

Evaluating mobile wimax in vehicle-to-grid system for communication between aggregator and vehicle



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In The Name of ALLAH, the Most Beneficent, the Most Merciful!!

DECLARATION

I declare that the work contained in this thesis is my own, except where explicitly stated otherwise. In addition, this work has not been submitted to obtain another degree or professional qualification.

Signed:

Asfa Javed _____

Date _____

DEDICATION

This research effort is dedicated to my beloved parents who hold my hands firmly in each hurdle of life, to my honorable teachers who support me to take up such challenges.

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O Lord! Let not our hearts deviate from the truth after you have guided us and bestowed upon us, mercy from your grace, verily you are the Giver of bounties without measure. Up and above, everything, all gratitude to **ALMIGHTY ALLAH**, the Compassionate and the Merciful, Who enabled us to elucidate a drop from the existing ocean of knowledge! Countless salutation be upon the **HOLY PROPHET MUHAMMAD (SAWW)**, the beacon of knowledge, who has guided his “Ummah” to seek knowledge from cradle to grave.

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ABSTRACT

The deployment of Electric Vehicles (EVs) has been proved as a very attractive option due to a great feasibility in transportation cost, reduction in carbon emission, and decrease in fuel dependency. However, this deployment threatens power grid operations due to varying temporal and spatial patterns of EVs' demand. Hence, for mainstream success, the capability to handle the potential extra load has become a major factor for power grid. For this integration it is necessary that the consumers and the power grid should coordinate with each other in harmony.

Vehicle-to-Grid (V2G) technology can be used for this purpose by interconnecting Electric Vehicles with the power grid by either level peak demands or by strangling their charging rate. One of the key elements in V2G architecture is Aggregator. This entity plays a very crucial role to provide an interface between a large group of EVs and the power grid. Thus, there is a need of two established wireless communication links in a V2G system, the first is the communication link between the control center and the Aggregator, and the other one is the communication link between the Aggregator and the Electric Vehicles of its assigned area.

This thesis aims to provide an investigative evaluation of the best suitable wireless access technology on the link between Aggregator and Electric Vehicles. For this purpose detailed communication architecture of V2G system has been explored to understand the exact role of Aggregator and its relationship with Electric Vehicle. Also the candidate wireless access technologies have been surveyed that can be employed in V2G communication system. Then mobile WiMAX has been selected for performance evaluation on the communication link between Aggregator and Electric Vehicles in a multipath mobile fading environment. It is a 4G technology that provides an infrastructure of wireless transmission that allows low maintenance costs as well as fast deployment.

Physical layer of mobile WiMAX was simulated in MATLAB Simulink, under considerations of Aggregator-to-Vehicle (A2V) communication channel. Due to the time-variant nature of the channel, all possible circumstances against the worst scenarios are tested to quantify the system's performance. The results obtained from the simulator were satisfactory and show that the mobile WiMAX is a suitable wireless technology that can provide a cost effective broadband internet access solution for A2V link.

This research work is an original contribution to the available literature and will prove helpful in implementation of the system to turn the concept into the reality, which points out a possible solution for cost-effective and robust communication between Aggregator and Electrical Vehicle.

TABLE OF CONTENTS

DECLARATION.....	IV
DEDICATION.....	V
ACKNOWLEDGEMENTS	VI
ABSTRACT.....	VII
CONTENTS.....	VIII
LIST OF TABLES	XI
LIST OF FIGURES.....	XII
ABBREVIATIONS.....	XIII
CHAPTER 1:INTRODUCTION	1
1.1. Background.....	1
1.2. Problem Statement	Error! Bookmark not defined.
1.3. Objectives	Error! Bookmark not defined.
1.4. Significance and Contribution of Research	Error! Bookmark not defined.
1.5. Overview of Thesis Contents.....	Error! Bookmark not defined.
CHAPTER 2:INTRODUCTION TO VEHICLE-TO-GRID (V2G) SYSTEM WITHIN SMART GRID	ERROR!
BOOKMARK NOT DEFINED.	
2.1. Introduction to Vehicle-to-Grid Environment	Error! Bookmark not defined.
2.1.1. Working of V2G System	Error! Bookmark not defined.
2.1.2. Ability of V2G System to Handle Peak Electric Demands	Error! Bookmark not defined.
defined.	
2.2. Major Concerns for Vehicle-to-Grid System.....	Error! Bookmark not defined.
2.2.1. Electric Vehicle Utilization Characteristics	Error! Bookmark not defined.
2.2.2. Battery Storage Capacity and the State of Charge	Error! Bookmark not defined.
2.2.3. Battery Degradation	Error! Bookmark not defined.
2.3. Electric Vehicle Aggregation.....	Error! Bookmark not defined.
2.3.1. Aggregation as a Load	Error! Bookmark not defined.
2.3.2. Aggregation as Generation or a Storage Device	Error! Bookmark not defined.
2.4. Control frameworks	Error! Bookmark not defined.

