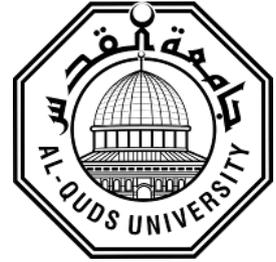


**Deanship of Graduate Studies
Al-Quds University**



**Contributions on Fading Channel Estimation
for 5G Mobile Systems**

Moataz Hussein Ali Qaroush

M.Sc. Thesis

Jerusalem-Palestine

1440-2018

Contributions on Fading Channel Estimation for 5G Mobile Systems

Prepared By:

Moataz Hussein Ali Qaroush

B.Sc.: Electrical Engineering/Birziet

University-Palestine

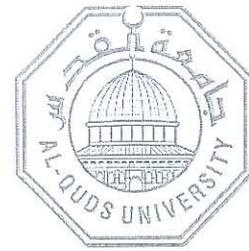
Supervisor: Dr. Ali Jamoos

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Electronic and Computer Engineering/Department of Electronic and Computer Engineering/ Faculty of Engineering/ Graduate Studies

Jerusalem-Palestine

1440-2018

Al-Quds University
Deanship of Graduate Studies
Electronics and Computer Engineering
Faculty of Engineering



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Contributions on Fading Channel Estimation for 5G

Mobile Systems

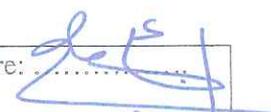
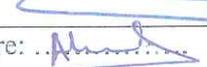
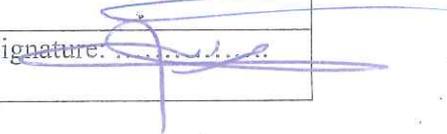
Prepared By: Moataz Hussein Ali Qaroush

Registration No: 21411608

Supervisor: Dr. Ali Jamoos

Master thesis submitted and accepted, Date: 18/12/2018

The name and signatures of examining committee members are as follows:

1- Head of the committee	Dr. Ali Jamoos	Signature: 
2- Internal Examiner	Dr. Ahmed Abdou	Signature: 
3- External Examiner	Dr. Murad abu Subaih	Signature: 

Jerusalem-Palestine

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Declaration

I certify that this thesis submitted for the degree of Master, is the result of my own research, except where otherwise acknowledged, and that this study (or any part of the same) has not been submitted for a higher degree to any other university or institution.

Signed by: 

Moataz Hussein Ali Qaroush

Date: 18/12/2018

Acknowledgments

I would like to bless my God for everything.

I would like to express my deepest gratefulness to my family especially my parents, my wife, my children for the endless care they have provided advice, support, patience, and me.

Special thanks go out to my supervisor, Dr. Ali Jamoos, whose give me more knowledge and skills in the communication field. In addition, his guidance helped me in all the time of research and writing of this thesis.

My sincere thanks also go to the electronics and computer department at Al-Quds University for helping me in topics that are related to digital signal processing.

I would like to express my thanks to president of Al-Quds Open University Prof. Younes Amro and President Assistant for technology and production at Al-Quds Open University Dr. Islam Amro for their encouragement to complete higher education.

I would like to express my thankfulness to all those who helped me during the period of my study and give me motivation and encouragement.

Abstract

Universal filtered multi-carrier (UFMC) modulation is a very powerful candidate to be employed for future 5G mobile systems. It overcomes the limitations and restrictions in current modulation techniques employed in 4G mobile systems such as orthogonal frequency division multiplexing (OFDM) and Filter bank multicarrier (FBMC). In addition, UFMC can support future applications like machine-to-machine (M2M), device-to-device (D2D), and vehicle-to-vehicle (V2V) communications.

In this thesis, we address the estimation of UFMC fading channels based on the comb-type pilot arrangement in the frequency domain. The basic solution is to estimate the fading channel based on the mean square error (MSE) or least square (LS) criteria with adaptive implementation using least mean square (LMS) or recursive least square (RLS) algorithms. However, these adaptive filters seem not effective, as they cannot fully exploit fading channel statistics. To take advantage of these statistics, the time-variations of the fading channel is modelled by an autoregressive process (AR) and tracked by an H_∞ filter. Nevertheless, this requires the AR model parameters, which are estimated by solving the Yule-Walker equation (YWE), based on the Bessel autocorrelation function (ACF) of the fading channel with known Doppler rate.

