UNIVERSITI PUTRA MALAYSIA

DYNAMIC CHANNEL ALLOCATION FOR WIRELESS ATM

FEI WANG LI

DYNAMIC CHANNEL ALLOCATION FOR WIRELESS ATM

By

FEI WANG LI

Thesis Submitted in Fulfilment of the Requirement for the Degree of Master of Science in Faculty of Engineering Universiti Putra Malaysia

December 2000

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

DYNAMIC CHANNEL ALLOCATION FOR WIRELESS ATM

By

FEI WANGLI

December 2000

Chairman: Associate Professor Borhanuddin Mohd. Ali, Ph.D.

Faculty: Engineering

This thesis examines distributed Dynamic Channel Allocation (DCA) for the wireless environment through simulation. A wireless ATM network simulator was developed in C language. Performance is judged in terms of Normalized User Payload Throughput (NUPT), Percentage of Frequency Change (PFC), Ratio of Frequency Reuse (RFR), Frame Size (F_s) and Frame Delay (F_d) against traffic load. Some Distributed DCA channel selection strategies are examined, namely Two Frame Transmission (TFT) strategy, Access In Rotation (AIR) strategy and Intensive Access (IA) strategy. The performance of these strategies has been compared with Magic Wand Resource Reservation strategy first.

In the Two Frame Transmission (TFT) strategy, Access Point (AP) requests for a channel assignment every two frames, therefore the communication complexity is reduced. The Percentage of Frequency Change (PFC) is reduced by about 50%, but the Normalized User Payload Throughput (NUPT) of TFT strategy is lower than Magic Wand Resource Reservation Strategy first.

In the Access In Rotation (AIR) strategy, Mobile Terminals (MT) are divided into two groups, which access in rotation. In AIR strategy, the Normalized User Throughput (NUPT), and reduce Ratio of Frequency Reuse (RFR) are improved.

In the Intensive Access (IA) strategy, MTs access with a relative smaller interarrival. The simulation results show that the Normalized User Payload Throughput (NUPT) is improved when IA strategy is applied.

A criteria of performance evaluation has been developed to evaluate the performance of wireless ATM network, they are namely Stability factor of physical layer (SPHY), Stability factor of traffic load (S_t), Ratio of Frequency Reuse (RFR).

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia untuk memenuhi keperluan ijazah Master Sains

PERUNTUKAN SALURAN DINAMIK UNTUK ATM TANPA WAYAR

Oleh

FEI WANGLI

Disember 2000

Pengerusi: Profesor Madya Borhanuddin Mohd. Ali, Ph.D.

Fakulti: Kejuruteraan

Tesis ini mengkaji pengagihan peruntukan saluran dinamik untuk persekitaran ATM Tanpa Wayar melalui simulasi yang diaturcara dalam bahasa pengaturcaraan C. Prestasi dinilai berdasarkan Truput Pengguna Ternormal (NUPT), peratusan perubahan frekuensi (PFC), nisbah penggunaan semula frekuensi (RFR), saiz bingkai (F_s) dan lengah masa tetingkap (F_d) berbanding beban trafik. Tiga strategi pemilihan pengagihan saluran telah dikaji, iaitu strategi Penghantaran Dua Tetingkap (TFT), strategi Pencapaian Putaran (AIR) dan strategi Pencapaian Intensif (IA). Prestasi strategi-strategi ini telah dibandingkan dengan Strategi Pemesanan Sumber Magic Wand 1.

Pada strategi Transmisi Dua Tetingkap (TFT), Titik Pencapaian (Access Point) memohon satu peruntukan saluran untuk setiap dua tetingkap, maka kerumitan komunikasi dikurangkan. TFT juga boleh mengurangkan peratusan perubahan frekuensi sebanyak 50 %, tetapi Truput Pengguna Ternormal (NUPT) untuk strategi

TFT adalah lebih rendah jika dibandingkan dengan Strategi Pemesanan Sumber Magic Wand 1.

