Sudan University of Science and Technology

College of Engineering

School of Electronics Engineering

Educational Cellular Network Simulator

محاكي شبكة الهاتف الخليوي التعليمي

A Research Submitted In Partial fulfillment for the Requirements of the Degree of B.Sc. (Honors) in Electronics Engineering

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بسم الله الرحمن الرحيم

(وَقُلِ اعْمَلُوا فَسَيَرَى اللَّهُ عَمَلَكُمْ وَرَسُولُهُ
وَالْمُؤْمِنُونَ ۖ وَسَتُرَدُّونَ إِلَىٰ عَالِمِ الْغَيْبِ
وَالشَّهَادَةِ فَيُنَبِّئُكُم بِمَا كُنتُمْ تَعْمَلُونَ)

[التوبة - 105]

(And say, "Do [as you will], for Allah will see your deeds, and [so, will] His Messenger and the believers. And you will be returned to the Knower of the unseen and the witnessed, and He will inform you of what you used to do ")

[Chapter 9 - Versus 105]

Dedication

We dedicate this work to our families. A special feeling of gratitude to our loved parents; whose words of encouragement and reassurance for tenacity, are ringing in our ears...

To whose love flows in our veins and our hearts always remember them; to our friends and colleagues...

We also dedicate this achievement to many persons who have supported us throughout the difficulties...

We will always appreciate all what they have done...

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All praise to Allah, today we fold the days' tiredness and the errand summing up between the cover of this humble work.

To the utmost knowledge lighthouse, to our greatest and most honored prophet Mohamed -May peace and grace from Allah be upon him-.

To those who taught us letters of gold and words of jewel of the utmost and sweetest sentences in the whole knowledge. Who reworded to us their knowledge simply and guided us through the knowledge and success path, to our honored teachers.

Then great thanks to our father and supervisor Dr. Ashraf Gasim El-Said for his care and precious advices which enlightened the path to us.

Special thanks are also to those who have done everything possible to help us get our mission accomplished.

ABSTRACT

A theoretical study of traffic in cellular networks usually requires long and complex calculations. For this reason, simulation appears to be a practical alternative for analyzing traffic in mobile radio systems.

This project presents a traffic simulator for mobile cellular networks. The model implemented includes the blocked-cleared traffic module, handoff scheme and fixed channel assignment. Several simulations have been experimented in order to measure network performances in different situations. Different channel assignment techniques that are both fixed and dynamic are compared.

The results of this traffic simulation confirm the practical efficiency of this tool in mobile wireless network environment. Also, it supports the academic field in better understanding of cellular principles in an easy simplified way for under-graduate students.

المُستخلَص

الدّراسة النّظرية لنظم الحركة في شبكات المحمول النّقّالة عادةً ما تتطلّب حسابات طويلة ومعقّدة. لذا ظهرت المحاكاة كبديل عملي لتحليل هذه الحركة في أنظمة الهواتف الرّاديوية (الخليوية).

يقدّم هذا المشروع محاكاة لشبكات الهواتف الخليوية، ويتضمّن النّموذج المطبّق نظام حركة يقوم بإلغاء المكالمات في حالة عدم توفر قناة ، خُطط تبديل قنوات للمستخدمين في الخلايا المختلفة وطرق حجز قنوات على نحو ثابت. تمّ القيام بعدّة عمليّات مُحاكاة بغرض قياس أداء الشّبكة في ظروف مختلفة. قُورِن بين طرق الحجز الدّيناميكيّة (المتغيّرة) والأخرى الثّابتة (غير المتغيّرة) للقنوات.

تثبت نتائج هذا المُحاكي كفاءته العملية في بيئة المحمول الخليوي. وهي كذلك تدعم الحقل الأكاديمي في فهمٍ أفضل لمبادئ الخليوي بطريقة مبسّطة وسهلة الاستيعاب وخاصّةً لطلّاب مرحلة ما قبل التّخرّج.