2.4.1. Centralized-Control.....	Error! Bookmark not defined.
2.4.2. Distributed-Control.....	Error! Bookmark not defined.
2.5. Survey of the State-of-the-Art.....	Error! Bookmark not defined.
CHAPTER 3:ARCHITECTURE OF VEHICLE-TO-GRID COMMUNICATION SYSTEM	ERROR!
BOOKMARK NOT DEFINED.	
3.1. Communication Infrastructure of V2G System	Error! Bookmark not defined.
3.2. Communication Needs and Requirements for V2G System.....	Error! Bookmark not defined.
3.3. Candidate Wireless Access Technologies for V2G System.....	Error! Bookmark not defined.
3.3.1. Survey for end-to-end V2GCommunication.....	Error! Bookmark not defined.
3.3.2. Communications between Aggregator and Mobile EV.....	Error! Bookmark not defined.
3.3.3. Mobile WiMAX – Chosen Wireless Access Technology for A2V Communication.....	Error! Bookmark not defined.
CHAPTER 4:SIMULINK IMPLEMENTATION OF MOBILE WIMAX ACCESS LINK FOR A2V COMMUNICATION	ERROR! BOOKMARK NOT DEFINED.
4.1. Introduction to the Key Technology of Mobile WiMAX ...	Error! Bookmark not defined.
4.1.1. Orthogonal Frequency Division Multiplexing (OFDM).....	Error! Bookmark not defined.
4.1.2. Orthogonal Frequency Division Multiple Access (OFDMA).....	Error! Bookmark not defined.
4.2. Implementation Considerations	Error! Bookmark not defined.
4.2.1. Subcarrier Allocation	Error! Bookmark not defined.
4.2.2. Slot &Frame Structure for Allocated Users.....	Error! Bookmark not defined.
4.2.3. 512-Point FFT OFDMA Time and Frequency Domain Description.....	Error! Bookmark not defined.
4.2.4. Calculation of Symbol Time	Error! Bookmark not defined.
4.3. Implementation of Mobile WiMAX Transceivers in Simulink.....	Error! Bookmark not defined.
4.3.1. Transmitter Design.....	Error! Bookmark not defined.
4.3.2. Receiver Design	Error! Bookmark not defined.
CHAPTER 5:A2V COMMUNICATION LINK DESIGNING FOR PERFORMANCE EVALUATION OF MOBILE WIMAX	ERROR! BOOKMARK NOT DEFINED.
5.1. Introduction to Mobile Communication Channel	Error! Bookmark not defined.

5.2. Multipath Propagation	Error! Bookmark not defined.
5.2.1. Fading Channel Description.....	Error! Bookmark not defined.
5.2.2. Delay Spread and Doppler Spread	Error! Bookmark not defined.
5.3. Channel Modeling for A2V Communication Link	Error! Bookmark not defined.
5.3.1. AWGN Block Considerations.....	Error! Bookmark not defined.
5.3.2. Short Term-Rayleigh Fading	Error! Bookmark not defined.
5.3.3. Long Term Fading-Path Loss Estimation	Error! Bookmark not defined.
CHAPTER 6:RESULTS AND DISCUSSIONS	ERROR! BOOKMARK NOT DEFINED.
6.1. Assumptions & Simplifications	Error! Bookmark not defined.
6.2. Channel Considerations	Error! Bookmark not defined.
6.2.1. Types of Channels used in the Simulator.....	Error! Bookmark not defined.
6.2.2. Channel-Metrics.....	Error! Bookmark not defined.
6.3. Testing the Validation of the Designed Model	Error! Bookmark not defined.
6.4. BER vs. SNR Analysis forA2V Channel.....	Error! Bookmark not defined.
6.4.1. Results for Urban, Suburban, & Rural Environmental Considerations	Error!
Bookmark not defined.	
6.4.2. Comparison of Specific Receiver Speeds	Error! Bookmark not defined.
6.5. Generation of Different Data Rates	Error! Bookmark not defined.
CHAPTER 7:CONCLUSIONS AND FUTURE WORK	ERROR! BOOKMARK NOT DEFINED.
7.1. Conclusions.....	Error! Bookmark not defined.
7.2. Future Directions	Error! Bookmark not defined.
REFERENCES	ERROR! BOOKMARK NOT DEFINED.
APPENDIX A	ERROR! BOOKMARK NOT DEFINED.0

LIST OF TABLES

Table 3.1: V2G System Communications Needs	Error! Bookmark not defined.
Table 3.2: Communication Technologies in V2G w.r.t Applications [42], [43], [50]	Error! Bookmark not defined.
Table 3.3: Summary of Candidate Wireless Technologies Applicability	Error! Bookmark not defined.
Table 3.4: Basic Features of Mobile WiMAX	Error! Bookmark not defined.
Table 4.1: 512-FFT OFDMA AMC Subcarrier Allocations ...	Error! Bookmark not defined.
Table 4.2: Different Convolutional Coding Rates with Puncturing Vectors	Error! Bookmark not defined.
Table 5.1: Parameters for Three Terrains	Error! Bookmark not defined.
Table 5.2: Values of Different Parameters for Path-loss Calculation	Error! Bookmark not defined.

