UNIVERSITI PUTRA MALAYSIA

INTER-SATELLITE LINK CHANNEL MANAGEMENT FOR MOBILE SATELLITE SYSTEMS

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
In Fulfillment of the Requirements for the degree of Master of Science

April 2003

To God and my family……..

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Master of Science

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May 2003

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Low Earth Orbit (LEO) satellite constellations are foreseen as appropriate alternatives to the geostationary satellite systems for providing global personal communications services (PCS). Compared to geostationary satellites, these constellations offer a significantly smaller round trip delay between earth and space segments. Furthermore, the use of inter-satellite links (ISLs) has been identified as a means to provide global connectivity in space, thereby enhancing system autonomy and flexibility, and has been retained in the design of systems like Teledesic and SkyBridge. From a network point of view, a major benefit of a ISL subnetwork in space lies in the possibility to transport long distance traffic over reliable and high capacity connections, thus forming a good base for ATM (asynchronous transfer mode) operation. With the development of the third generation (3G) and fourth generation (4G) wireless networks, ATM is regarded as one of the potential promising candidates for providing QoS guaranteed broadband telecommunication services. It is possible to integrate the mobile satellite and ATM by applying the inter/intra satellite links (ISLs) as the physical layer of WATM and

considering a connection between two satellites as a virtual path connection (VPC) in ATM.

A handoff event will cause re-allocation on the affected ISL channel resources. As the increasing of the arrival rate of handoff calls, channel management becomes a very important issue in providing QoS. Methods to keep the frequency of handoff as low as possible, and how to alleviate the side-effects of handoff events on the whole network are very important in providing QoS promised service. A good routing scheme is always highly related to the happening of handoff events.

In order to best utilize the network resource and provide better network QoS, a dynamic channel allocation scheme (DCAS) is considered, giving higher priority to handoff calls compared to new calls and real time traffic over non real time traffic. The higher priority traffic will have a larger probability to access a channel, while the lower priority traffic will have a smaller probability to obtain a channel. In this way, we give highest priority to the real time handoff calls, followed by the non real time handoff calls, then the real time new calls and lastly the non real time new calls. The channel access probability also depends on the mobility of call (handover call arrival rate over the new call arrival rate) and the channel resources. A suitable routing method was used based on the Modified Dijkstra Shortest Path algorithm. For an efficient channel management scheme, the dynamic channel allocation and shortest path routing methods are combined. The new channel management scheme allows the higher priority call to obtain a larger call acceptance probability and utilize the shortest path, while the lower priority call will have a smaller call acceptance probability and utilize the longer routes.

The network performance is measured from its end-to-end delay, new call blocking probability, and handoff call blocking probability. The new channel management scheme improves the utilization of the network resources by reducing the handover call blocking probability while guaranteeing a certain quality of service for the new call blocking probability.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai
memenuhi sebahagian daripada keperluan ijazah Master Sains

PENGURUSAN SALURAN ANTARA SATELLITE UNTUK SISTEM SATELLITE BERGERAK

Oleh

ANGELINE ANTHONY DASS

Mei 2002

Pengerusi : Profesor Dr. Borhanuddin Mohd. Ali

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Buruj satelit orbit-bumi-rendah telah dikenalpasti sebagai gantian sesuai kepada sistem satelit geopegun untuk membekalkan perkhidmatan komunikasi peribadi global (PCS). Berbanding dengan satelit geopegun, buruj-buruj ini menawarkan kelengahan pusingan perjalanan yang lebih kecil di antara segmen bumi dan angkasa. Tambahan pula, penggunaan hubungan antara satelit (ISL) telah dikenalpasti sebagai cara mengadakan sambungan global di angkasa, dan meningkatkan autonomi dan kefleksibelan sistem, dan telah digunakan dalam rekabentuk system seperti Teledesic dan SkyBridge. Dari kacamata rangkaian, satu kebaikan subrangkaian hubungan antara satelit (ISL) adalah kemudahan mengangkut trafik jarak jauh di atas sambungan yang dipercayai dan berkapasiti tinggi, sekaligus membentuk satu asas yang baik untuk operasi cara pindahan tak segerak (ATM). Dengan pembangunan rangkaian wayarles generasi ketiga (3G) dan generasi keempat (4G), ATM telah dikenali sebagai calon yang baik untuk membekalkan perkhidmatan telekomunikasi jalur lebar dengan perkhidmatan kualtitinya (QoS)

terjamin. Adalah mungkin untuk menggabungkan satelit bergerak dan ATM dengan menggunakan hubungan inter/intra sebagai lapisan fizikal ATM wayarles (WATM) dan menganggap sambungan antara dua satelit sebagai litar laluan maya (VPC) dalam ATM.

