UNIVERSITI PUTRA MALAYSIA

PERFORMANCE COMPARISON OF HANDOVER REROUTING SCHEMES IN WIRELESS ATM NETWORKS

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By

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LIST OF ABBREVIATION

AAL	ATM Adaptation Layer
ABR	Available Bit Rate
ACK	Acknowledgement
AP	Access Point
ATM	Asynchronous Transfer Mode
B-ISDN	Broadband Integrated Service Digital Network
BS	Base Station
CAC	Connection Admission Control
CBR	Constant Bit Rate
CCITT	Consultative Committee on International Telephone and Telegraphy
CDMA	Code Division Multiple Access
CONACTIVATE	Connect Activate
CONACTIVE	Connect Active
CONACTIVEACK	Connect Active Acknowledgement
COS	Crossover Switch
CS	Control Station
DISCACK	Disconnect Acknowledgement
DLC	Data Logic Control
HOCOMP	Handover Complete
HOCOMPACK	Handover Complete Acknowledgement
HOREQ	Handover Request
HORES	Handover Response
HS	Handover Switch
IE	Information Elements
IP	Internet Protocol
ITU-T	International Telecommunications Union-Telecommunication Standardisation Sector
LAN	Local Area Network
MAC	Medium Access Control
MAHO	Mobile Assisted Handover

MCHO	Mobile Control Handover
M-NNI	Mobile Network Node Interface
MSVC	Meta Signalling Virtual Channel
MT	Mobile Terminal
NCHO	Network Controlled Handover
NCN	Nearest Common Node
NCNR	Nearest Common Node Rerouting
N-ISDN	Narrowband Integrated Service Digital Network
NNI	Network Node Interface
nrt-VBR	non real time-VBR
OAM	Operation and Maintenance
ORL	Olivette Research Lab
PC	Personal Computer
PCN	Personal Communication Network
PCS	Personal Communication Services
PHY	Physical Layer
PNNI	Private Network Node Interface
PVC	Permanent Virtual Channel
QoS	Quality of Service
R-RAL	Radio-Radio Access Layer
RR-REQ	Resource Reservation Request
rt-VBR	real time-VBR
SAAL	Signalling ATM adaptation Layer
SCR	Sustained Cell Rate
SS7	Signalling System number 7
SVC	Switched Virtual Connection
SONET	Synchronous Optical Network
TDM	Time Division Multiplexing
TDMA/TDD	Time Division Multiple Access/Time Division Duplex
UBR	Unspecified Bit Rate
UNI	User Network Interface
UPC	Usage Parameter Control

VBR	Variable Bit Rate
VC	Virtual Channel
VCC	Virtual Channel Connection
VCI	Virtual Channel Identifier
VP	Virtual Path
VPC	Virtual Path Connection
VPI	Virtual Path Identifier
WAND	Wireless ATM Network Demonstrator
WATM	Wireless ATM
WATM TA	WATM Terminal adapter
WCAC	Wireless Connection Admission Control

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The major issue of the integration of wireless and wired ATM is the support of user mobility. In effect, many technical challenges have been posed due to mobility support. One of the most important challenges is the rerouting of active connections of mobile user during handover. The rerouting of connections must exhibit low handover latency, limit the handover delay or disruption time, maintain efficient routes and minimise the impact on existing infrastructure.

To date, two dominant approaches have been proposed to support mobility into fixed ATM network. The first is the mobility enhanced switches approach and the second is the separate network-elements specific to mobility approach. The first approach implies updating the existing ATM switches with mobile specific features. The mobility functions in the second approach are entrusted to a control station attached to the ATM switch as is implemented by the Magic WAND projects.

In this thesis, we investigate how mobility can be supported using both approaches. To demonstrate the effectiveness of the above approaches, we compare the performance by analytically derived formulae for their handover latency, handover delay, buffer size, and bandwidth requirements. The formulae were derived for both backward and forward handovers using a number of potential rerouting schemes proposed for wireless ATM network.

