CONTEXT-AWARE MULTI-ATTRIBUTE DECISION MAKING FOR RADIO ACCESS TECHNOLOGY SELECTION IN ULTRA DENSE NETWORK

SWETHA INDUDHAR GOUDAR

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Awang Had Salleh
Graduate School
of Arts And Sciences

Universiti Utara Malaysia

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Abstrak

Rangkaian Ultra Padat (UDN) merupakan kepadatan ekstrem pelbagai Teknologi Capaian Radio (RAT) yang diletakkan berdekatan antara satu sama lain dalam koordinasi selaras atau tidak selaras. Kepadatan RAT ini membentuk pertindihan zon liputan isyarat yang menyebabkan kekerapan penyerahan perkhidmatan antara RAT yang mengakibatkan pengurangan prestasi sistem secara keseluruhan. Pendekatan pemilihan RAT semasa lebih cenderung kepada kriteria berpusatkan rangkaian yang berkaitan dengan kekuatan isyarat. Namun, anjakan paradigma daripada pendekatan berpusatkan rangkaian kepada pendekatan berpusatkan pengguna memerlukan proses pemilihan pelbagai kriteria, dengan metodologi yang mengaitkan pilihan rangkaian dan pengguna dalam konteks rangkaian generasi masa hadapan. Oleh itu, pendekatan pemilihan yang berkesan diperlukan bagi mengelak penyerahan RAT yang tidak perlu. Tujuan utama kajian ini adalah untuk mencadangkan pembuatan keputusan Peka Konteks Pelbagai-Atribut untuk pemilihan RAT (CMRAT) bagi menyelidik keperluan dalam memilih RAT yang baharu dan seterusnya menentukan kaedah yang terbaik di kalangan kaedah yang ada. CMRAT terdiri daripada dua mekanisma iaitu Proses Analisis Hierarki Peka Konteks (CAHP) dan Teknik Peka Konteks untuk Keutamaan Susunan Keserupaan dengan Penyelesaian Ideal (CTOPSIS). Mekanisma CAHP mengukur keperluan menukar daripada RAT semasa, manakala CTOPSIS pula membantu dalam membuat keputusan untuk memilih sasaran RAT yang terbaik. Satu siri kajian eksperimental telah dijalankan untuk mengesahkan keberkesanan CMRAT bagi memperbaiki prestasi sistem. Kajian ini menggunakan senario pusat membeli belah dan rangkaian bandar yang padat bagi menilai prestasi pemilihan RAT melalui simulasi. Dapatan kajian menunjukkan bahawa pendekatan CMRAT mengurangkan kelengahan dan bilangan serahan yang membawa kepada peningkatan daya pemprosesan dan nisbah penghantaran paket berbanding pendekatan A2A4-RSRQ yang selalu digunakan. Pendekatan CMRAT adalah berkesan untuk pemilihan RAT dalam persekitaran UDN dan seterusnya menyokong penggunaan pelbagai RAT dalam rangkaian 5G masa hadapan. Dengan pemilihan peka konteks, ciri berasaskan pengguna juga telah diberikan penekanan.

Kata kunci: Pemilihan peka konteks, Rangkaian pelbagai, Teori pembuatan keputusan pelbagai-atribut.

Abstract

Ultra Dense Network (UDN) is the extreme densification of heterogeneous Radio Access Technology (RAT) that is deployed closely in coordinated or uncoordinated manner. The densification of RAT forms an overlapping zone of signal coverage leading to the frequent service handovers among the RAT, thus degrading overall system performance. The current RAT selection approach is biased towards network-centric criteria pertaining to signal strength. However, the paradigm shift from network-centric to user-centric approach necessitates a multi-criteria selection process, with methodology relating to both network and user preferences in the context of future generation networks. Hence, an effective selection approach is required to avoid unnecessary handovers in RAT. The main aim of this study is to propose the Context-aware Multi-attribute decision making for RAT (CMRAT) selection for investigating the need to choose a new RAT and further determine the best amongst the available methods. The CMRAT consists of two mechanisms, namely the Context-aware Analytical Hierarchy Process (CAHP) and Context-aware Technique for Order Preference by Similarity to an Ideal Solution (CTOPSIS). The CAHP mechanism measures the need to switch from the current RAT, while CTOPSIS aids in decision making to choose the best target RAT. A series of experimental studies were conducted to validate the effectiveness of CMRAT for achieving improved system performance. The investigation utilises shopping mall and urban dense network scenarios to evaluate the performance of RAT selection through simulation. The findings demonstrated that the CMRAT approach reduces delay and the number of handovers leading to an improvement of throughput and packet delivery ratio when compared to that of the commonly used A2A4-RSRQ approach. The CMRAT approach is effective in the RAT selection within UDN environment, thus supporting heterogeneous RAT deployment in future 5G networks. With context-aware selection, the user-centric feature is also emphasized.

Keywords: Context-aware selection, Heterogeneous networks, Multi Attribute Decision Making Theory.

Declaration Associated with This Thesis

Some of the works presented in this thesis have been published or submitted as listed below.

[1] Adib Habbal, **Swetha Indudhar Goudar** and Suhaidi Hassan. "Context-aware Radio Access Technology Selection in 5G Ultra Dense Networks", 2017. IEEE Access , vol.PP, no.99, pp.1-1 doi: 10.1109/ACCESS.2017. 2689725.