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ABBREVIATIONS AND ACRONYMS

A

AMPS Advance Mobile Phone System

B

BDCL Borrowing with Directional Channel Locking

BS Base Station

BSC Base Station Controller

BTS Base Transceiver Station

C

CCR Call completion rate

CCI Co-channel interference

CDF Cumulative Distribution Function

CDMA Code Division Multiple Access

CSD Circuit Switched Data

D

D-AMPS Digital Advance Mobile Phone System

DCA Dynamic Channel Assignment

DECT Digital Enhanced Cordless Telecommunications

DRCL Distributed Real-time Computing Laboratory

E

EBHC Equated Busy Hour Calls

EDGE Enhancement Data Rates for GSM Evolution

EH Erlang hours

EIRP Effective Isotropic Radiated Power

ERP	Effective Radiated Power

F

FCA	Fixed Channel Assignment
FDD	Frequency Division Duplex
FDMA	Frequency division multiple access

G

GloMoSim	Global Mobile Information System Simulator
GoS	Grade of Service
GPRS	General Packet Radio Service
GSM	Global System Mobile

I

IMT_2000	International Mobile Telecommunications-2000
IMTS	Improved Mobile Telephone Service
ISO	International Organization for Standardization
IT	Information Technology
ITU	International Telecommunication Union

J

J_Sim	Java Simulator

L

LTE	Long Term Evolution

M

MAC	Media Access Control
MAHO	Mobile Assists Handoff
MANETs	Mobile Ad_hoc Networks
MCHO	Mobile Control Handoff
MS	Mobile Station
MSC	Mobile Switching Center
MTS	Mobile Telephone System

N

NCHO	Network Control Handoff
NMT	Nordic Mobile Telephone
NS	Network Simulator
NTC	National Telecommunication Corporation

O

OFDMA	Orthogonal Frequency-Division Multiple Access
OMNET	Object Modular Network
OPNet	Optimized Network

P

PCM	Pulse Code Modulation
PDF	Probability Distribution Function

Q

QoS	Quality of Service
QualNet	Qualified Network

S

SM	Speech Minutes
SLA	Service Level Agreement

T

TACS	Total Access Communication System
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TD-SCDMA	Time Division Synchronous Code Division Multiple Access

U

UMTS	Universal Mobile Telecommunication System

W

WiMAX	Worldwide Interoperability for Microwave Access
WCDMA	Wideband Code Division Multiple Access

LIST OF SYMBOLS

N	-	Custer size (No. of Cells)
k	-	Number of Channels per Cell
S	-	Total Number of Channels
C	-	System Capacity
M	-	Number of Duplicated cluster
U	-	User
Pt	-	Transmitted Power
Pr	-	Received Power
d	-	Distance
L	-	system loss factor
Gt	-	Transmitter antenna gain
Gr	-	Receiver antenna gain
Ac	-	effective aperture
f	-	carrier frequency in Hertz
ω_c	-	carrier frequency in radians per second
c	-	speed of light given in meters/s
PL	-	Path Loss
λ	-	Wavelength (in mobile radio propagation calculations)
f_c	-	Operating frequency (MHz)
h_{te}	-	Transmitting station antenna height (m).
h_{re}	-	Mobile unit antenna height (m).
$a\ (h_{re})$	-	Correction factor for mobile unit antenna height
n	-	average number of calls

λ	-	calling rate (in Traffic calculation)
T	-	Time period
H,h	-	The average holding time
μ	-	service rate
A	-	average occupancy
s	-	service time
E	-	Erlang

Chapter One

Introduction

Introduction

1.1 Preface

The performance and the behavior of a real cellular network can be evaluated using simulation systems without the need to perform field experiments and develop prototypes. The simulation solutions give us the opportunity to develop some aspects such as channel allocation schemes, network structure traffic flows etc, towards to a desired cellular network. Due to the complexity of real cellular networks the simulation software development strategy becomes a very important factor that influences the resulted network model. The structure of the simulation environment affects the performance of simulated cellular network and for that reason we try to study the design and the development of such system.

Many approaches to simulation systems have been made using various simulation languages. Languages such as Simula, Parsec and other of special purpose offer high flexibility for simulation systems development but introduce lack of portability and lag in terms of general purpose optimizations, etc. Other software tools like Matlab, have a plethora of libraries and capabilities for flexible script code development but suffer from low performance execution. A Large scale simulation system requires a high performance environment with advanced characteristics such as portability, internetworking, etc. The invention of new simulation languages introduce important drawbacks which are:

- New languages are domain-specific and are rarely adapted by scientific community.
- The corresponding libraries impose the designers to adapt their applications in specific requirements.
- Designers can't achieve high adaptability of the simulation kernel in their applications.

