Salwa Akl

بسم اللّه الرحمن الرحيم

مركز الشبكات وتكنولوجيا المعلومات

قسم التوثيق الإلكتروني

Salwa Akl

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها

علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات

AIN SHAMS UNIVERSTY
FACULTY OF ENGINEERING
CAIRO – EGYPT
Electronics and Communication Engineering Department

Designing of reliable and scalable 5th_generation cellular communication system using UAVs

Dissertation submitted to the faculty of Engineering – Ain-Shams University in partial fulfilled of the requirements for the degree of Master of Science in Electrical Engineering

Submitted By

Eng. Mohamed EL-Sayed Kotb EL-Sayed
Electronics and Communication Eng. Department
Faculty of Engineering – Ain-Shams University

Supervised By

Prof. Dr. Wagdy Anis
Professor in Electronics and Communication Eng. Department
Faculty of Engineering – Ain-Shams University (ASU)
Cairo – Egypt

Ass. Prof. Dr. Ahmed Ali Abdel-hafez
Communications Department
Military Technical Collage (MTC)
Cairo – Egypt

AIN SHAMS UNIVERSTY
FACULTY OF ENGINEERING
CAIRO – EGYPT

Examiners Committee

Name : Mohamed EL-Sayed Kotb EL-Sayed

Thesis: Designing of reliable and scalable 5th_generation cellular communication system using UAVs

Degree: Master of Science

Name, Title, and Affiliate **Signature**

1. **Prof. Dr. Mohamed Hassan Abd-ElAzeem ………… professor in Electronics and Communication Eng. Department, Faculty of Engineering Arab Academy for Science, Technology and Maritime Transport.**
2. **Prof. Dr. Ismail Mohamed hafz ………… professor in Electronics and Communication Eng. Department, Faculty of Engineering Ain Shams University.**
3. **Prof. Dr. Wagdy Refaat Anis ………… Professor in Electronics and Communication Eng. Department, Faculty of Engineering Ain Shams University.**

Date: / / 2022

STATEMENT

This dissertation is submitted to Ain Shams University in partial fulfillment of the degree of Master of Philosophy in Electrical Engineering.

The work included in this dissertation was out by the author in the department of electronics and Communication Engineering, Ain Shams University.

No part of this dissertation has been submitted for a degree or qualification at other university or institution.

Name: Mohamed EL-Sayed Kotb EL-Sayed
Signature: …….....................

Date : / / 2022

Abstract

Heterogeneous networks (HetNets), device-to-device communications networks (D2D), and unmanned 5G wireless networks are all investigated in this thesis (UAVs). HetNets, which are made up of macro and small cells, have become more common in current wireless networks and 5G systems to meet the rising need for higher data transmission. There are new difficulties in power transmission discrepancies across various basic types of cells (BSs), the somewhat random employment of SBSs, and network densification in compared to classic cell networks, such as macro-small loads and severe intercell interference. This technique is proposed to cache popular store material for BSs and user devices to minimize repetitive wireless transfers, in contrast to the rising number of tablets and smartphones.

Coverage is a major issue for future generations of mobile communication, especially in five-ground networks, where performance expectations have grown, requiring service providers to construct additional stations. Despite the fact that this extra deployment is not cost-effective, it does necessitate network changes. Integration of Unmanned Aerial Vehicles (UAVs) into the current communication infrastructure might readily alleviate this problem. As a result of this challenge, an intelligent solution for the correct and effective use of UAVs in demand areas is given, therefore increasing wireless network capacity and coverage. To address the two challenges mentioned in the thesis, the Macro Base Station (MBS) decision problem and the UAV allocation cooperation problem, the solution provided employs priority and entropy approaches. Finally, these solutions define the NTB, allowing UAVs to be precisely matched to areas of interest, resulting in significant improvements in network parameters such as throughput, capability per EU, 5th percentile spectral efficiency,

network retardations, and guaranteed interference signal plus noise ratios of 6.3 percent, 16.6 percent, and 55.9%, respectively, and 48.2 perceived per EU.

The usage of microcells, user selection, and drone design criteria are all covered in the thesis (selecting the position of the UAV that minimises the network delay). Following the definition of the requirements, a comprehensive evaluation is conducted to determine the program's effectiveness. Our findings demonstrate that processing time affects the system's performance and the time it takes to handle requests, regardless of how the system is configured.

The prototype of a 5G-ready aerial base station will be shown next. The proposed system allows customers to move their drones while they are flying, thanks to advanced optimization technology that improves customer experience by utilizing real-time network data. In UABSs, the use of cellular network metrics has been demonstrated to increase network performance and enable self-orientation.

For numerical analysis, we utilized **MATLAB** to test our technique through simulation.

Acknowledgement

First and foremost, I would like to express my gratitude to ALLAH, the Ever-Living and the Sustainer of all existence, the One who neither begets nor is born, nor is there any comparable to Him.