Pada strategi Pencapaian Dalam Putaran (AIR), terminal boleh alih dibahagikan kepada dua kumpulan, yang membuat pencapaian secara bergilir. Strategi AIR boleh meningkatkan Truput Pengguna Ternormal (NUPT) dan mengurangkan nisbah penggunaan semula frekuensi.

Strategi Pencapaian Intensif (IA) merujuk kepada situasi di mana terminal boleh alih membuat pencapaian dengan ketumpatan yang tinggi. Hasil simulasi menunjukkan Truput Pengguna Ternormal (NUPT) dapat diperbaiki apabila strategi in dipraktikkan.

Satu kriteria pengujian prestasi telah dirumus untuk mengkaji prestasi rangkaian ATM tanpa wayar. Ia terdiri daripada faktor kestabilan, faktor kestabilan beban trafik dan nisbah penggunaan semula frekuensi.

ACKNOWLEDGEMENTS

I would firstly like to thank IRPA for funding this wok. This thesis has been fully funded by Malaysian Government IRPA grant 04-01-04-0002. I also wish to express my thanks to some of the individuals who made this work possible. Foremost of these is my supervisor, Dr. Borhanuddin Mohd. Ali, the chairman of my supervisory committee, gave me the opportunity to work on a very interesting and practical problem.

I am grateful to my two supervisors Mr. Ashraf Gasim Elsid Abdalla and Dr. V. Prakash for their time, support and patience and without which much of this work would not have been possible. My sincerest thanks go to Dr. Sabira for all her informative discussions and constructive suggestions during these graduate studies.

I am also glad to express my gratitude in particular to research team including without their support and advices, this work would not have been possible at all.

Finally, I would also like to thank my wife for giving me great support to proceed with the thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure **Page**

LIST OF ABBREVIATION

ABR	Available Bit Rate
AIR	Access In Rotation
AMPS	Advanced Mobile Phone Service
AP	Access Point
ARQ	Automatic Retransmission reQuest
ATM	Asynchronous Transfer Mode
BER	Bit Error Rate
BRAN	Broadband Radio Access Networks
CBR	Constant Bit Rate
CIR	Carrier to Interference Ratio
CLR	Cell Loss Ratio
DCA	Dynamic Channel Allocation
DCESA	Dynamic Cell Size Adjustment
DLL	Data Link Layer
DPSK	Different Phase Shift Keying
DSA	Dynamic Slot Assignment
ETSI	European Telecommunication Standards Institute
FAC	First Available Carrier
FCA	Fixed Channel Assignment
FEC	Forward Error Correction
FH	Frame Header
GSM	Group Special Mobile
HIPERLAN	High Performance Radio Local Area Network

HTA	Highest interference below Threshold Algorithm
IA	Intensive Access
IntrA	Interarrival
ISDN	Integrated Digital Service Network
JVTOS	Joint Viewing and Teleoperation Service
LAN	Local Area Network
LFA	Lowest Frequency below threshold Algorithm
LIA	Least Interference Algorithm
LOLIA	Locally Optimized Least Interference Algorithm
LTA	Least interference below Threshold Algorithm
MAC	Medium Access Control
MASCARA	Mobile Access Scheme based on Contention And Reservation for ATM
MBS	Mobile Broadband System
MIA	Marginal Interference Algorithm
MPDU	MAC Protocol Data Unit
MT	Mobile Terminal
NUPT	Normalized User Payload Throughput
OFDM	Orthogonal Frequency Division Multiplexing
PCR	Peak Cell Rate
PCS	Wireless personal communication service
PDU	Protocol Data Unit
PFC	Percentage of Frequency Change
PHY	Physical Layer
PSK	Phase Shift Keying

QoS	Quality of Service
RFR	Ratio of Frequency Reuse
RSSI	Receive Signal Strength Indicator
SC	Same Carrier
SCR	Sustain Cell Rate
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TFT	Two Frame Transmission
TS	Time Slot
UBR	Unspecified Bit Rate
VC	Virtual Channel
VBR	Variable Bit Rate
WAND	Wireless ATM Network Demonstrator
WATM	Wireless ATM
WLAN	Wireless Local Area Network