Java language is the most suitable for building flexible, portable and high performance network applications and is adapted by the majority of scientific community. With this simulation program, we attempt to build a generic simulation system for cellular communication systems for 3rd generation.[1]

1.2 Problem Statement

Nowadays most of the simulators that used in the communication field are complex to deal with, due to the limitation that it needs a background of databases and some experience in the IT field. That resulted in making the majority of simulators have been built by IT engineers only. Which in turn expanded the gap between telecom engineers and Simulating.

The other challenge is that learning the simulation principles and concepts is time consuming when compared to focusing on the basics of telecom field. Besides the experience which cannot be gained without spending a long time of practice, this is compulsory for IT engineers.

Most of the local operators in Sudan suffer from a lack in simulation field, because they directly operate systems built on the data given to them (by NTC), without doing any simulation processes. This leads to more cost and resource wastage as described previously.

1.3 Proposed Solutions

Studying the concepts of mobile cellular networks and traffic engineering which will help to generate a reliable and conceptual simulation code.

The first problem can be overlapped by simplification and modification of simulation tools in order to be familiar to the telecom field. This can be accomplished by a high level language code that simulates the traffic of mobile networks.

Writing a simple code that mimics the traffic of the mobile network based on knowledge of a telecom engineer will shorten the path to realize the structure of the simulator compared to that built by an IT expert. Following this method in simulation will help to solve the second problem.

By analyzing the traffic generated by this code, the mobile network can be adjusted in order to improve the Quality of Service (QoS).

1.4 Research Aim

The project aims to create a simplified simulation tool (code) that generates traffic for a mobile network which is easy to understand and powerful in performance.

1.5 Objectives

- To study the concepts of cellular mobile networks.
- To study and analyze of traffic generation and traffic modules.
- To study the simulation concepts and principles.
- To investigate the most suitable language that fits our aim.

1.6 Methodology

We identify a set of concepts which are related to the mobile wireless systems and describe a set of flexible modules which can be used to model the various components and their integration. These modules are simulated using the java language. By modeling the various components and their integration, this simulation environment is able to accurately mimic the performance of a wireless network system and provide efficient measurements and validation of algorithms which were not possible through experimentation, too complex for analysis and costly. In our simulation we follow random process (stochastic simulation) in generation of customers in a way that when every running of the

simulator the number of customers change randomly depending on a Poisson distribution probability function. Also by using tele-traffic engineering modules and generation we set a number of parameters which are related to wireless cellular network fundamentals such as handoff schemes, queuing theory and blocking probability. By applying these aspects in our simulation and use of mathematical and statistical probabilities we can easily build up the simulator and compare the output results with real system so as to select the optimal choice.

Very important to be mentioned that this is a re-publishing of a previous thesis in September-2005 by students in our school.

1.7 Research Outlines

- **Chapter 1:**

This chapter includes an introduction to the project, defines the problem statement, illustrates the proposed solutions and an explanation for the methodology plan in order to reach to the desired goal.

- **Chapter 2:**

This chapter contains a Background that offers a general view of the project, it also includes literature review for researchers' previous works which are related to the field of this project.

- **Chapter 3:**

This chapter presents the concepts and fundamentals of wireless cellular system such as frequency reuse, channel allocation, handoff strategies, etc. Moreover it explains the concepts of interference and radio wave propagation in

addition to Hata model as a basic model for calculating path loss in this simulator.

- **Chapter 4:**

This chapter introduces conceptual framework for the traffic engineering, traffic design requirements, traffic statistics, modeling of traffic, need for traffic models. Moreover it introduces traffic concepts, GoS, trunking theory and blocking probability.

- **Chapter 5:**

This chapter reviews the basic concepts for the simulation process added to that the investigated model, taking into account two major aspects; probability concept and random variables generation functions. Attached to that there is the source code functions.

- **Chapter 6:**

This chapter presents the results for the output of the simulator and statistical analysis for it.

- **Chapter 7:**

Finally, this chapter discusses the results concluded from the simulator mentioned in chapter six, reviews the conclusions from the analysis of those results and then make recommendations that project expect future researchers have to do.