Kejadian pengambilalih akan menyebabkan peruntukan semula sumber saluran ISL yang terlibat. Ketinggian kadar ketibaan panggilan pengambilalih, membuatkan pengurusan saluran menjadi isu yang sangat penting untuk mengekalkan QoS. Cara-cara untuk mengurangkan kejadian pengambilalih dan kesannya terhadap seluruh rangkaian adalah sangat penting dalam mengekalkan perkhidmatan kualiti yang terjamin. Skim penghalaan yang baik sentiasa dikaitkan dengan kejadian pengambilalihan.

Demi menggunakan sumber rangkaian dengan baik dan membekalkan perkhidmatan kualiti yang lebih baik, satu skim peruntukan saluran dinamik (DCAS) telah dipertimbangkan, dengan memberi keutamaan yang lebih tinggi kepada panggilan pengambilalih berbanding kepada panggilan baru, dan trafik masa nyata berbanding kepada trafik bukan masa nyata. Trafik yang berkeutamaan lebih tinggi akan mempunyai kebarangkalian yang lebih tinggi untuk mendapat saluran, manakala trafik yang berkeutamaan lebih rendah akan mempunyai kebarangkalian yang lebih kecil. Dengan cara ini, kita memberi keutamaan tertinggi kepada panggilan pengambilalih masa nyata, panggilan pengambilalih bukan masa nyata, panggilan baru masa nyata dan akhirnya panggilan baru bukan masa nyata. Kebarangkalian perolehan saluran juga bergantung kepada mobiliti panggilan (kadar ketibaan panggilan pengambilalih kepada kadar ketibaan panggilan baru) dan keadaan sumber saluran. Suatu cara laluan yang sesuai digunakan berasaskan algoritma Modified Dijkstra Shortest Path. Untuk skim pengurusan saluran yang efisien, skim peruntukan saluran dinamik dan laluan jalan terpendek telah digabungkan. Skim pengurusan saluran yang baru membenarkan panggilan berkeutamaan tinggi untuk mendapat kebarangkalian panggilan diterima yang lebih besar dan menggunakan laluan terpendek, manakala panggilan berkeutamaan lebih rendah mempunyai kebarangkalian panggilan diterima yang lebih kecil dan menggunakan laluan yang lebih jauh.

Kebolehan rangkaian diukur dari kelewatan hujung ke hujung, kebarangkalian halangan panggilan baru dan kebarangkalian halangan panggilan pengambilalih. Skim baru pengurusan saluran memperbaiki penggunaan sumber rangkaian dengan mengurangkan kebarangkalian halangan panggilan pengambilalih dan mengekalkan servis kualiti tertentu bagi kebarangkalian halangan panggilan baru.

ACKNOWLEDGEMENTS

I would like to express my greatest appreciation and gratitude to God the almighty and merciful for giving me the strength and ability to complete my research.

I would like to express my sincere appreciation to Prof. Borhanuddin Mohd. Ali, chairman of my supervisory committee for his time and guidance. I would like to express my deepest gratitude to Dr. Hadi Mohd. Habaebi for being in my supervisory committee and for his time, guidance and motivation. I would like to thank Dr. V. Prakash for his ideas and support as a committee member throughout my research.

I would also like to thank Puan Nor Kamariah Nordin, for her helpful suggestions, guidance and time. Special thanks goes to Mr. Ashraf Gasim Elsid Abdalla for his encouragement and support. I wish to thank Dr. Sabira Khatun for her help with the mathematical models.

I am very grateful to Sahar Talib who has been a great help in the simulation part of this research, and fellow students Shamini, Khalid, Zubeir, Coulibaly, Prihandoko, Michael, Aduwati and Saravanan, from the wireless group who were always willing to spend time and provide any help they could.

Finally, I would like to thank my family members and friends for their unlimited love, encouragement and support.

