UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Frequency Reuse in Orthogonal Frequency Division Multiple Access Network

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor`s Degree in Electronic Engineering Technology (Telecommunication) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering Technology (Telecommunications) (Hons.). The member of the supervisory committee are as follow:

………………………………..

(Project Supervisor)

Win Adiyansyah Indra

ABSTRACT

Telecommunication technology plays a vital role in everyone`s life. It becomes one`s necessity in life. In this millennium era, the number of telecommunication users increases drastically without any age limit. People have been frustrated, when the performance of the network does not fulfil their expectations. This leads to a dissatisfaction. Interferences between the cells is the root cause of this problem. Interferences occur when different customers are utilizing the same portion of the frequencies at the same geographic area and time. In this research, the focus would be on how to overcome this problem and also to improve the network performance. Since the recent technology that`s being newly introduced in Malaysia is 4G, so this project will focus on overcoming interferences in OFDMA Network. OFDMA provides flexibility in the development of frequency bands in a systems such as LTE and LTE Advanced. Fractional Frequency Reuse (FFR) is a method that is chosen to overcome interferences between cells in this research. FFR offers an alternative solution to the frequency reuse problem in multicellular OFDMA networks. FFR is developed as a flexible frequency reuse scheme to strike a better trade-off between spectral efficiency and interference mitigation than the generic frequency reuse.

ABSTRAK

Teknologi telekomunikasi memainkan peranan penting dalam kehidupan manusia. Ia menjadi satu keperluan asas dalam kehidupan. Dalam era milenium ini, bilangan pengguna telekomunikasi meningkatkan secara drastik tanpa sebarang had umur. Para pengguna kecewa dengan prestasi rangkaian yang tidak memenuhi harapan mereka, ini membawa kepada rasa tidak puas hati. Gangguan diantara sel-sel adalah punca kepada masalah ini. Gangguan berlaku apabila pelanggan yang berbeza menggunakan bahagian yang sama frekuensi di kawasan geografi yang sama dan pada masa yang sama. Dalam kajian ini, tumpuan akan diberikan kepada bagaimana untuk mengatasi masalah ini dan juga untuk meningkatkan prestasi rangkaian. Sejak kebelakangan ini teknologi yang baru diperkenalkan di Malaysia adalah 4G, maka projek ini akan memberi tumpuan kepada mengatasi gangguan dalam rangkaian *OFDMA*. *OFDMA* menyediakan fleksibiliti dalam pembangunan jalur frekuensi dalam sistem seperti *LTE* dan *LTE Advanced.* Kekerapan Penggunaan semula pecahan (*FFR*) adalah kaedah yang dipilih untuk mengatasi gangguan antara sel-sel dalam kajian ini. FFR menawarkan penyelesaian alternatif kepada masalah kekerapan penggunaan semula dalam rangkaian *OFDMA* multisel. *FFR* dibangunkan sebagai skim kekerapan penggunaan semula yang fleksibel untuk menyerang keseimbangan yang lebih baik antara kecekapan spektrum dan pengurangan gangguan daripada kekerapan penggunaan semula generik.

DEDICATION

To my beloved parents (Mr Jayraman and Mrs Amudam) and family (Vijayendiran, Anusha, Urmila and Brownie).

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LIST OF SYMBOLS AND ABBREVIATIONS

BPSK	=	Binary Phase Shift Keying
BS	=	Base Station
CCI	=	Co-channel Interference
CDMA	=	Code-Division Multiple Access
D-AMPS	=	Digital-American Mobile Phone Service
DEM	=	Digital Elevation Models
FDMA	=	Frequency Division Multiple Access
FFR	=	Fractional Frequency Reuse
FR	=	Frequency Reuse
GSM	=	Global System for Mobile Communication
HFR	=	Hard Frequency Reuse
LTE	=	Long Term Evaluation
NMT	=	Nordic Mobile Telephone
OFDM	=	Orthogonal Frequency Division Multiplexing
OFDMA	=	Orthogonal Frequency Division Multiple Access
PDC	=	Personal Digital Cellular
PDCCH	=	Physical Downlink Control Channel
PDSCH	=	Physical Downlink Shared Channel
QAM	=	Quadrature Amplitude Modulation
QPSK	=	Quaternary Phase Shift Keying
SFR	=	Soft Frequency Reuse
SINR	=	Signal-to-Interference-plus-Noise Ratio
TACS	=	Total Access Communication System
TDMA	=	Time Division Multiple Access
UE	=	User Equipment
UTM	=	Universal Transverse Mercator
WGS	=	World Geodetic System

CHAPTER 1

INTRODCTION

This chapter covers the introduction of the project, background study, the problem statement, and the project objective, the scope of work, the project significance and the summary of this project.