I am thrilled to express my heartfelt gratitude and appreciation to my superiors:

Prof. Dr. Wagdy Anis (ASU)

Ass. Prof. Dr. Ahmed Ali Abdel-Hafez (Egyptian Armed Forces)

Throughout my research, I am grateful for their supervision, direction, generous suggestions, criticism, and constant support.

My heartfelt gratitude goes to my commander-in-chief. Prof. Ahmed Aly Abd El-Hafez for his advice, open door policy, and numerous helpful feedbacks during the dissertation writing process. I believe that your guidance has helped me develop as a researcher.

Finally, I'd like to express my gratitude to my family, to whom I owe so much. To **my father**, **mother**, **wife**, and **children**, as well as **my sisters.**

I sincerely apologise to **my wife** and **children** for all of the late nights, weekends, and holidays that I have missed. Thank you for your unending encouragement, understanding, and assistance with all of my projects.

Dear …. Thanks for all ….

Mohamed Elsayed Kotb Elsayed

List of Acronyms

Abbreviation	
ADRF	Average Delay Reduction Factor
BLE	Bluetooth Low Energy
BS	Base Station
CQI	Channel Quality Indicator
FCU	Flight Controller Unit
HetNet	Heterogeneous Network
HIRO-NET	Heterogeneous Intelligent Robotics NETwork
HSS	Home Subscriber Server
LPN	Low Power Node
LTE	Long Term Evolution
MME	Mobile Management Entity
OAI	Open Air Interface
PGW	Packet Gateway
QoE	Quality of Experience
QoS	Quality of Service
RAN	Radio Access Network
SDR	Software-Defined Radio
SPSA	Simultaneous Perturbation Stochastic Approximation
SWG	Serving Gateway
UABS	Unmanned Aerial Base Station
UAV	Unmanned Aerial Vehicle
UE	User Equipment
UHF/VHF	Ultra High Frequencies/Very High Frequencies
WSN	Wireless Sensor Networks

ABS	almost blank subframe
ASE	area spectral efficiency
AWGN	additive white gaussian noise
BS	base station
CRE	cell range expansion
DC	deterministic caching
DGPA	discrete generalized pursuit algorithm
D2D	device-to-device
eICIC	enhanced inter-cell interference coordination
HCN	heterogeneous cellular networks
HPPP	homogeneous poisson point process
IMC	idle mode capacity
IU	important user
HAP	high altitude platform
IoT	internet of things
IPM	interior point method
LAP	low altitude platform
LOS	line of sight
MIMO	multiple input multiple output
OFDMA	orthogonal frequency-division multiple access
SINR	signal to interference plus noise ratio
SWIPT	simultaneous wireless information and power transfer
UAV	unmanned aerial vehicle
UAV-MR	UAV-assisted mobile relay
UAV-SR	UAV-assisted static relay

List of Symbols

Symbol	
N	Number of UAVs
+	Addition
R.	Radio range
K	Number of Users
S_r	Number of Requests
≤	Less Than Or Equal
h	latitude of the UAVs
Z	the MBS's faraway demand area
S_u	Number of service requests
A_L	Complete Area load
P	Transmission Power
S_e	Spectral Efficiency
B'	demand areas

Table of Contents

STATEMENT………………………………………………………………………………iv
Abstract…………………………………………………………………………………v-vi
Acknowledgement………………………………………………………………………vii
List of Acronyms………………………………………………………………………viii-ix
List of Symbols…………………………………………………………………………x
Table of Contents………………………………………………………………………xi-xiii
List of Figures…………………………………………………………………………xiv-xv
List of Tables…………………………………………………………………………xvi
CHAPTER 1
Introduction……………………………………………………………………………1
1.1 Overview…………………………………………………………………1
1.2 Problem Statement………………………………………………………3
1.3 Solution Overview ………………………………………………………4
1.4 Related Work……………………………………………………………6
1.5 Publications………………………………………………………………7
1.6 Thesis Organization………………………………………………………8
CHAPTER 2
UAVs (Unmanned aerial vehicles) ………………………………………………9
2.1 Introduction ……………………………………………………………………9
2.2 UAVs……………………………………………………………………………10
2.3 the different kinds of UAVs ……………………………………………………10
2.4 Unmanned Aerial Vehicles (UAVs) are being used in a variety ……………………12
2.4.1 Predicting and recovering from disasters with UAVs ……………………12
2.4.2 Unmanned aerial vehicle use in agriculture and farming……………………13
2.4.3 monitoring with unmanned aerial vehicles ……………………………14
2.4.4 Drones are utilised in the construction business. ……………………14
2.4.5 Other uses of UAVs …………………………………………15
2.5 Ad-hoc and UAV networks ………………………………………………15