LIST OF FIGURES

Figure 2.1: Working of Vehicle-to-Grid System.....	Error! Bookmark not defined.
Figure 2.2: Function of the Battery According to SOC.....	Error! Bookmark not defined.
Figure 2.3: The Concept of the Aggregator.....	Error! Bookmark not defined.
Figure 3.1: EV Demand Management and Communications Interdependency	Error! Bookmark not defined.
Figure 4.1: Block Diagram of OFDM System	Error! Bookmark not defined.
Figure 4.2: Establishing Subcarrier Groups in OFDMA System.....	Error! Bookmark not defined.
Figure 4.3: Downlink Sub-Frame Structure for Users' Allocation.....	Error! Bookmark not defined.
Figure 4.4: Mobile WiMAX Transmitter	Error! Bookmark not defined.
Figure 4.5: Convolution Encoder of Native Rate $\frac{1}{2}$	Error! Bookmark not defined.
Figure 4.6: Constellation Diagram for QPSK Modulation.....	Error! Bookmark not defined.
Figure 4.7: OFDMA Burst Structure obtained after Assembling.....	Error! Bookmark not defined.
Figure 4.8: Designed Receiver Block Diagram for Mobile WiMAX.....	Error! Bookmark not defined.
Figure 5.1: Multi-path Propagation Phenomena	Error! Bookmark not defined.
Figure 5.2: Propagation Mechanisms in an Urban Area	Error! Bookmark not defined.
Figure 5.3: Block Diagram of Designed Model	Error! Bookmark not defined.
Figure 5.4: Path Loss vs. Distance by using SUI Model.....	Error! Bookmark not defined.
Figure 6.1: Block Diagram for Simulation Setup.....	Error! Bookmark not defined.
Figure 6.2: SNR vs BER in AWGN Channel.....	Error! Bookmark not defined.
Figure 6.3: BER vs. SNR for Urban Environment	Error! Bookmark not defined.
Figure 6.4: BER vs. SNR for Suburban Environment.....	Error! Bookmark not defined.
Figure 6.5: BER vs. SNR for Rural Environment	Error! Bookmark not defined.
Figure 6.6: BER vs. SNR for Worst Case Scenario at 56kbps.....	52

ABBREVIATIONS

A2V	Aggregator-to-Vehicle
AMC	Adaptive Modulation Coding
AMI	Advanced Metering Infrastructure
AWGN	Additive White Gaussian Noise
BCW	Broadband Cellular Wireless
BE	Best Effort
BER	Bit Error Rate
BV	Battery Vehicle
CC	Convolution Coder
DL	Downlink
DR	Distributed Resource
DSP	Digital Signal Processing
EMU	Energy Management Unit
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FCH	Frame Control Head
FFT	Fast Fourier Transform
FEC	Forward Error Correction
FUSC	Full Usage Subcarriers Permutation
IFFT	Inverse Fast Fourier Transform
IoEV	Internet of Electric Vehicles
ISO	Independent System Operator

LoS	Line-of-Sight
LS	Least Square
LTE	Long Term Evolution
MATLAB	Matrix Laboratory
MC-CDMA	Multi-Carrier Code Division Multiple Access
NLOS	Non-Line of Sight
nrtPS	Non-real time Polling Service
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
PHEV	Plug-in Hybrid Electric Vehicles
PUSC	Partial Usage Subcarriers Permutation
RMS	Root Mean Square
rtPS	real time Polling Service
SNR	Signal to Noise Ratio
SOC	State-of-Charge
SUI	Stanford University Interim (Model)
TASE	Tele control Application Service Element
TDD	Time Division Duplex
UL	Uplink
UGS	Unsolicited Grant Service
V2G	Vehicle-to-Grid
WiMAX	Worldwide Interoperability for Microwave Access
QoS	Quality of Service

Chapter 1

INTRODUCTION

1.1. Background

All around the world, there are growing concerns about global warming issues and energy independence. Like other developing countries, energy independence is a major social and political issue in Pakistan because a large portion of the budget is spent to import oil from other countries every year and virtually, most of the fuel is consumed for the purpose of transportation [1]. This strong addiction of oil together with the growing awareness of CO₂ emissions impacts on global warming is the key driver for the trend of developing and adopting the new technologies for transportation. Such technologies, by turning vehicles to alternate energy sources or by making them more fuel efficient, aim to drastically reduce the oil dependency.

In particular, the development of the Electric Vehicles(EVs) is directly addressing both of these issues. Both Plug-in Hybrid Electric Vehicles(PHEVs) and EVs have a common characteristic that they own a battery which acts as a source for all types of required energy. Call for the generation of new Electric Vehicles has been heeded by car manufacturers to design new products. Toyota and Chevrolet are expected to launch a large number of new hybrids in the early 2018 [2]. A massive deployment of Electric Vehicles can be expected over the next few years because of all the various underway activities of car manufacturers. Such an explosive growth of this trend will result in a huge load on the power grid due to thousands of charging batteries. That can only be managed by effective integration of Electric Vehicles into power grid.