UNIVERSITI PUTRA MALAYSIA

DATA LINK CONTROL LAYER PERFORMANCE FOR WIRELESS ATM NETWORKS

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By

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Dedicated to

My Parents, Salma and Khalifa Yaklaf, and to my wife Aziza and my children (Aimen, Monia and Tasnim) for their patience and encouragement throughout this work.

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Chairman: Associate Professor Dr. Borhanuddin Mohd. Ali

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The growing demand for ATM-based technology and recent proliferation of wireless access technologies have motivated researchers to examine the feasibility of extending the ATM paradigm from the wireline to the wireless domain and create a new research area known as Wireless ATM (WATM) (Toh, 1997). Dealing with lossy wireless links, characterized by limited bandwidth and high, bursty error rates, breaks the main assumption of conventional ATM systems, which is that of using no-errors per links.

Therefore, WATM systems must provide a transparent mechanism to ensure reliable end-to-end data transmission over the wireless portion of the network. The identification of a wireless-specific data link control layer (W-DLC), sitting between the traditional ATM layer and a wireless-specific medium access control layer (W-MAC), is the responsible entity for guaranteeing the quality of service (QOS) requested by individual ATM-based virtual connections. Thus the main focus is to investigate the performance of DLC protocol for ABR traffic over wireless ATM network. Retransmissions are only required for non-real time traffic and are

implemented using a Go-Back-N and Selective Repeat (SR) ARQ (Lin et al., 1984), (Schwartz, 1987).

Wireless channels are usually time–varying and the channel bit error rates vary as the surrounding environment changes. Since these factors put in jeopardy the performance of the DLC protocol and higher layer end-to-end protocol at large, additional link-level mechanisms are added to provide reliability over impaired radio links. The DLC protocol implementation represents an attempt to achieve these goals under the strict constraints imposed by impaired wireless links.

This thesis studies and compares the two Automatic Repeat Request (ARQ) protocols, i.e., Go-Back-N (GBN) and Selective Repeat (SR) ARQ and analyse them for variable packet size and fixed packet size (WATM packet) by using C programming for simulation.

The results show that the performance of SR ARQ is better than the GBN ARQ for variable packet size. The results also show that SR ARQ protocol has better performance than GBN ARQ in terms of error detection for fixed WATM packet in the range of 50 – 70 bytes, which is the WATM packet range (ATM Forum, 1997).

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

PRESTASI LAPISAN KAWALAN PAUTAN DATA UNTUK RANGKAIAN ATM WAYARLES

Oleh

SLIMAN KA. A. YAKLAF

April 2000

Pengerusi: **Profesor Madya Dr. Borhanuddin Mohd Ali**

Fakulti: **Kejuruteraan**

Permintaan yang semakin meningkat untuk teknologi berasaskan ATM dan pertumbuhan pesat teknologi capaian wayarles sekarang telah menggalakkan penyelidik untuk mengkaji kebolehlaksanaan mengembangkan paradigma ATM daripada jalur wayar kepada domain wayarles dan mencipta satu ruang penyelidikan baru yang dikenali sebagai ATM Wayarles (WATM) (Toh, 1997). Berurusan dengan hubungan wayarles "terhilang", disebabkan dibentuk oleh lebar jalur yang terhad dan kadar ralat yang tinggi dan bertaburan. telah memecahkan jangkaan utama sistem ATM konvensional yang melibatkan penggunaan setiap hubungan tanpa ralat.

Oleh yang demikian, sistem WATM mesti menyediakan satu mekanisma lutsinar untuk memastikan penghantaran data hujung-ke-hujung yang diyakini menerusi bahagian wayarles sesuatu rangkaian. Pengenalpastian satu lapisan kawalan data berkhususkan-wayarles (W-DLC), yang berada di antara lapisan ATM tradisional dan lapisan kawalan capaian medium berkhususkan wayarles (W-MAC), adalah entiti yang bertanggungjawab untuk menjamin kualiti perkhidmatan (QoS) yang dikehendaki oleh sambungan maya individu berasaskan-ATM. Oleh itu, fokus

kami adalah menyelidik prestasi protokol DLC kami untuk trafik ABR menerusi rangkaian ATM wayarles. Penghantaran semula hanya dikehendaki untuk trafik bukan masa nyata dan dilaksanakan menggunakan satu protocol ARQ Balik-ke-N dan Ulangan Terpilih (SR) (Lin et al., 1984), (Schwartz, 1987).