LIST OF NOTATIONS

ALPHA	-	ATM cell producing rate
L	-	Traffic load
L_t	-	Traffic load factor
F_d	-	Frame delay
F_{max}	-	Maximum frame size
F_s	-	Frame size
p	-	OFF-ON transition
q	-	ON-OFF transition
S_t	-	Stability factor of traffic load
α	-	Probability factor
λ'	-	Average arrival rate
μ	-	Mean transmission rate
μ'	-	Average service rate
σ	-	Standard deviation
σ'	-	Time increment

CHAPTER I

INTRODUCTION

Wireless ATM Overview

Wireless personal communication service (PCS) and broadband networking for the delivery of multimedia information represent two well established trends in telecommunications. While technologies for PCS and broadband communications have historically been developed somewhat independently, harmonization into a single architecture framework is motivated by an emerging need to extend multimedia services to a single portable terminals as well as by service integration and operational efficiency considerations. It is reasonable to consider extension of standard ATM services into next generation microcellular wireless and PCS scenarios (Yuan *et al*., 1997).

Future wireless networks however, will have to provide support for multimedia services (Ramanathan, 1999). With the growing acceptance of ATM as the standard for broadband networking, in which QoS is used to form a service contract between applications and the network (Chen *et al*, 1997), wireless ATM is emerging as a potential transport solution for broadband wireless networks. The interest for wireless multimedia services has grown rapidly (Berg, 1998), therefore provision of a flexible broadband wireless infrastructure that can support emerging multimedia services along with traditional data services is desirable (Kim and Krunz, 2000). In order to achieve this goal, wireless ATM must support the quality-of-service (QoS) requirements associated with various ATM services (Kim and Krunz, 1999). In such a system, the management of the available frequencies has a significant impact on system performance (Marias, 1998).