The results show that the mobility enhanced switches approach has slightly better performance than the separate network elements approach. The results also show that backward handover has better performance than forward handover in terms of the handover delay and buffer requirement. Finally, the results show that the Anchor Switch rerouting scheme is the best among other rerouting schemes proposed for wireless ATM.

Abstrak tesis yang dikemukakan pada Senat Universiti Putra Malaysia sebagai memenuhi sebahagian daripada keperluan untuk ijazah Sarjana Sains

PERBANDINGAN KEUPAYAAN ANTARA SKEMA PENYERAHAN PANGHALAAN-SEMULA PADA RANGKAIAN ATM TANPA WAYAR

Oleh

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Isu utama dalam integrasi ATM tanpa wayar dan ATM berwayar ialah sokongan terhadap kebolehgerakan pengguna. Pelbagai cabaran teknikal telah dikenal pasti dalam usaha memberi sokongan terhadap kebolehgerakan dan salah satu cabaran yang terpenting ialah penghalaan-semula sambungan aktif saluran tanpa wayar semasa proses penyerahan. Penghalaan-semula saluran tersebut mestilah mempunyai ciri-ciri seperti masa penyerahan yang singkat, masa gangguan dan lengah penyerahan yang kecil, keupayaan mengekalkan sambungan yang cekap dan meminimumkan kesan terhadap infrastruktur yang sedia ada.

Pada masa kini, dua pendekatan yang dominan telah dicadangkan supaya rangkaian ATM berwayar berupaya memberi sokongan kebolehgerakan. Pendekatan pertama menggunakan suis mudah-alih yang dipertingkatkan keupayaan kebolehgerakannya, manakala pendekatan yang kedua pula menggunakan pengasingan elemen rangkaian spesifik terhadap pendekatan mudah-alih. Pendekatan pertama melibatkan peningkatan keupayaan ciri-ciri

mudah-alih yang spesifik untuk suis yang sedia ada. Pendekatan yang kedua pula melibatkan penggunaan fungsi-fungsi kebolehgerakan pada stesen kawalan yang disambung kepada suis ATM, seperti yang diimplementasikan dalam projek Magic WAND.

Di dalam tesis ini, kami telah menguji cara kebolehgerakan disokong menggunakan kedua-dua pendekatan tersebut. Untuk mendemonstrasikan keberkesanan protokol-protokol tersebut, kami membandingkan prestasi protokol tersebut dengan menerbitkan formula-formula secara analitik untuk masa penyerahan, lengah penyerahan, saiz penimbal dan keperluan lebar-jalur. Formula-formula untuk penyerahan depan dan pergerakan belakang telah diterbitkan dengan menggunakan pelbagai skema penghalaan-semula, yang berkemungkinan besar dicadangkan untuk rangkaian ATM tanpa wayar.

Hasil keputusan menunjukan suis mudah-alih yang dipertingkatkan keupayaan kebolehgerakannya memberi pencapaian yang lebih baik berbanding dengan pendekatan pengasingan elemen rangkaian. Keputusan juga menunjukkan penyerahan belakang memberi keputusan yang lebih baik, dari segi lengah penyerahan dan penggunaan penimbal, berbanding dengan penyerahan depan. Akhir sekali, hasil keputusan menunjukkan bahawa skema penghalaan semula suis sauh merupakan skema terbaik berbanding skema-skema lain yang dicadangkan untuk ATM tanpa wayar.

CHAPTER I

INTRODUCTION

Background

Today, there is much talk about ATM (Asynchronous Transfer Mode) since it brings new meaning to high-speed networking. It promises to be the key networking enabler for multimedia applications, video conferencing and even video on demand. However, the most important benefit of ATM is that it can provide direct bandwidth needed for a certain application. Of course, this will certainly lead to significant cost saving in addition to an efficient and reliable use of the bandwidth.

