PERFORMANCE ANALYSIS OF RADIO OVER FIBER BASED ON IEEE 802.11a

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To my beloved husband

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ABSTRACT

In future wireless communication system, the essential for increased capacity per unit area leads to higher operating frequencies and smaller radio cells. To reduce the system installation and maintenance cost of such system, it is very important to make the Remote Access Point (RAP) or Base Station (BS) as simple as possible. This may be achieved by consolidating signal processing functions at central station (CS). This is the reason why Radio over Fiber (RoF) is introduced. RoF technology entails the use of optical fiber transmission link to distribute Radio frequency (RF) signals from a CS to BS. The purpose of this project is to analyze the performance of a RoF system based on IEEE 802.11a standard by experiment. The idea of employing IEEE 802.11a standard is due to several advantages: the low cost of equipment, its operation in the unlicensed spectrum and its higher data rates. However, original IEEE 802.11a standard is designed for service range of less than 1km. So, it cannot provide a high speed link for long distance. Fortunately, this problem is more on the Medium Access Control (MAC) layer only. By modifying the parameter in the MAC layer, it is possible to overcome the problem. A RoF system design is proposed in this project by using one of the modified protocols. The results show that the performance of the proposed system is excellent for more than 5km of service range. Previous study has been shown that the standard IEEE 802.11a MAC protocol working procedure is feasible for point to point links of up to 2.7 km only when IEEE 802.11a technology is used. Combining the results, it is concluded that a RoF system based on IEEE 802.11a with higher speed and longer distance is achievable.

ABSTRAK

Dalam sistem komunikasi tanpa wayar masa hadapan, keperluan untuk menambahkan kapasiti per unit kawasan membawa kepada frekuensi operasi yang lebih tinggi dan sel radio yang lebih kecil. Untuk mengurangkan kos pemasangan dan penyelenggaraan sistem, adalah penting untuk stesen tapak (BS) menjadi seringkas yang boleh. Ini dapat dicapai dengan menjalankan semua fungsi pemprosesan isyarat di stesen pusat (CS). Oleh sebab inilah, radio atas gentian (RoF) diperkenalkan. Teknologi RoF melibatkan penggunaan talian penghantaran gentian optik untuk menyebarkan isyarat frekuensi radio (RF) dari CS ke BS. Projek ini bertujuan untuk menganalisa perlaksanaan system RoF berdasarkan piawai IEEE 802.11a secara eksperimen. Idea menggunakan piawaian IEEE 802.11a adalah kerana beberapa kelebihan: kos peralatan yang rendah, beroperasi pada spektrum tanpa lesen dan kadar penghantaran data yang lebih tinggi. Walau bagaimanapun, pada mulanya piawaian IEEE 802.11a direkabentuk untuk jarak operasi kurang dari 1km. Oleh itu, ia tidak boleh melakukan penghantaran untuk jarak yang jauh. Tetapi, masalah ini hanyalah pada lapisan kawalan akses media (MAC). Dengan mengubah parameter dalam lapisan MAC, masalah ini mungkin boleh diatasi. Satu rekabentuk sistem RoF dicadangkan dalam projek ini dengan menggunakan salah satu protokol yang telah diubahsuai. Keputusan menunjukkan perlaksanaan sistem yang dicadangkan adalah cemerlang sehingga melebihi jarak 5km. Kajian sebelum ini telah menunjukkan prosedur kerja IEEE 802.11a boleh melakukan penghantaran isyarat titik ke titik sehingga 2.7km. Bila semua keputusan diambilkira, dapatlah disimpulkan bahawa sistem RoF menggunakan IEEE 802.11a dengan kelajuan yang lebih tinggi dan jarak yang lebih jauh dapat dicapai.

