UNIVERSITI PUTRA MALAYSIA

CDMA SLOTTED ALOHA MAC PROTOCOL FOR ABR TRAFFIC OVER SATELLITE LINKS

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To my family…

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

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Faculty: Engineering

The design of a packet radio network with a large number of terminals and a single hub station involves the use of two basically different types of communication channels and channel architectures. One type of channel is a broadcast channel used to transmit data from the hub station to the terminals.

Transmitting data from a single hub station to a large number of terminals (one to many) is a relatively simple problem. This channel architecture is almost always configured in a simple time division multiplexed (TDM) mode. The other type is transmitting data from terminals to a single hub (many to one) which is much more challenging problem.

In general the choice of multiple access protocol for a particular application should depend on two primary factors:

(1) The traffic characteristic of the data network of interest

(2) The state of technology development at the time the network is deployed

In this thesis we investigate the combination of two multiple access schemes, slotted Aloha and DS- CDMA spread spectrum protocol (DS-CDMA slotted Aloha) over LEO satellite link in the uplink from terminals to the satellite.

In this protocol the channel is divided into time slots. Each user is assigned a time slot equal to the packet transmission. Prior to transmission each user randomly choose unique code sequence different from other users. After transmission the unsuccessful packets should be re-transmitted after a random time delay.

The simulation is done by an OPNET package in the presence of LEO satellite system with non-real time traffic type (ABR traffic). The investigation includes the throughput performance of the DS-CDMA slotted Aloha, Packet loss ratio, and the bit errors in the packet transmission in the presence of MAI, AWGN and the error correction mechanism.

The simulation shows high throughput performance is obtained against other conventional narrowband protocols such as pure Aloha and slotted Aloha protocols due to the capability of the spread spectrum technique to increase the channel capacity. The simulation also shows an improvement in the throughput performance by implementing the error correction mechanism.

Abstrakt tesis yang dikemukakan kebada Senat Universiti Putra Malaysia
sebagi memenuhi keperluan untuk Ijazah Master Sains

CDMA ALOHA DISLOT PROTOKOL CAPAIAN PELBAGAI UNTUK KADAR BIT ADA KE ATAS PUATAN SATELLITE

Oleh

SALEM KRIEM EMHEMD

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Merekabentuk radio rangkaian paket dengan bilangan terminal yang banyak dan satu stesen hab, melibatkan dua jenis saluran komunikasi dan senibina saluran yang berbeza. Salah satu jenis saluran ialah saluran penyiaran yang digunakan untuk menghantar data dari stesen hab ke terminal.

Penghantaran data daripada satu stesen hab ke bilangan terminal yang banyak (daripada satu ke banyak) adalah satu masalah yang mudah manakala saluran senibena selalunya dikonfigurasikan dalam mod pemultipleksan pembahagi masa (TDM). Penghantaran data daripada banyak terminal kepada satu hab (banyak ke satu) adalah lebih mencabar.

Pada amnya pemilihan protokol capaian pelbagai (multiple access protocol) untuk kegunaan tertentu adalah bergantung kepada dua faktor utama:

(1) Ciri trafik bagi rangkaian data

(2) Tahap pembangunan teknologi pada masa rangkaian itu diperkenalkan

Dalam kajian ini, kami mengkaji dua jenis skim capaian pelbagai Aloha dislot dan protokol spektrum sebar (DS-CDMA slotted Aloha) ke atas pautan satelit Orbit Bumi Rendah (LEO) dan terminal ke satelit.

Dalam protokol ini saluran dibahagikan kebada slot-slot masa. Setiap pengguna mengambli slot masa yang sama untuk penghantaran paket. Sebelum penghantaran, setiap pengguna memilih secara rawak jujukan kod yang berbeza dengan pengguna lain. Selepas penghantaran paket yang tidak berjaya perlu dihantar semula selepas melepasi kelewatan masa rawak.

Proses simulasi dijalankan menggunakan OPNET dengan kehadiran sistem satelit LEO bukan masa-nyata jenis Kadar Bit Ada (ABR). Penyelidikan ini termasuklah mengkaji prestasi DS-CDMA Aloha dislot, nisbah kehilangan paket, ralat dalam paket penghantaran dengan kehadiran multiple access interference(MAI), additive white guassian noise (AWGN) dan mekanisme pebetulan ralat.