Originally, the intent of ATM was to form a backbone network for high-speed data transmission regardless of traffic types. ATM was seen by the telecommunication operators as the transport technique that is specially designed for high-speed customer premises networks. Today, ATM scales well from backbones to the customer premises networks and it is independent of the bit rate of the physical medium.

The basic idea of ATM is to segment the data into small cells and then transported by cell switching to the destination at which the data is re-assembled.

The cell as defined by ATM standards has a fixed size with a length of 53 octets (48 octets for payload and 5-octet header). The transmission line speeds currently used are either 12, 25, 34, 45, 155, or 622 Mbps. Furthermore, ATM is a connection-oriented technique that is a path has to be established between users before information can be exchanged. During the setup procedure, each connection has a transfer capacity (bandwidth) assigned to it according to the user's request. This is usually done using a process called Connection Admission Control (CAC). There is another process called Usage Parameter Control (UPC) that monitors the connection and takes action if the connection attempts to exceed the limits that have been allocated to it.

The connections created by ATM network are called Virtual Connections (VCs). These connections are divided into two types: The Virtual Path Connections (VPCs) and the Virtual Channel connections (VCCs). VPCs/VCCs are identified by a reference number carried by the cell headers of active connections. The identifying reference numbers are called Virtual Path Identifiers (VPIs) and Virtual Channel Identifiers (VCIs). Note that VPCs/VCCs may be either provisioned as Permanent Virtual Circuits (PVCs) or established via signalling protocols as Switched Virtual Circuits (SVCs).

A fundamental concept of ATM is that traffic is routed according to VPI/VCI field of each cell. In each ATM switch, there is a routing table with information for all active connections passing through the switch. Note that VPI/VCI values must be unique on a specific transmission path (TP) for the entire life time of the connection. In addition, VPI/VCI values of a single connection do not necessarily have the same values on different links. If the routing is done only according to the VPI value, the value of VCIs must remain unchanged.

Efforts to define ways of signalling have been developed. Two equivalent candidates for signalling over the UNI are the Q.2931 standardised by ITU-T (the CCITT at the time) and the UNI-signalling of the ATM Forum. On the other hand, the signalling protocol to be used over NNI is the NNI-signalling defined by the ATM Forum, which is based on the signalling system 7 (SS7) as used in N-ISDN.

The ATM signalling is done by allocating one or more VCC or VPC (within a UNI or NNI) which carry signalling information. These connections are then called Signalling Virtual Channel. At the UNI, a Meta Signalling Virtual Channel (MSVC) is always available. The MSVC has a fixed bandwidth and is always found in the virtual path with VPI = 0 with a certain VCI value. The MSVC is used to establish and release point-to-point signalling virtual channels (SVCs). At the NNI, meta signalling virtual channel is not used. Instead, one VCI is reserved per VP as a permanent-signalling channel.

As a result of the impressive success and commercial growth of wired ATM networks, it is reasonable to consider extension of standard ATM services into next-generation wireless and PCS systems. In order to use ATM as a wireless network backbone, it is appropriate to add additional functionalities that will provide ATM services over a wireless medium (radio access layer) and to enable terminal migration (mobile ATM).

The radio access layer is required to provide high bandwidth wireless transmission with appropriate wireless physical layer, medium access control and data link control. Mobile ATM is required for interconnection of access points (base stations) with appropriate support of mobility related functions capable of location management and handover/handoff control. Design issues for both the radio access layer and mobile ATM are currently under active consideration and the final specification for wireless ATM is yet to come.

Handover Algorithms and Handover Rerouting Schemes for Wireless ATM Networks

A key feature of any wireless network is the capability to support freedom of motion of a user between the radio access points while maintaining connectivity. This will require the wireless network to implement handover/handoff protocols that is harmonised with the principles of ATM cell switching and support the Quality of Service (QoS) requirements of both loss and delay sensitive multimedia services.

The aim of handover is to enable mobile terminals to move seamlessly between base stations without affecting active connections that have certain Quality of Service (QoS). However, this may not always be possible due to unavoidable dropping of an active connection. In such cases, the QoS has to be re-negotiated.