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LIST OF ABBREVIATIONS

RAP	-	Remote Access Point
BS	-	Base Station
CS	-	Central Station
RS	-	Remote Station
RoF	-	Radio over Fiber
MU	-	Mobile Unit
WTU	-	Wireless Terminal Unit
BB	-	Base Band
IF	-	Intermediate Frequency
RF	-	Radio Frequency
DCF	-	Distributed Coordination Function
MAC	-	Medium Access Control
2G	-	Second Generation
3G	-	Third generation
CDMA	-	Code Division Multiple Access
GPRS	-	General Packet Radio Service

WLAN	-	Wireless Local Area Network
SMF	-	Single Mode Fiber
EMI	-	Electromagnetic Interference
NF	-	Noise Figure
DR	-	Dynamic Range
RIN	-	Relative Intensity Noise
OFDM	-	Orthogonal Frequency Division Multiplexing
BER	-	Bit Error Rate
AM	-	Amplitude Modulation
FM	-	Frequency Modulation
PM	-	Phase Modulation
ASK	-	Amplitude Shift Keying
FSK	-	Frequency Shift Keying
PSK	-	Phase Shift Keying
OOK	-	On-off Keying
BB	-	Baseband
PD	-	Photodiode
IMDD	-	Intensity Modulation Direct Detection
PSTN	-	Public Switched Telephone Network
LD	-	Laser Diode
EOM	-	External Optical Modulator
MH	-	Mobile Host
SDRAM	-	Synchronous Dynamic Random Access Memory
DDR	-	Double Data Rate
CPU	-	Central Processing Unit

LIST OF SYMBOLS

km	-	Kilometer
μs	-	Microsecond
nm	-	Nanometer
mm	-	Milimeter
G	-	Giga
H	-	Hertz
T	-	Tera
dB/km	-	Decibels per Kilometer

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CHAPTER 1

INTRODUCTION

1.1 Project Background

In cellular networks, the current trends now are to reduce cell size to accommodate more users and to operate in the microwave/millimeter wave frequency bands to avoid spectral congestion in lower frequency bands. This requires a large number of base stations (BS) to cover a service area. The base station also must be cost effective to make it success in market. This requirement has led to the development of system where functions such as signal routing or processing, handover and frequency allocation are carried out at a central control station (CS), rather than at the BS. An interesting way for connecting a CS with BSs in such a radio network is through an optical fiber network, since fiber has low loss, immunity to EMI and broad bandwidth. The radio signals from CS are transmitted over optical fiber and will be radiated by remote antennas. The cost is reduced since the BS or Remote Station (RS) needs to perform only simple functions, and it is in small size. Besides that, the resources provided by the CS can be shared among many antenna BSs. This technique of modulating the radio frequency (RF) subcarrier onto an optical carrier for distribution over a fiber network is known as radio over fiber (RoF) technology [1].

Interest in RoF network has been gaining increasing popularity for RF distribution networks. This project examines the link transmission quality and performance characteristics of RoF between the CS and RS by experiment. The signal used in this project is 5GHz signal compliant to IEEE 802.11a standard. Signal strength, speed and throughput of the experimental link are presented as a performance indicator to show the effectiveness of RoF signal distribution. A proposed system of RoF based on IEEE 802.11a is used for this purpose.

1.2 Problem Statement

Figure 1.1 illustrates the configuration of narrowband wireless access systems (e.g. GSM). The central office handles call processing and switching, while the Base Stations (BS) act as the radio interfaces for the Mobile Units (MU) or Wireless Terminal Units (WTU). The BSs may be linked to the central station (CS) through either analogue microwave links or digital fiber optic links. Once the baseband signals are received at the BS, they are processed and modulated onto the appropriate carrier. The radius covered by the signal from the BS is the cell radius.

All the MU/WTU within the cell, share the radio frequency spectrum. In general, low carrier frequencies offer low bandwidth. Low-frequency RF signals allow for larger cells, due to the longer reach of the radio waves. The larger cells enable high mobility, but lead to poor spectrum efficiency, since the spectrum is shared by all MUs/WTUs operating within the cell. Therefore, for broadband wireless communication systems to offer the needed high capacity, it appears inevitable to increase the carrier frequencies and to reduce cell sizes [2].

The need for increased capacity per unit area leads to higher operating frequencies (above 6GHz) and smaller radio cells. To reduce the system installation and maintenance costs of such system, it is imperative to make the remote access point (RAP) as simple as possible. This may be achieved by consolidating signal processing functions at a centralized headend or central station. Because of this, RoF technology is introduced and IEEE 802.11a is a very attractive standard due to several advantages.