Hasil daripada simulasi yang dijalankan satu prestasi yang tinggi diperolehi dintara protokol jalursempit biasa seperti Aloha asli dan Aloha dislot disebabkan kemampuan teknik spektrum sebar yang boleh meningkatkan kapasiti saluran. Simulasi ini juga dapat memperbaiki ralat prestasi pengeluaran dengan memperkenalkan mekanisme pembetulan ralat

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TABLE OF CONTENTS

LIST OF TABLES

TABLE **.PAGE**

LIST OF FIGURES

LIST OF ABBRIVATIONS

ABR	Available bit rate
ACK	Acknowledgement
AWGN	Additive White Guassian Noise
BER	Bit error rate
BPSK	Binary phase shift keying
CDMA	Code division multiple access
CLSP	Channel load sensing protocol
CRC	Cyclic reduncy check
CSN	Cell sequence number
DAMA	Demand assignment multiple access
DPSK	Differential phase shift keying
DSSS	Direct sequence spread spectrum
E_b	Bit energy
FDMA	Frequency Division Multiple Access
FHSS	Frequency hopping spread spectrum
FSM	Finite state machine
GEO	Geostationary earth orbit
HI	Header identifier
LEO	Low earth orbit
MAC	Medium access control
MAI	Multiple access interference
MCLSP	Modified channel load sensing protocol
MEO	Medium earth orbit
MSK	Minimum shift keying
PCN	Personal communication network
PDF	Probability density function
PLR	Packet loss ratio
PN	Pseudo noise
PT	Payload type
QPSK	Quadrature phase shift keying
SNR	Signal to noise ratio
TDMA	Time Division Multiple Access
UTIA	Us telecommunication industry association
VCI	Virtual circuit identifier
WATM	Wireless asynchronous transfer mode

CHAPTER I

INTRODUCTION

Background

Future global personal communication networks (PCNs) promise to be far more ambitious in terms of the number and category of user terminals. It is expected that there will be an increase in the order of millions of subscribers, as mobile and personal services are provided by satellites (Rizwan,1998).

The services to subscribers of the future satellite networks based on personal (PCNs) will not be limited to metropolitan areas and will be spread out in all of the world including developing countries and even unpopulated areas. Satellite of various sizes and capabilities has been launched to serve almost any country in the world.

The main advantages inherent to satellite communication are the broadcasting capability, the full connectivity of stations, the flexibility of station organization, the capacity to support mobile users, and high transmission quality.

The most crucial problem in the satellite system is the long propagation delay of the user satellite links, noise, and limited bandwidth, which require

special consideration at the data link control layer (DLC) of the OSI model (Rizwan.,1998).

The low earth orbit satellite (LEO) system is the most promising candidate, since these systems can provide global coverage to small hand held, low power terminals without essential need of any existing terrestrial facilities.

In addition the LEO satellite provides additional advantages to the global communication network, e.g. low propagation delay (250ms), low propagation loss, and high elevation angle at high latitudes resulting from non-equatorial orbits constellation (Jamalipour and Akira.,1997).

A satellite link is normally used by many earth stations. Since not all stations can transmit data on the link at the same time (at least not using the same frequency) there has to be some mechanism to determine which station is currently allowed to use the link to avoid the collision between stations during the transmission process. The protocols that are used to provide this mechanism are called Medium Access Control (MAC).

The MAC protocols are responsible for deciding which station gets to use the link when there is a competition for it. The MAC protocols are only needed on the satellite up link (many to one). The down link has only one sender (broadcast), the satellite, and thus has no need for the mechanisms

provided by a MAC protocol because there is only one sender (one to many) and any access schemes such as time division multiple access TDMA can be applied.

Multiple access schemes are used to allow many users to share simultaneously a finite amount of radio spectrum. The sharing of spectrum is required to achieve high capacity by simultaneously allocating the available bandwidth (or the available amount of channels) to multiple users. For high quality communication, this must be done without severe degradation in the performance of the system (Jamalpour and Akira 1997).

In addition, medium access can be defined as the method to control the access to the channel to minimize the probability of collision, which may occur between multiple users when sending their packets simultaneously through a common receiving point.

Multiple Access Schemes in Wireless Channel

Multiple access schemes in wireless channel can be classified into:

- Fixed assignment schemes
- Demand assignment schemes
- Random assignment schemes

Fixed Assignment protocols

In fixed assignment protocols, the transmission of the users are scheduled in either time (TDMA) or frequency (FDMA). By assigning a specific duration of time or frequency band to each user, it is possible to avoid the collision between their signals. In fixed assignment protocols the traffic from each user in the network is steady and fixed (Prasad,1996).