The results of MATLAB simulations show the effectiveness of the proposed H_∞ filter based channel estimator as compared with Kalman filter, and conventional adaptive filters such as RLS and LMS algorithms. Furthermore, the low pass interpolation is confirmed to outperform both spline and linear interpolation.

Keywords: fading channel, channel estimation, autoregressive model, 5G, UFMC, H_∞ filter, Kalman filter, LMS Filter, RLS Filter.

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Chapter 1

Introduction

In wireless communication systems, 1G refers to the first generation of the mobile wireless communication system. To this date, there are main fourth mobile generation named (1G-4G). Since 1G was introduced in the early 1979s, a new wireless mobile telecommunications technology has been released roughly every 10 years. All of them refer to the technology used by the mobile carrier and device itself. They have different speeds and features that improve on the previous generation. The next generation is 5G, which is scheduled to launch in 2020-2030.

1.1 Evolution of Mobile Generation

1.1.1 Zero Generation (0G)

0G is also known as mobile radio telephone systems. It was invented before 1979. This system was analog in nature. Generally, 0G provides half-duplex communications. These mobile telephones were placed in ships, trains and vehicles. In addition, it was very costly [1].

1.1.2 First Generation (1G)

In 1979, the first mobile generation (1G) was launched. The main growth that differentiated the 1G from the previous generation was the use of multiple cell sites and the capability to move calls from one site to the next as the user moved between cells during a conversation [1]. Each base station (cell site) supporting service to a specific area (cell). The cell sites would be set up such that cells partially overlapped. In a cellular system, a signal between a base station (cell site) and a terminal (phone) only require be strong enough to reach between them, so the same channel can be employed simultaneously for individual conversations in another cells.

1.1.3 Second Generation (2G)

In the 1990s, the second generation (2G) mobile phone systems was launched. The main difference of the 2G from the previous generation was the use of digital transmission instead of analog transmission. The rise in mobile phone usage as a result of 2G was explosive and this era also saw the advent of prepaid mobile phones. The 2G introduced a new different to communication, as SMS text messaging became possible, initially on GSM networks and eventually on all digital networks [1-2]. Several advantages of 2G were digital signals need use less battery power, so it betters mobile batteries to keep long. Digital coding betters the voice clarity and decreases noise in the line. Digital encryption has granted secrecy and safety to the data and voice calls.

1.1.4 Third generation (3G)

3G was launched in 2000. As the usage of 2G phones became more widespread and people began to use mobile phones in their daily lives, it became clear that demand for data services

like web browsing, sending emails, media streaming and stream radio was growing. The major technological difference that distinguishes 3G technology from 2G technology is the use of packet switching rather than circuit switching for data transmission [3].

1.1.5 Fourth generation (4G)

4G is the current mobile generation. It is basically the expansion in the 3G technology with more bandwidth and services offers in the 3G. The main service for the 4G technology is high quality audio/video streaming over end to end internet protocol [4]. One of the major ways in which 4G differed technologically from 3G was employing an all internet protocol network instead of circuit switching.

1.1.6 Fifth Generation (5G)

5G is the fifth generation of cellular mobile communication, offering high data rate, faster speeds, higher connection density, energy saving. 5G development is under research, 5G networks are expected to launch across the world by 2020-2030.

Table (1.1) summarizes the main differences between the mobile generations (1G to 5G) in a wireless communication system [5].

Table 1. 1: Comparison of 1G to 5G technology [5]

Technology	1G	2G	2.5G	3G	4G	5G
Period	1980-1990	1990-2000	1995	2000-2010	2010-2020	2020-2030
Services	Analog Voice	Digital Voice, Short messages	Higher Capacity, Packetized Data	Higher Capacity broadband data 2Mbps	Higher Capacity complementary IP-Oriented, Multimedia Data	Dynamic information access, Wearable devices
Standards	AMPS TACS NMT	TDMA CDMA GSM	GPRS EDGE 1xRTT	WCDMA CDMA2000 UMTS	LTE WIFI WiMAX	WWWW

		PDC				
Data Rate	1.9Kbps	14.4Kbps	384Kbps	2Mbps	200Mbps	1Gbps-10Gbps
Bandwidth	900MHz	900MHz	100MHz	100MHz	100MHz	-
Channel	30KHz	200Khz	200Khz	5Mhz	200Mhz	
Band width						
Multiplexing	FDMA	TDMA CDMA	TDMA CDMA	CDMA	OFDMA	
Core Network	PSTN	PSTN	PSTN, Packet Network	Packet Network	Internet	Internet
Handover	Horizontal	Horizontal	Horizontal	Horizontal	Horizontal And Vertical	Horizontal And Vertical