Saluran-saluran wayarles biasanya berubah mengikut masa dan kadar ralat bit saluran berubah mengikut perubahan persekitaran. Oleh kerana faktor-faktor ini sangat mengancam prestasi protokol DLC dan protokol hujung-ke-hujung lapisan tertinggi, mekanisma-mekanisma peringkat-pautan tambahan dimasukkan untuk memberi kebolehpercayaan ke atas pautan radio yang terjejas. Pelaksanaan protokol DLC kami adalah satu percubaan untuk mencapai matlamat-matlamat tersebut dalam kekangan ketat yang dikenakan oleh hubungan wayarles terjejas.

Dalam tesis ini, kami menyelidik dan membanding dua Protokol Permohonan Ulangan Automatik (ARQ) yakni Balik-ke-N (GBN) dan Ulangan Terpilih (SR) serta menganalisis untuk saiz paket bolehubah dan saiz paket tetap (paket WATM) dengan menggunakan pengaturcaraan C di dalam simulasi kami.

Hasilnya menunjukkan prestasi ARQ SR adalah lebih baik daripada ARQ GBN untuk saiz paket bolehubah. Keputusan itu juga menunjukkan protokol ARQ SR mempunyai prestasi yang lebih baik dari ARQ GBN dari segi pengesanan ralat untuk WATM tetap dalam julat 50-70 bait, seperti mana yang dicadangkan oleh (ATM Forum, 1997).

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This thesis submitted to the Senate of Universiti Putra Malaysia and was accepted as fulfilment of the requirements for the degree of Master of Science.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

AAL	ATM Adaptation Layer
ABR	Available Bit Rate
ACK	Acknowledgement
ACTS	Advanced Communication Technologies and Services
AIRMAIL	Asymmetric Reliable Mobile Access In Link-Layer
AP	Access Point
ARQ	Automatic Repeat Request
ATM	Asynchronous Transfer Mode
ATMLC	ATM Link Control
BAHAMA	Broadband Ad-Hoc Wireless ATM LAN
BER	Bit Error Rate
B-R	Base-to-Remote
CBR	Constant Bit Rate
CITR	Canadian Institute of Telecommunication Research
CLP	Cell Loss Priority
CRC	Cyclic Redundancy Check
CSN	Cell Sequence Number
DLC	Data Link Control
DQRUMA	Distributed Queuing Request Up-date Multiple Access
ETSI	European Telecommunications Standards Institute
FEC	Forward Error Correction
FIFO	First-In-First-Out
GBN	Go-Back-N
HI	Hand-off-Indicator
IP	Internet Protocol
LAN	Local Area Network
MAC	Medium Access Control
MAX-SEQ	Maximum-Sequence
MT	Mobile Terminal
NAK	Negative Acknowledgement
PBS	Portable Base Station
PC	Personal Computer
PDU	Protocol Data Unit
PHY	Physical Layer
PTI	Payload Type Indicator
QoS	Quality of Service
R-B	Remote-to-Base
RRC	Radio Resource Control
SDLC	Synchronous Data Link Control
SN	Sequence Number
SR	Selective Repeat
SREJ	Selective Reject
SW	Stop-and-Wait
SWAN	Seamless Wireless ATM Network
TCP	Transmission Control Protocol
TDD	Time Division Duplex

TDMA	Time Division Multiplex Access
ToE	Time of Expiry
UBR	Unspecified Bit Rate
UTP	Unshielded Twisted Pair
VBR	Variable Bit Rate
VC	Virtual Channel
VCI	Virtual Channel Identifier
VCs	Virtual Connections
VP	Virtual Path
VPI	Virtual Path Identifier
WAN	Wide Area Network
WAND	Wireless ATM Network Demonstrator
WATM	Wireless ATM
WATMnet	Wireless ATM network
W-DLC	Wireless Specific Data Link Control
W-MAC	Wireless Specific Medium Access Control

CHAPTER I

INTRODUCTION

Background

The last few years have seen an explosion in wireline broadband networking technologies. This has been driven by an increased user demand for video teleconferencing, image applications, world-wide web access and other multimedia applications as well as advancements in key enabling technologies such as high-speed digital transmission using optical fibre, digital signal processing and high-speed integrated circuits. In this time Asynchronous Transfer Mode (ATM) has emerged as the front runner in integrated telecommunication technologies. ATM provides high-speed transfer, integration of traffic types, flexible bandwidth allocation and service type selection for a range of applications, efficient multiplexing of data from bursty data/multimedia sources and simplified network management. It is rapidly becoming a world-wide standard and has moved from concept to reality in the space of a few years.