1.1 Background

In this Hybrid age, humans-technology civilisation is a nationwide event where people co-evolve with technology. Telecommunication is a major part of it as most of the chores, work and task can be done by using gadgets. In order to stand equally with the latest technology, the quality of the communication is very important. But in some countries we can see that the degradation of the quality of communication and the worst part is, some cooperate sectors do faces losses due to this issue.

Interference are being one of the crucial problems in the degradation of the quality of communication over a decade. The major reason behind this problem is due to the limited resource in the radio spectrum and also the number of customer increases dramatically. The quality of the communication is degraded when several users are optimising the same part of the frequencies at the same time and place, which is known as interferences.

There are two types of interference which are nature interference and source interference. In by nature interference which is known as co-channel interference, the same spectrum used by the two different interfering signals. In adjacent-channel interference, insufficiently separated frequencies using the different interfering signal. Besides, in by source interference, different user interfacing signals are carried by the same factor is known as intra-cell interference. Inter-cell interference happen, when they are carried by different neighbouring portion.

In order to overcome this problem, frequency reuse is applied in Orthogonal Frequency Division Multiplexing Access (OFDMA) network. OFDMA is a method used for transmitting digital data over a radio wave. Meanwhile, frequency reuse is the method of using the same value of the frequency of the radio transmitter within a specific location that are divided by a minimal distance to result in less interference with each other.

1.2 Problem Statement

The problem statement of this project is when different customer is using the same sector of cells at the same geographic distance and time, there are interference in the system and this results in the degradation of quality of communications. Over the past decades, the number of users has expanded and the source is limited. In order to overcome this problem, frequency reuse is used in OFDMA network.

1.3 Objective

There are few purposes should be achieve from the completion of this project. The main purpose of this project is to mitigate the interferences between the frequencies from the adjacent cells and also to increase the network performance.

Due to the higher interference level and increasing traffic demand in metropolitan areas, a better solution has to be found which fulfils the demand of customers. As the number of channels is limited, those channels are reused based on the regular distance intervals. Frequency reuse is very crucial in order to gain a beneficial compromise between capacity and performance.

1.4 Scope

There are several techniques that can be used to overcome the interference of channel and also to improve the performance of the network. The scope of work for this project is a Fractional Frequency Reuse (FFR). This technique is chosen because the usage of FFR is still in early stage in Malaysia. There are researches have been done about the FFR, how it works and what are the differences of applying FFR in a network.

1.5 Project Significance

This project will give the most benefit to users in a wide range of industries, especially to the telecommunication company. The mobile company could develop and implement this project in order to provide better network performance and convenient to the users. This project is easy to implement and also low cost.

1.6 Summary

The network performance is poor due to the interference of the cell. FFR is introduced to overcome this problem in OFDMA Network. In this chapter are covered about the background, the problem statement, the objectives, the scope of work and the project significance of this project.

CHAPTER 2

LITERATURE REVIEW

This chapter mainly focuses on the information and theory related to the available networks, frequency reuse concept and also the research done by the mobile company. The factors and the characteristics that should consider while developing this project also will be covered.

2.1 Networks

2.1.1 FDMA Network

Frequency Division Multiple Access (FDMA) divides the entire quantity of spectrum into different number of channels. Either a call or a data transfer is specified to a different subscriber by each channel and it`s capable to handle the separate traffic. FDMA is generally used in analogue mobile radio, analogue cellular mobile telephone systems (AMPS, NMT and TACS). In FDMA, every subscriber shares the frequency channel or satellite transponder simultaneously at a single frequency (Joan, 2011). FDMA hardware with high performance filters aid it in avoiding the distance problems which can disintegrate the call quality. All subscribers transmit and receive on different frequencies because every user receives an individual frequency slots. Guard band is a small portion of bandwidth that is not used in between the different used frequency channels. This portion of bandwidth is essential to provide for frequency shifts and instability of the sender due to movement (Doppler Effect) and no-ideal filtering.