1.2 Global Mobile Data Traffic Forecast Update

In this section, we will introduce some figures for mobile data traffic and growth of owned smart devices. Figures (1.1, 1.2) [6], shows the growth of a number of smart devices between (2005-2013). In Peter's square in 2005 when Pope greeted the public, we notice a few persons had a smartphone. While in 2013 for the same occasion in Peter's square, most of the people have owned smartphones, which clearly shows that there is an increasing number of owned devices and connected devices to the internet in the future.



Figure 1. 1: The number of Smartphones in 2005 [6]



Figure 1. 2: The growth of the number of Smartphones in 2013 [6]

Figure (1.3) shows the expectation of growing traffic to (49) Exabyte per month at 2021, while the data traffic was (7) Exabyte at 2016 [7].

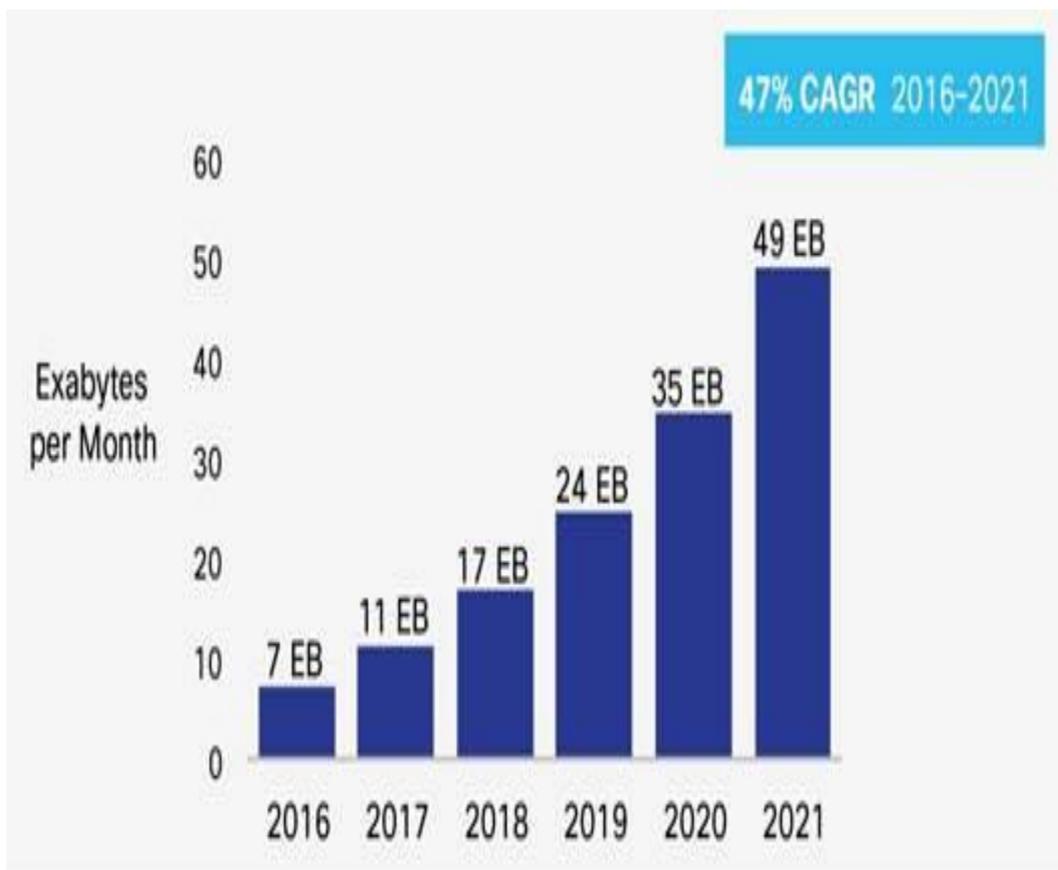


Figure 1. 3: Growth of Traffic between (2016 and 2021) [7]

Figure (1.4) shows cisco estimated mobile video traffic between 2016 and 2021. While mobile video represented more than half of global mobile data traffic beginning at 2012, the