Demand Assignment Protocols

When the traffic varies with time on day or seasons using fixed assignment schemes leads to inefficient use of the channel capacity .In this case assigning the capacity on demand in response to user requests is more practical. In Demand Assignment Multiple Access (DAMA), prior to the transmission, a user asks for a channel and after the permission it can transmit its signal.

DAMA needs a separate channel to request the capacity. DAMA can be allocated the channel based on fixed allocation or random allocation depending on the traffic states of the channel. If the number of terminals in the channel is limited the proper way is to employ the request channel based on the fixed request such as in Single-channel-per-carrier pulse-code-modulated multiple-access demand-assignment equipment(SPADE) system (Cacciamani,1970) and the Indonesian PALAPA network (Suryawan et al.,1982). The SPADE

system is limited to a maximum of 50-request channel for 50 terminals while the PALAPA system is limited to 120 terminals.

When the number of potential data terminal sharing the request channel is much larger than the number of terminals active at any given time, the fixed channel request becomes impractical. In this case the channel request based on random access allocation is the solution. An example of this method is in International Maritime Satellite Organization (INMARSAT satellite system). The INMARSAT network employs a simple ALOHA random access request channel for a large number of ship stations (Abramson.1977). The random access in INMARSAT network is used only to request channel capacity for full time voice and data.

Random Access protocols

In random access protocols the users send their packets randomly without any coordination among them. The users send their packets whenever they have packets ready to send. Aloha protocol is the earliest random access protocols invented by Abramason in 1970 in University of Hawaii (Abramson.,1970). In Aloha protocol the users send their packets at any time without any synchronization mechanism. If there is no ACK received it means a collision has occurred. When the collisions occur, the collided packets should be retransmitted after waiting a random time period.

The other random access protocol is Slotted Aloha which is a modified version of Aloha protocol. In this scheme the users are allowed to transmit only at the beginning of the time slot and the synchronization is required between all the stations in the system to avoid the overlap of packets.

Code Division Multiple Access (CDMA)

In CDMA scheme multiple users can access the channel at any time with the use of the whole bandwidth and for the complete duration by using spread spectrum technique. Each user is allocated a unique Pseudorandom code (PN code) that can be separated with other users. In the spread spectrum the transmitted signal is spread over a wider frequency band much wider than the required signal to be sent. Such that the users are allowed to share the same radio frequency spectrum simultaneously.

Spread spectrum based scheme is recommended because of its advantages such as effective in mitigating multipath fading because of their bandwidth introduces frequency diversity (Kohno et al.,1995).They are also useful in mitigating interference, again because of their widely spread bandwidth.

Statement of Problem

The choice of multiple access architecture for a data network should begin with an understanding of the statistic of the traffic to be transmitted on the multiple access channels. When the traffic is transmitted by a fixed set of transmitters the best choice is to use the fixed assignment protocols such as FDMA and TDMA. If the transmitters on the network changes rapidly enough, DAMA architecture to assign capacity on demand will be the best choice. Capacity within a DAMA can be allocated on the basis of frequency, on the basis of time or on the basis of both frequency and time.

The design of the request channel for DAMA system presents a new level of multiple access choice. When the set of transmitters is small, fixed allocation architecture in the request channel is possible. However, if the number of transmitters increase the best choice is to use the Aloha architecture in the request channel as used in both INMARSAT DAMA system and the Qualacomm CDMA system.

The DAMA system with the channel request based on Aloha will not solve the problem of the access with the increase of the number of transmitters with bursty traffic. In this case the solution is to design a data network using a random access protocol in the primary channel rather than in the request channel. The way to solve this problem is by using a hybrid multiple access scheme including CDMA and slotted Aloha protocols.

This is a combination of two multiple access schemes, slotted Aloha and CDMA (CDMA slotted Aloha). Slotted Aloha is known as the simplest and flexible random access method that can realize the share of communication channel to a large number of users. CDMA provide high bandwidth and high throughput spread spectrum.

In this protocol, the channel is divided into time slots equal to the packet length and each user is assigned a time slot and allowed to transmit only at the beginning of a time slot and all users are synchronized. When the packets are ready to transmit each user randomly chooses a unique code (PN code) and send their packets simultaneously in the next time slot.

The unsuccessful transmission are due to multiple access interference (MAI) and Additive White Gaussian Noise (AWGN). Retransmission then is required. CDMA slotted Aloha in the presence of large number of users with bursty traffic can improve the performance of the system by reducing the collision which may occur during transmission with high throughput performance.