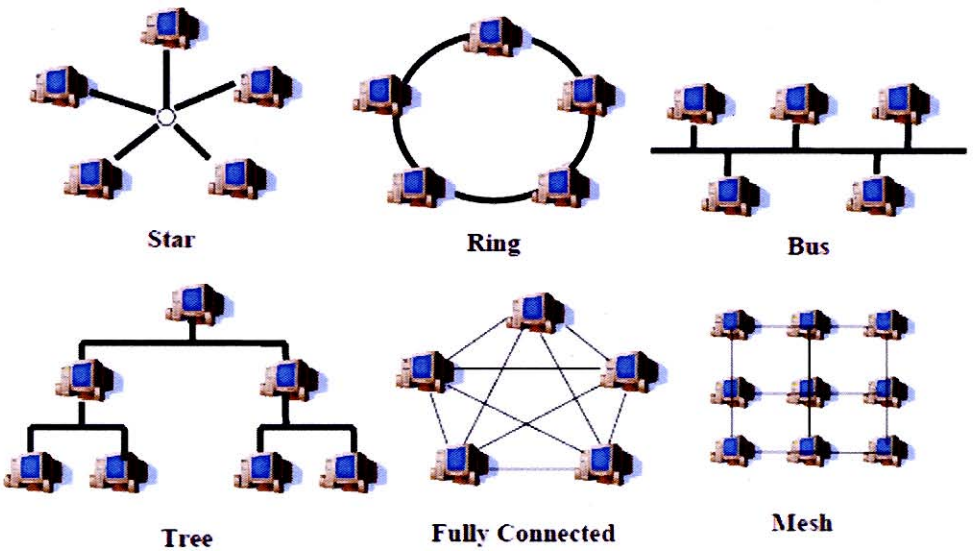

Figure 2.2 : Basic network topology for communication network [3]

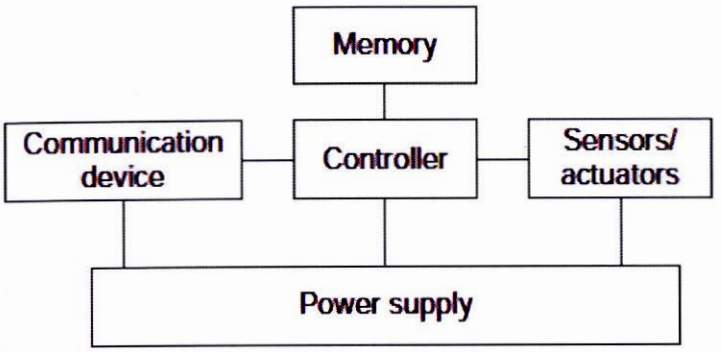

Figure 2.3: Overview of main sensor node hardware components

2.1.2 Sensor note hardware overview

Some factor should be considered while designing the wireless sensor note. The hardware component for wireless sensor node, the application requirement plays the main factor with regard mostly to size, cost and energy consumption of the nodes[4]. Figure 2.3 below are the 5 main components. One sensor node consists of controller, communication device, memory, sensor actuators and power supply.

i) Controller

A controller to process all the relevant data, capable of executing arbitrary code. The controller is the core of a wireless sensor node. It collects data from the sensors, processes the data, decides when and where to send it, receives data from other sensor nodes, and decides on the actuator's behavior. It has to execute various programs, ranging from time-critical signal processing and communication protocols to application programs; it is the Central Processing Unit (CPU) of the node. These processors are commonly referred as microcontroller. Microcontrollers are practically suited to embedded systems are their flexibility in connecting with other devices or sensor. In addition, they are freely programmable and hence very flexible. Microcontroller are also suitable for WSN since they are commonly have the possible to reduce their power consumption by going into 'sleep states' where only parts of the controller are active.

ii) Memory

Memory is used to store programs and intermediate data. Usually, different types of memory are used for programs and data. Random Access Memory (RAM) is needed to store intermediate sensor readings, packets from other nodes. The main disadvantage of this memory is the data might be loss if the power supply is interrupted while The RAM is running fast. Flash memory can also serve as intermediate storage of data in case RAM is insufficient or when the power supply of RAM should down for some time. The long read and write access delay of flash memory should be taken into account as well as the high required energy.

iii) Communication Device

The communication device is used to exchange data between individual nodes. In some cases, wired communication can actually be the method of choice and is frequently applied in many sensor networks like setting using field buses. Radio frequency (RF) based communication is by far the most relevant one as in best fits the requirements of WSN application. It provides relatively long range and high data rate, acceptable error rates at reasonable energy expenditure and does not require line of sight between sender and receiver. For a wireless, RF based system the carrier frequency has to be carefully chosen. The frequency required is 433MHz and 2.4GHz.

iv) Transceiver

For actual communication, both transmitter and receiver are required in a sensor node. Transceiver task is to convert a bit stream coming from the microcontroller or a sequence of bytes or frame and convert them to and from radio waves. For practical purpose, it is usually convenient to use a device that combines these two tasks in a single entity. Such combined devices are called transceiver. In order to keep the total cost and complexity of sensor network at reasonable level, the sensors are usually designed to be broadcasting devices. That is, they do not have receiving capability. The access points can be directly pickup the signal and use data fusion to extract information for the collected data. In addition to the coded