2.5.1 ad hoc mobile (MANET)…………15
2.5.2 Ad hoc vehicle (VANET)…………16
2.5.2.1 WAVE protocol architecture …………17
2.5.3 Ad-hoc network in the air (FANET)…………18
2.5.4 Drone Internet (IoDs)…………20
2.5.5 Private unmanned aerial vehicle network …………20
2.5.6 Wireless ad hoc routing methods for unmanned aerial vehicle networks …………21
2.5.6.1 Protocols for static routing …………22
2.5.6.2 Protocols for Point-to-Point Routing …………22
2.5.7 UAV network communication protocols …………25
2.6 Summary…………25

CHAPTER 3

5TH generation mobile network…………26
3.1 Introduction …………26
3.2 Evolution of Mobile Wireless Technologies…………26
3.2.1 First Generation (1G)…………27
3.2.2 Second Generation (2G)………… 27
3.2.3 Third Generation (3G…………27
3.2.4 Fourth Generation (4G)…………28
3.3 (5G) Mobile Network…………28
3.3.1 (5G) vs (4G) capabilities…………29
3.3.2 Benefits of (5G)…………29
3.4 (5G) Network Architecture…………30
3.5 Main Components for 5G Network…………30
3.5.1 Millimeter Waves…………31
3.5.2 Massive MIMO…………32
3.5.3 Heterogeneous Network (HetNet)…………32
3.6 Summary…………32

CHAPTER 4

Drone Cellular Networks…………33
Introduction …………33
4.1 Proposed System Architecture…………34
4.1.1 Features of a BS-equipped drone…………36
4.2 design for unmanned aircrafts: user clustering strategy …………38
4.3 Unmanned aerial system design: user offloading strategies …………44
4.4 simulation outcomes …………46
4.4.1 cluster selection strategy …………47
4.4.2 Selection criterion for offloaded users …………50
4.4.3 Key highlights …………52
4.5 summary…………53

CHAPTER 5

UAV Deployment for 5G Coverage Improvement…………..…………...**54**
5.1 Introduction…………………………...………………….….…....54
5.2 The assumptions and considerations related to the network. …...…....54
5.3 Network Model ……………………………………..……….........55
5.4 Proposed Approach……………………………………..……….....58
5.4.1 The Deployment of Unmanned Aerial Vehicles (UAVs) as a Decision Problem …………………………………………….....59
5.4.2 Deployment of Unmanned Aerial Vehicles as a Cooperative Problem …………………………………………..…......61
5.4.2.1 Negotiating Network Allocation for UAVs ……..….…....62
5.4.2.2 The Entropy of the Network Can Be Reduced By Mapping ……………………………………………………………….63
5.4.2.3 The determination of the UAV controllers for the demand area..65
5.4.2.4 Long-Term Connectivity Enhancement ……….……...69
5.5 work appraisal ……..……………………………………………70
5.5.1 Coverage of the Throughput ……………………………………72
5.5.2 Delays caused by the network …………………………………74
5.5.3 Users' Chances of Receiving a Guaranteed SINR ……………...76
5.5.4 Efficiency in the Spectral Domain ………………………..….77
5.5.5 Packet Delivery Success Rate …………………………..….78
5.5.6 Mapping Precision ……………………………………..…….79
5.5.7 Improvements in the capacity of each UE ………………..…….81
5.5.8 Handling Additional Users ……………………………………..82
5.6 Summary…………………..…..…………………...…………….83

CHAPTER 6

Conclusion and Future Work……………………………………………………………….84
6.1 Conclusions…………………...………….……………….....84
6.2 Future Work……………………………..…………………...….85
References…………………………………………………………………………………….86

List of Figures

Fig. No.	Title	**Page**
Figure 1.1	The UAV classification	1
Figure 1.2	A UAV-based network with a heterogeneous design	5
Figure 2.1	The structure of VANETs	17
Figure 2.2	WAVE protocol architecture	18
Figure 2.3	Architectural design for the FANET network	19
Figure 2.4	Three unmanned aerial vehicles (UAVs) operate in a private network.	21
Figure 2.5	Protocols for Point-to-Point Routing	23
Figure 2.6	Network routing techniques based on topology	24
Figure 3.1	Evolution of Wireless Technologies	27
Figure 3.2	Penetration of MM-wave	28
Figure 3.3	General (5G) Mobile Network Architecture	30
Figure 3.4	MM-wave Spectrum	31
Figure 3.5	Overview System for 5G Network	31
Figure 3.6	Network Architecture Combining and MMIMO and mm-wave	32
Figure 4.1	Macro-BS supports all $\mathcal{N}$ users	34
Figure 4.2	Scenario A: users spread over a vast area	38
Figure 4.3	Scenario B: users near to each other	39
Figure 4.4	Scenario A coverage analysis	40
Figure 4.5	Scenario B coverage analysis	40
Figure 4.6	Scenario A Bandwidth analysis	42
Figure 4.7	Scenario B Bandwidth analysis	42
Figure 4.8	Scenario A Bandwidth analysis	43
Figure 4.9	Scenario B Bandwidth analysis	43