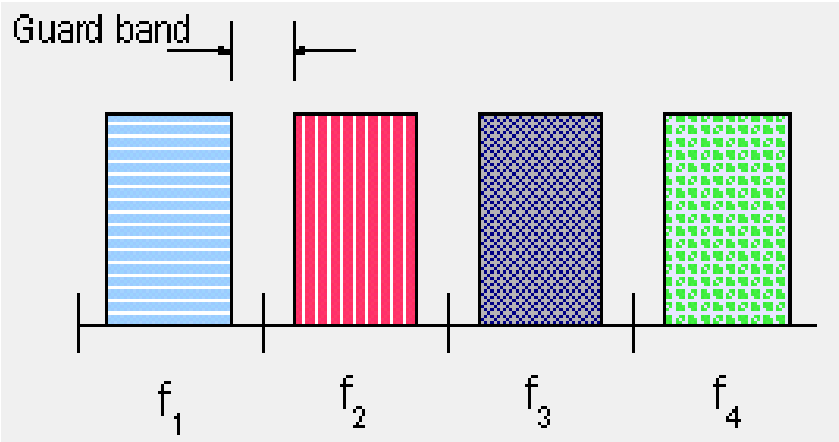

Figure 2.1.1.1: The Principle of FDMA

By using Frequency Division Multiple Access (FDMA), a traditional satellite circuits are designed to share satellite transponder bandwidth. In this technique each remote location transmits continuously into a designated frequency slot. The frequency slot required for each circuit is proportional to the peak speed desired. This technique is important when fixing analog signals to common place (Frederick, n.d.)

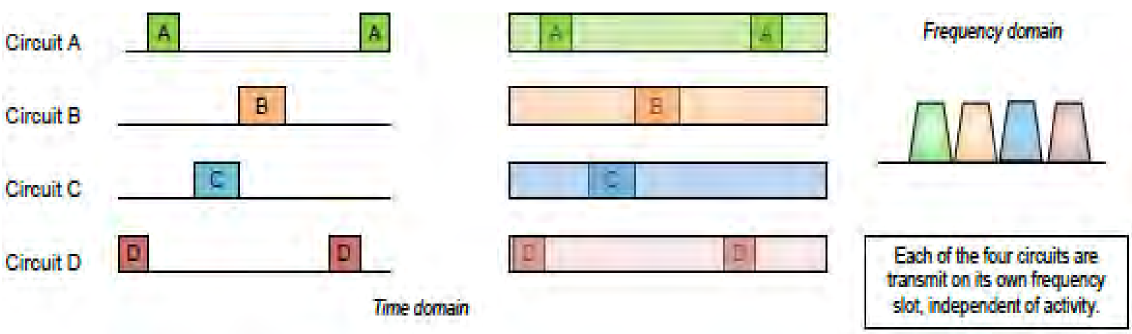

Figure 2.1.1.2: Frequency Division Multiple Access (FDMA)

Channel medium is capable to transmit the frequencies of signal wave from source to destination (i.e. Bandwidth of Channel). The Bandwidth of channel is divided into a small band of frequencies. In order to transmit the data, each transmitter is granted a small band of frequency. These result in wide transmission of data signal from same channel but different frequency. (Preethi S.J., 2012).

In FDMA, the non-overlapping frequency bands used in uplink and downlink signals to transmit data. In Figure 2.1.1.3 shows "Normal FDMA". The f_1Hz would be the uplink originating at Terminal 1 while at the f_2Hz would be uplink originating from Terminal 2. In order the two signals do not overlap with each other, the carrier centre frequencies are far apart (Preethi S.J., 2012).