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LIST OF ABBREVIATIONS

GII - Global Infonnation Infrastructure

PCS - Personal Communications Services

3G - Third generation

4G - Fourth generation

LEO - Low Earth Orbit

MEO - Medium Earth Orbit

GEO - Geosynchronous Earth Orbit

HEO - Highly Elliptical Orbit

ATM - Asynchronous Transfer Mode

WATM - Wireless Asynchronous Transfer Mode

SATATM - Satellite Asynchronous Transfer Mode

NCBP - New Call Blocking Probability

HCBP - Handoff Call Blocking Probability

MDSP - Modified Dijkstra Shortest Path

RNH - Rerouting Nodes Handoff

DCAS - Dynamic Channel Allocation Scheme

CDS - Channel Detection Scheme

IMT-2000 - International Mobile Telecommunications, after 2000

B-ISDN - Broadband Integrated Service Digital NetworK

TDMA - Time Division Multiple Access

MF-TDMA - Multi-Frequency Time Division Multiple Access

ATDM - Asynchronous Time Division Multiplexing

FDMA - Frequency Division Multiple Access

SDMA - Space Division Multiple Access

EIRP - Effective Isotropic Radiated Power

COCC - Constellation Operations Control Centers

NOCC - Network Operations Control Centers

QoS - Quality of Service

UNI - Usernetwork Interface

NNI - Network–Network Interface

VP - Virtual Path

MT - Mobile Terminal

MU - Mobile User

MES - Moving Estimation Scheme

MHz - Mega Hertz

GHz - Giga Hertz

ITU - International Telecommunication Union

VPI - Virtual Path Identifier

VCI - Virtual Channel Identifier

VCC - Virtual Channel Connection

CAC - Connection Admission Control

UPC - Usage Parameter Control

SVC - Signaling Virtual Channel

MSVC - Meta Signaling Virtual Channel

LAN - Local Area Network

PCN - Personal Communication Network

RSSP - Responsible Satellite Selection Procedure

DVTR - Dynamic Virtual Topology Routing

AAL - ATM Adaptive Layer

MAC - Medium Access Control

DLC - Data Link Control

FSS - Fully Shared Scheme

BS - Base Station

GCS - Guard Channel Scheme

DCRS - Dynamic Channel Reservation Scheme

TDS - Traffic Detecting Scheme

PRS - Path Reservation Scheme

QPSK - Quadrature Phase Shift Keying

PSK - Phase Shift Keying

CRC - Cyclic Redundancy Check

FSS - Fixed Satellite Service

ISL - Inter Satellite Link

FHRP - Footprint Handover Rerouting Protocol

GCAC - Geographical Connection Admission Control

LW - Link Weight

TLW - Total Link Weight

LIST OF NOTATIONS

λ_h - Arrival Rate of Handoff Calls

λ_n - Arrival rate of New Calls

C - Total Number of Channels

T - Treshold

i - Number of Occupied Channels

L_S - Location of Satellite

Δx - Horizontal Difference

Δy - Vertical Difference

D_0 - Length of the shortest path

N_o - Number of Shortest Paths Between Two Satellites

$E[N_o]$ - Expected Number of Shortest Paths

TW - Traffic Weight

Ave_AC - Average Number of Available Channels

Min_AC - Minimum Number of Available Channels

LW - Link Weight

TLW - Total Link Weight

T_{del} - Average Satellite Switching Delay Factor

μ - Average Call Duration Time

P_C - Probability of C Users in the System

P_{Accept} - Access Probability

CHAPTER 1

INTRODUCTION

1.1 **Background and Motivation**

Satellite will continue to be an essential element in the establishment of long-distance telecommunications for many years, and it will have a major role in the implementation of the so-called global information infrastructure in the future. This is because of the particular feature of the satellite that can provide wide coverage independent of the actual land distance between any pair of communicating entities. The demand for global broadband telecommunication services is increasing rapidly. Several plans for next generation satellite communications are being proposed to satisfy the global broadband requirements. Pervasive and ubiquitous exchange of information is the idea behind most proposals for creating an integrated global information infrastructure (GII) [(Chitre, et. al.,1999), (Toh, et. al., 1998)] in which users can freely move around, and still access public and private databases and communicate with each other in an efficient and cost effective way.

Low Earth and Medium Earth Orbit (LEO/MEO) satellite constellations are foreseen as appropriate alternatives to the geostationary satellite systems for providing global personal communications services (PCS). Compared to geostationary satellites, these constellations offer a significantly smaller round trip delay between earth and space segments. Furthermore, the use of inter-satellite links (ISLs) has been identified as a