CHAPTER ONE
Introduction

1.1 Background

Wireless communication is, by any measure, the most vibrant area and fastest growing segment of the communication field today. It has now become an integral part of people's daily life and a critical business tool. Moreover, the popularity of wireless communication is set to increase with the development of various new wireless systems and applications, such as Wi-Fi network (also known as IEEE 802.11).

The IEEE 802.11 technology has been implemented to provide various network services, for example, home and personal applications, internet hotspot service and bridge for different wired or wireless networks. Another implementation is Wi-Fi based long distance networks, The unlicensed Wi-Fi spectrum and a variety of commodity IEEE 802.11 hardware make Wi-Fi an attractive communication method because of its wide availability and low cost, however, extending the range is one of the main issues that faces this networks, one of the technologies that help solving this problem is MIMO.[1]

Multi-Input Multi-Output (MIMO) antenna systems have been the subject of intensive study in recent years [2, 3, 4, 5] and have been incorporated in communication system standards. Commercial products employing MIMO technology are available at this time.

Much of discussion of MIMO revolves around its remarkable ability to increase the capacity of the system in proportion to the number of antennas being used [6], by performing spatial multiplexing. While capacity is a key performance measure of wireless systems, a no less important measure is the range of the communication link over which communications at a specified data rate can be sustained. It is generally understood that increased capacity can be traded off against increased range. In other words, instead of using the MIMO system to its full

capacity it can be operated at a lower data rate, and a correspondingly lower required signal-to-noise ratio (SNR), which means a longer range. However, somewhat surprisingly few specific results on this important issue seem to be available (see [7] which studies a closely related issue). The objective of this thesis is to study the range increase afforded by a MIMO system compared to a Single-Input Single-Output (SISO) system.

1.2 Problem Statement

Wi-Fi is one of the most popular and cheapest wireless technology, however the short distance of this technology is one of the problematic issues that faces the technology when being applied in many applications. There are many techniques by various researchers were proposed recently to help extending the distance, such as increasing the transmit power, however this technique can work for some application well and fail in other application ,For example it fails for line of sight (LOS) links in rural areas such as highways where there is limitation on increasing transmit power.

Case study: The speed enforcement radar of traffic police in Sudan need to report captured images to the server at the main center. The working scenario of their mobile radar is that they use 3G network to transmit the violation ticket from the first node that capture the violation, then forward it to the central server, then to the second node. The problem with such scenario is that many locations in the highway not covered with 3G network.

1.3 Proposed Solution

The proposed solution considers establishment of point to point link between the first node and the second node to facilitate the transmission of data with the absence of 3G network, the solution aim to achieve the maximum possible range with reliable data rate, by using Wi-Fi technology and MIMO antennas, and to examine extensively the ability of various MIMO antenna systems to increase the range.

1.4 Aim and Objectives

The main aim of this project is to study the range increase afforded by a MIMO system compared to a Single-Input Single-Output (SISO) system. and that is achieved by the following objectives:

- Evaluating the SNR with increasing distance.
- Evaluating the channel capacity with increasing distance for MIMO systems with different numbers of antennas.

1.5 Methodology

Doing a compression between propagation models to compute the path loss $PL(d)$, then it will be proceeded as follows. For a given distance D, The SNR and the capacity of the channel will be evaluated. The capacity vs. range functions will be evaluated. The software that will be used is MATLAB for simulation.

1.6 Thesis outlines

This thesis consists of five chapters described as follow:

Chapter Two: Contains a background of Wireless Communication, Propagation and Fading of The Wireless Channel and MIMO Antenna System.

Chapter Three: Discusses path loss, SNR and capacity equations, and their parameters has been described in details; describe the methodology used to study the capacity vs. range tradeoff.

Chapter Four: Present a series of numerical examples illustrating the capacity vs. distance tradeoff for different cases.

Chapter Five: States the conclusion and proposes recommendation for future work.