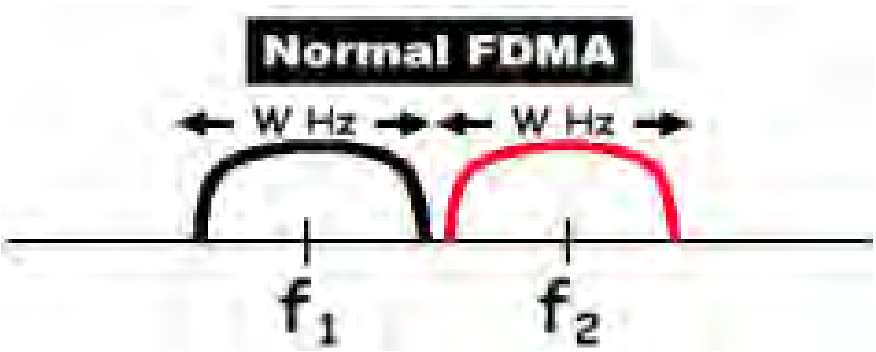

Figure 2.1.1.3: Normal FDMA

2.1.2 TDMA Network

Time Division Multiple Access (TDMA) is a Multiple Access Scheme that is used in GSM. In GSM, every frequency channel is separated into various time slots (eight per radio frame), and each subscriber is allocated one or more slots. TDMA is a one of the technology applied in digital cellular communication. It separates each channel into three different time slots so that the number of data that can be carried is expanded. Digital-American Mobile Phone Service (D-AMPS), Global System for Mobile communications (GSM) and Personal Digital Cellular (PDC) using TDMA. In TDMA, different users specified to a non-overlapping time slots in a round-robin fashion (Syed A. Ahson, 2009).

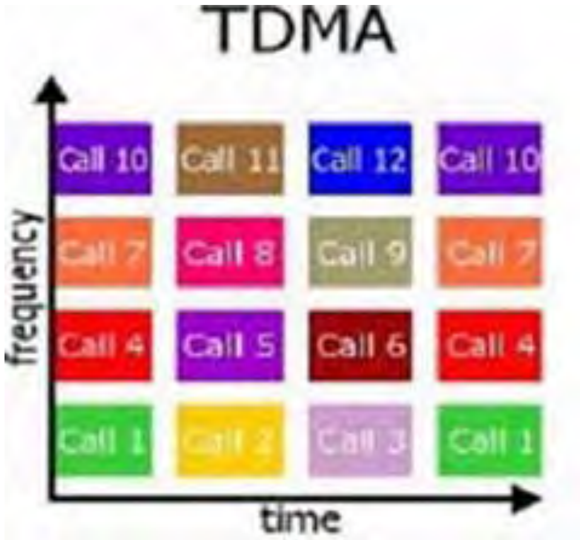

Figure 2.1.2.1: TDMA

The operation of TDMA is slightly complicated to execute. This is because of the timing needed to distinct the data packets. The operating cost of synchronization higher due to the multiple packets that required to be gathered to form a single signal. In a TDMA system (Figure 2.1.2.2), the total usable bandwidth is utilised by one subscriber, but only for specific periods. The frequency channel is split into time slots, and allocated to the same subscriber. Different time slots are required for the uplink and the downlink. (Emuoyibofarhe O.J, 2012).

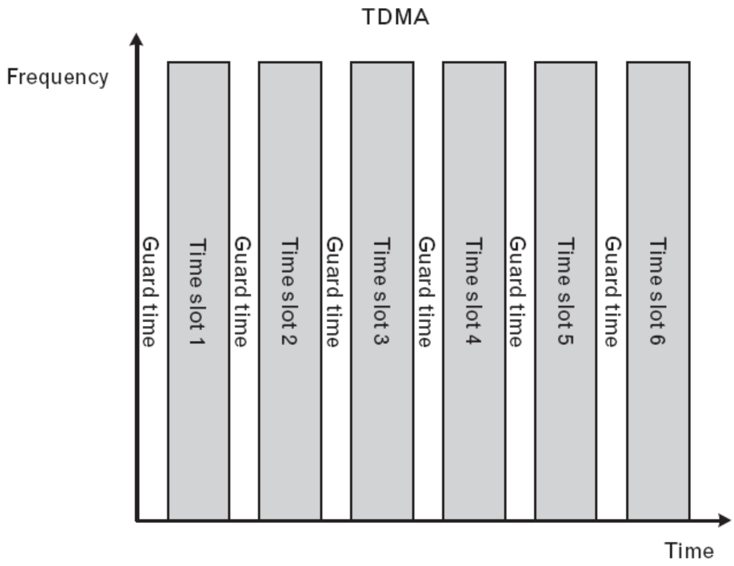

Figure 2.1.2.2: TDMA System

For orthogonal Multiple Access (MA) techniques, there are two types of TDMA, fixed TDMA and adaptive TDMA. The length of the two time slots is the same in the fixed TDMA. This results in an identical instantaneous rates. Besides, in adaptive TDMA the slot length and instantaneous rate are identified based on channel conditions. It can be varied for the two users and different frame by frame. Every frame is split into two time slots for two users in both situations (Joan, 2011).