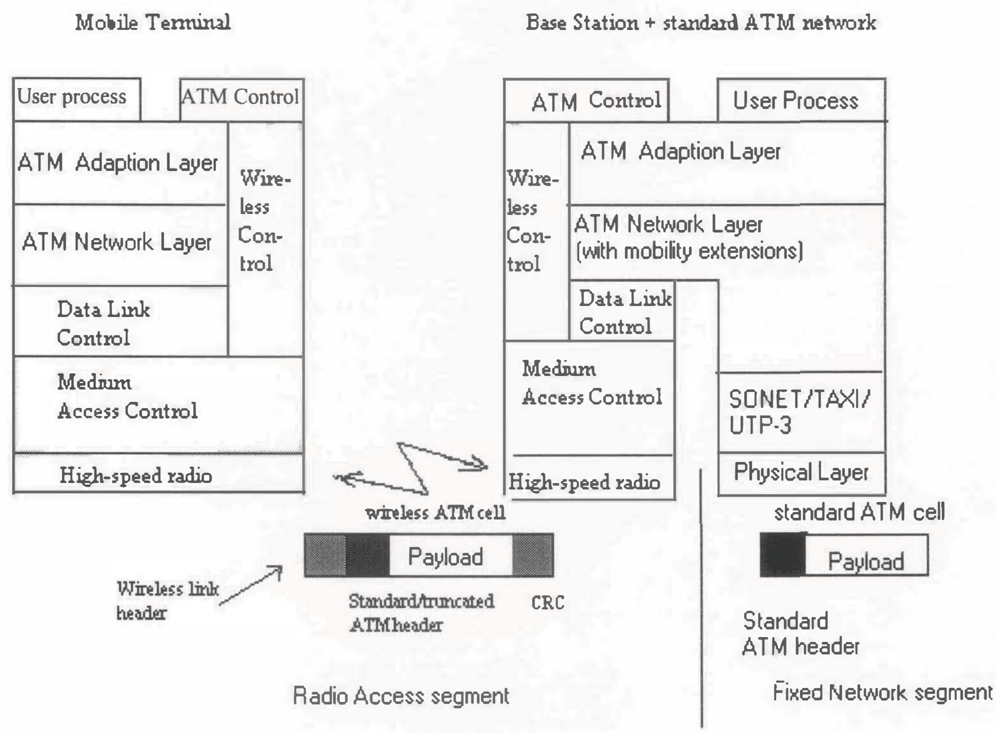

Figure 1. Wireless ATM protocol stack

The concept of wireless ATM is now being studied intensively and is still far from stable. The main advantage of Wireless ATM technology will be the seamless radio extension of ATM to mobile users. Today in most instances separate networks are used to carry voice, data, and video information, mostly because these traffic types have different characteristics. With ATM, separate networks will no longer be required. ATM is the only standards-based technology which has been designed from the beginning to accommodate the simultaneous transmission of data, voice, and video, improving efficiency as well as manageability (Fankhauser *et al.*, 1996). In such a multi-service supported wireless environment, QoS guarantees are critical for real-time voice and video (Kim and Krunz, 1999). Data connections with relaxed time constraints can use Automatic Retransmission request (ARQ), while voice and video connections that require low delay, delay jitter, and minimal packet loss may need a combination of Forward Error Control (FEC) and ARQ with time-constrained retransmission (Kim and Krunz, 2000).

Some common features of most works on wireless ATM can however be identified (Mitts, 1996):

- Wireless ATM is viewed as a 'natural' extension of fixed ATM networks. It provides users wireless access to the multitude of services and applications expected to be deployed, over time, on fixed ATM networks. While this does not exclude dedicated wireless applications, they seem to play a lesser role.
- As an extension of fixed ATM networks, wireless ATM must embrace the key features of ATM networks such as the capability to provide bandwidth on demand and to support many different traffic classes (service categories) with different Quality of Service (QoS) objectives.

Wireless ATM systems are typically based on a cellular network layout with very small cells (micro or pico-cells). Due to the small cell size, handover between radio cells will be very frequent. The basic idea of wireless ATM is to use a standard

ATM cell for network-level functions, while adding a wireless header/trailer on the radio link for wireless channel specific protocol sublayers. The proposed protocol stack is fully harmonized with that of standard ATM. Therefore, the normal ATM services, QoS and Q.2931 signaling can be used for mobile services.

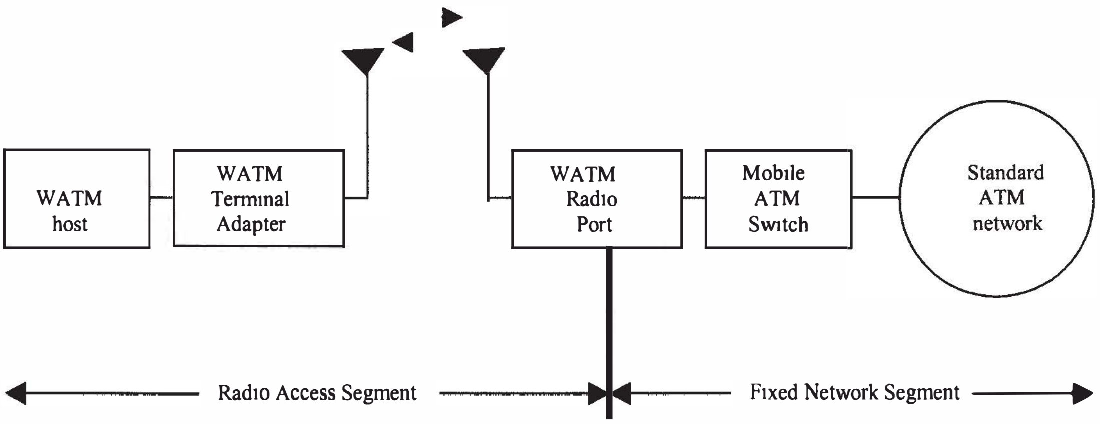

Figure 2. Wireless ATM reference architecture

Wireless ATM Architecture

Wireless ATM (WATM) system reference model mainly contains the following major components:

- WATM terminal: the end-user device.
- WATM terminal adapter: wireless ATM network interface at end user.