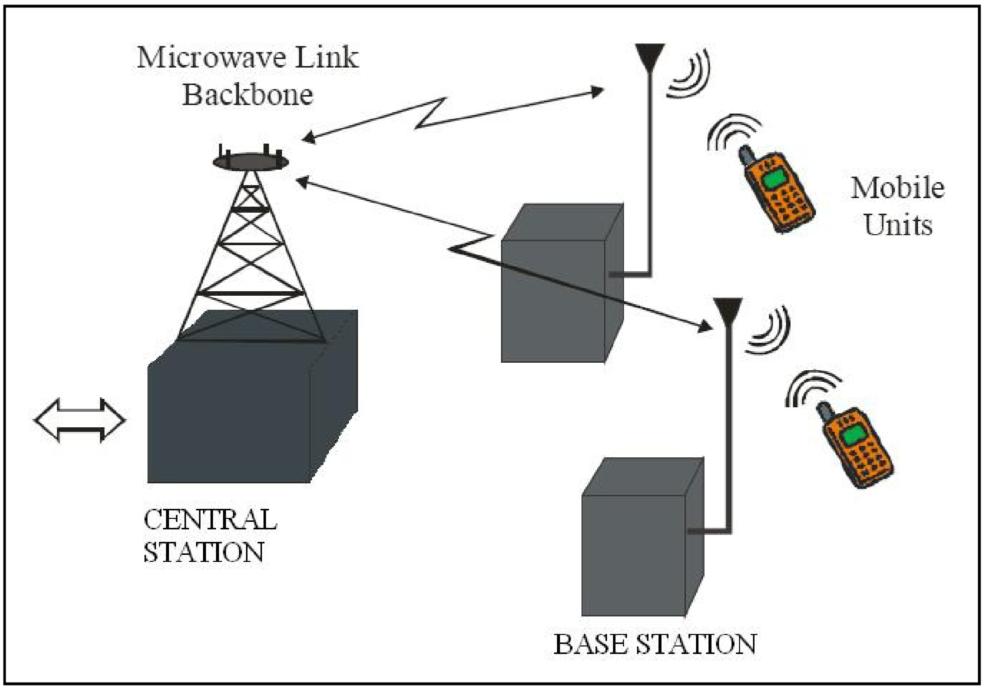

Figure 1.1: Components of a narrowband wireless access network [8]

However, in RoF systems, the longer the fiber length the higher the delay imposed to the system. For example, using 1km of fiber introduces approximately 5µs of delay to each packet that passes through. This extra propagation delay poses a challenge to the system design since this delay exceeds the 1µs propagation delay boundary defined in the IEEE 802.11 standard where only wireless propagation is assumed [6]. As a result, the performance of the distributed coordination function (DCF) of the medium access control (MAC) layer may degrade significantly or even break down entirely. It is noted that network fails long before physical layer limitations due to the timeout values defined within the MAC protocol.

1.3 Objective

The objective of this project is to analyze the performance of RoF system by experiment. A proposed system of RoF is used for this purpose. The performance parameter such as signal strength, speed and throughput is measured by experiment. The measurement of the performance parameter is analyzed.

1.4 Scopes

In order to achieve the objective of this project, there are following scopes will be covered:

(i) To study and understand the concept of RoF system.
(ii) This project will focus on set up and analyze the performance of RoF system.
(iii) The equipments that will be used for the experiment are recognized.
(iv) The analysis will be carried out by experiment.

1.5 Project Report Outline

The project report consists of six chapters which include Introduction; RoF Technology; IEEE 802.11 WLAN Protocol; Research Methodology; Results and Analysis, and finally Conclusion and Future Works.

For Chapter Two, RoF technology, will explain about the introduction of RoF, its advantage, its application and its optical transmission link.

In Chapter Three, IEEE 802.11 WLAN standards will cover about the characteristics of IEEE 802.11 standards, the IEEE 802.11 MAC protocol and the feasibility of applying RoF into WLAN standard. Besides that, this chapter also shows brief explanation about current and past researches regarding the issue on this project.

Chapter Four is explained about the research methodology. While Chapter Five shows the result and analysis of this project. And lastly, the conclusion and future work are stated in Chapter Six.

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