2.1.3 CDMA Network

CDMA is known as Code-Division Multiple Access is being used in the second-generation (2G) and the third-generation (3G) wireless communications. CDMA is a type of multiplexing that lets several signals use up a single transmission channel and also optimise the usage of available bandwidth. CDMA uses analog-to-digital conversion by compounding with spectrum technology. The frequency of the transmitted signal is varied according to the specific code and it can only be stopped by a receiver which is programmed with the same code frequency response. The CDMA networks apply a system which is known as soft hand-off. When handset passes from one cell to another, these systems, prevent the breakup of signal. CDMA used as a worldwide roaming, as it is capable to use with any cellular technologies. (Rouse, n.d.)

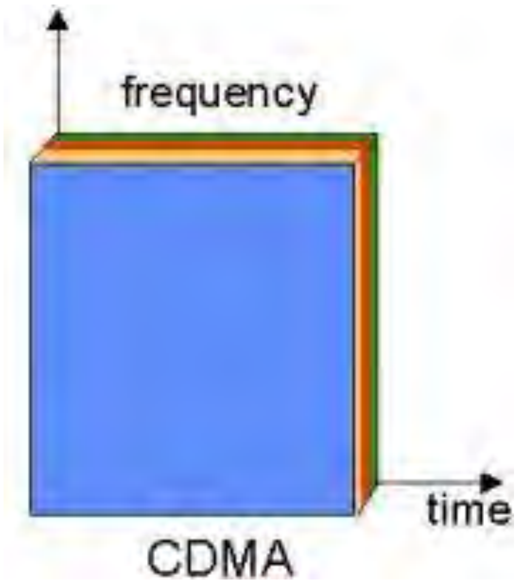

Figure 2.1.3.1: CDMA in graphical form

CDMA is a spread spectrum, which assigns codes instead using frequency and time as a resource. In CDMA, the low bandwidth data message (eg .voice) is multiplied with large bandwidth PN sequence (Pseudo Random). By using the PN codes, CDMA provides more secure communication under high noise environment, but it is limited to less number of users.

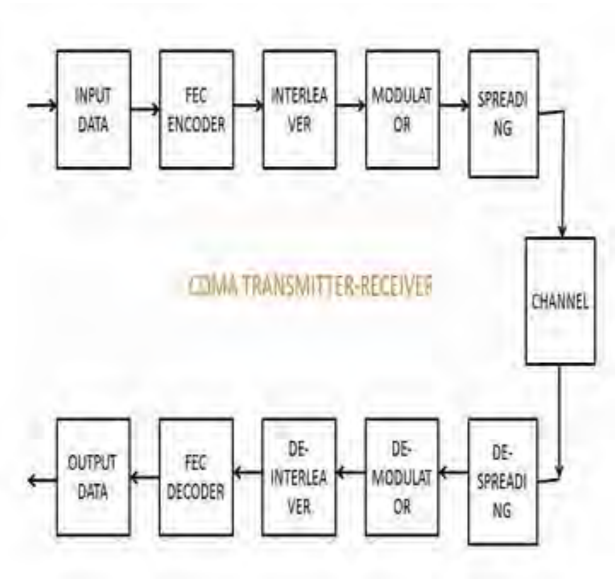

Figure 2.1.3.2: CDMA System Block Diagram

The users of CDMA system use the same time space and band with different codes. The signal that is transmitted can be retrieved back by the transmitter using the same PN code. CDMA uses a single carrier technique as it does not have the IFFT module.

2.1.4 OFDM Network

Orthogonal Frequency Division Multiplexing (OFDM) is a method used for transmitting digital data over a radio wave. This technology function by dividing the radio signal into multiple smaller sub-signals. Then, the sub-signals are transmitted simultaneously to the receiver at different frequencies. The OFDM modulation schemes supports high data rates. This characteristic provides a lot of advantages in broadband wireless transport. OFDM also reduces the amount of crosstalk in signal transmission.