[2] **Swetha Indudhar Goudar**, Adib Habbal, and Suhaidi Hassan. "5G: Next Wave of Digital Society Challenges and Current Trends". Journal of Telecommunication, Electronic and Computer Engineering, e-ISSN: 2289-8131 Vol. 9, pp-63-66, 2017.

[3] **Swetha Indudhar Goudar**, Adib Habbal, and Suhaidi Hassan. Context-aware Multi-criteria Framework for RAT Selection in 5G Networks. Advanced Science Letters, 2017. [Accepted for publication in the SCOPUS INDEXED Journal]

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List of Abbreviations

1G	First Generation
2G	Second Generation
3G	Third Generation
3GPP	Third Generation Partnership Project
4G	Fourth Generation
5G	Fifth Generation
ANDSF	Access Network Discovery Selection Function
AP	Access Point
AC	Actual Context
ANOVA	Analysis of Variance
AHP	Analytic Hierarchy Process
ANP	Analytical Network Process
CDMA	Code Division Multiple Access
CR	Coherence Ratio
CI	Consistency Index
CAHP	Context-aware Analytical Hierarchy Process
CMRAT	Context-aware Multiple Attribute Radio Access Technology
CTOPSIS	Context-aware Technique of Order Preference by Similarity to Ideal Solution
DF	Degree of freedom
DS-I	Descriptive Study-I
DS-II	Descriptive Study-II
DRM	Design Research Methodology
D2D	Device to Device
DIA	Distance to Ideal Alternative
EPC	Evolved Packet Core
EC	Expected Context
FDMA	Frequency Division Multiple Access
GPRS	General Packet Radio Services
GSM	Global System for Mobile
GRA	Grey Relational Analysis

HeNB	Home evolved Base station
HT	Horizontal Techniques
IT	Information Technology
ITU	International Telecommunication Union
IoT	Internet of Things
LTE	Long Term Evolution
LTE-A	Long Term Evolution-Advanced
M2M	Machine to Machine
MST	Mean Square for Treatment
MSE	Mean Square of Error
MIH	Media Independent Handover
METIS	Mobile and wireless communications Enablers for the 2020 Information Society
MCHO	Mobile Controlled Handover
MME	Mobility Management Entity
MN	Moving Networks
MADM	Multiple Attribute Decision Making
MIMO	Multiple Input Multiple Output
MEW	Multiplicative Exponent Weighting
NIST	National Institute of Standards and Technology of the United States
NCHO	Network Controlled Handover
NS-3	Network Simulator 3
NGN	Next Generation Network
PDR	Packet Delivery Ratio
PGW	Packet Gateway
PoA	Point of Attachment
PC	Power Consumption
PS-I	Prescriptive Study-I
QCI	Quality Channel Index
QoE	Quality of Experience
QoS	Quality of Service
RAT	Radio Access Technology
RSRQ	Radio Signal Receiving Quality

RI	Random Index
RIF	RAT Initiation Factor
RSS	Received Signal Strength
RC	Research Clarification
SGW	Serving Gateway
SINR	Signal into Interference Noise Ratio
SAW	Simple Additive Weighting
SSE	Sum of Squares of Errors
SST	Sum of Squares Treatment
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution
TDMA	Time Division Multiple Access
UDN	Ultra Dense Networks
UMTS	Universal Mobile Telecommunication Systems
UE	User Equipment
V2V	Vehicle to Vehicle
VHO	Vertical Handover
VOIP	Voice Over IP
WPM	Weighted Product Method
WRMA	Weighted Rating of Multiple Attributes
Wi-Fi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WWW	World Wide Web
WWWW	Wireless World Wide Web

CHAPTER ONE
INTRODUCTION

The recent societal development and explosion of smart phone usage with ubiquity support are leading to the avalanche of mobile and wireless traffic volume forecasted to intensify thousand fold over the next decade [1]. This phenomena is compelling academia and industry alike toward investigating new approaches in mobile wireless communication systems infrastructure. Furthermore, the increased demand for service support for a plethora of existing and new applications has accelerated the evolution of wireless networks into the Fifth Generation (5G) technology, which is more of a revolution rather than evolution from previous generations [2].

In short, the 5G technology is an augmentation of legacy wireless Radio Access Technologies (RATs), such as Wireless Fidelity (Wi-Fi), Global System for Mobile Communications (GSM), Universal Mobile Telecommunications System (UMTS), Worldwide Interoperability for Microwave Access (WiMAX), Long Term Evolution (LTE), and Long Term Evolution-Advanced (LTE-A) to support the thousand fold increase in traffic with massive connectivity [3]. Figure 1.1 shows the transformation in support of traffic types and evolution from the First Generation (1G) to 5G Technology. Initially, the 1G aimed at achieving voice-only communication, while the Second Generation (2G) enhanced voice communication with short text messages. Next, the Third Generation (3G) introduced multi-media applications with voice and text, but encountered bandwidth limitation issues.

Meanwhile, the Fourth Generation (4G), also known to be the all Internet Protocol (IP) or the mobile Internet era, camouflaged all issues of the previous generation for better coverage and service with all voice, text, and multi-media applications being supported [4]. The superior expectations of the users are converging toward the future

The contents of the thesis is for internal user only

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