Wireless personal communication networks have also emerged as an important field of activity in telecommunications. This surge of interest is due to several factors such as the increased availability of wireless personal computing, entertainment and communication devices, and liberalisation of spectrum allocation procedures and advances in digital signal processing and radio modem technologies. While these systems have initially focused only on voice and primitive packet data applications, it is recognised that they will have to evolve toward supporting a wider range of applications involving video and multimedia. The increased dependence on networking for business, recreation and communications, the growing demand for multimedia applications together with a human desire for mobility and freedom from office-only or home-only computing constraints makes a strong argument for wireless integrated networks.

Motivation and History

The growing interest in wireless integrated networks has motivated several researchers to examine the feasibility of extending the ATM paradigm from the wireline to the wireless domain, and create new research area known as wireless ATM (WATM) (Toh, 1997). ATM was designed for a time-invariant, reliable medium where bandwidth is not a significant constraint. However, the wireless channel is usually time varying with a high bit error rate and limited bandwidth.

The ATM protocol provides no built-in mechanism to recover from errors or cell losses due to problems with the underlying transport medium. Thus one of the requirements for making wireless ATM a reality is a method of compensating for the low reliability of the wireless channel. The obvious solution to this problem is to create a protocol at the data link level that handles the error recovery and control over the wireless channel and provides the ATM layer with a more reliable transport medium.

Wireless ATM Protocol Architecture

Wireless ATM adopts ATM to provide the data communications services so the overall architecture is based on the ATM protocol stack A wireless ATM protocol architecture is currently proposed by ATM Forum The WATM items are divided into two distinct parts

- Mobile ATM
- Radio Access Layer

Mobile ATM deals with the higher layer control and signalling functions needed to support mobility These control and signalling include handover, location management, routing, addressing, and traffic management

Radio Access layer is responsible for the radio link protocols for wireless ATM access Radio Access Layer consists of Physical Layer (PHY), Medium Access Control Layer (MAC), Data Link Layer (DLC), and Radio Resource Control (RRC)

Data Link Control Layer Protocols for Wireless ATM

The DLC layer is responsible for providing services to the ATM layer Mitigating the effect of radio channel errors should be done in this layer before cells are sent to the ATM layer Since end-to-end ATM performance is sensitive to cell loss, powerful error control procedures are required for the WATM radio access segment In order to fulfil this requirement, Automatic Repeat Request (ARQ) schemes are used to improve the performance of communication So, error detection/retransmission protocols and forward error correction methods are recommended.

The three main protocols used in ARQ schemes are stop-and-wait (SW), go-back-N (GBN), and selective repeat (SR). The SW protocol is inefficient due to the idle time spent waiting for the receiver to acknowledge each transmission. GBN and SR schemes make use of sliding window principle in which the window slides along as sequence numbers of packets in a transmit window are acknowledged, enabling more packets to be sent. In GBN scheme, if an error is detected in a packet, the receiver discards all subsequent packets, until an uncorrupted version of this packet is received. In GBN protocol, the loss of a packet is detected only after the next packet has been correctly received. This requires a continuous stream of packets being ready to send; otherwise unacceptably long delays are experienced while the receiver waits for the next packet which is transmitted by the sender, and is stopped when an acknowledgement (ACK) indicating its correct reception is received. If an ACK is not received before its time-out interval expires, the packet is retransmitted.

In selective repeat (SR) protocol, if a corrupted packet is received, it is discarded, but this does not have any effect on the acceptance of subsequent packets. This protocol uses the channel bandwidth efficiently, but requires more buffering at the receiver than Go-Back-N ARQ technique. The SR scheme uses two ways to retransmit:

- Implicit retransmission where the transmitter determines from the sequence of ACK frames that a frame has been lost.