So far, two dominant approaches on how mobility could be provided to the existing wired ATM networks have been proposed. At one extreme, the mobility is supported using separate network-elements specifi[illegible]. In this approach, the impact on the existing ATM infrastructure is minimised and the mobility functions are entrusted to a control station attached to ATM switches. At the other extreme, mobility is provided by modifying or upgrading each ATM switch to be able to understand the mobility functions.

Much work has been done on handovers for wireless ATM networks. So far, different types of handover can be identified. The classification given below provides an overview of these types.

Handover can be classified into Hard and Soft according to the radio links between the mobile terminal and the base stations. According to network component relevant to handover it can be classified as Intra or Inter-Switch handover. Moreover, according to who requires and decides the handover, it can be classified as Backward or Forward ones. Aditionally, there are different types of execution methods for handover proposed for wireless ATM networks. They can be broadly classified into Path Extensions, Partial Path Re-establishment, Full Path Re-establishment and Multi-cast Re-establishment schemes.

Research Objectives

The aim of this research can be summarised as follows:

1. To investigate the design issues for supporting mobility in wireless ATM networks.
2. To investigate different types of handover techniques that are used to support terminal mobility.

3. To study how a wireless ATM network may reroute a user connection during handover.
4. To determine the most suitable handover rerouting scheme for a wireless ATM LAN environment.

Significance of the Study

This thesis attempts to overcome some of the shortcomings of previous studies in handover for mobile ATM networks. In previous studies, the focus was on Backward handover for a number of handover rerouting schemes using Mobility Enhanced Switches approach only. This thesis extends the study to Forward handover using the same approach as Backward and Forward handovers with Separate Network Elements approach. A comparison between the above arguments is presented to highlight the advantages and drawbacks of the handover procedures in each approach.

Thesis Organisation

The remainder of this thesis is organised as follows: Chapter II starts with a brief description of the concept of Wireless ATM, then a brief discussion of Raychaudhuri and Wilson proposal for WATM architecture is presented. This includes the basic concepts, the protocol stack, the reference architecture, and the wireless ATM subsystem design. Secondly, this chapter describes handover algorithms, handover requirements, and handover rerouting. A detailed description of handover procedure is also presented in this chapter.

Chapter III concerns with the modelling of the handover (handoff) algorithms and the handover rerouting schemes proposed for wireless ATM networks. The detailed modelling for each handover execution method proposed for wireless ATM networks is presented. The modelling is concerned with the different issues for supporting mobility in wireless ATM networks.

Chapter IV presents a performance evaluation of each handover model using analytically derived formulae for handover latency, handover delay (disruption time), buffer size and bandwidth requirements. Then a comparison of all handover models is made, the comparison includes the advantages and disadvantages of each model. Finally, we conclude our work in Chapter V with a brief summary of the overall work and our proposal for the best handover-execution method that could be used in Wireless ATM LAN environment.

CHAPTER II

LITERATURE REVIEW

Review of Wireless ATM Network

Since ATM has been adopted as an important technology for all types of services and networks, wireless ATM can be viewed as a direct result to provide wireless access to the fixed ATM network. The following subsections study the motivation, concepts and architectures of wireless ATM (WATM) network.

Why Wireless ATM

Due to the great success of ATM on wired networks, it can be expected that the user may favor to exploit all the capabilities of the ATM transport technology in wireless communications. One of the main reasons that motivate the need of wireless ATM is the increasing importance of portable computing and telecommunication applications in both business and consumer markets.

The rapid penetration of cellular phones and laptop PCs during the previous decade is proof that users place a significant value on portability as a key feature, which enables tighter integration of such technologies with their daily lives [1]. By preserving the essential characteristics of ATM transmission, wireless ATM offers the promise of improved performance and quality of service not attainable by other wireless communication systems like cellular systems or wireless LANs [2].

Wireless ATM Network Architecture

The wireless network architecture contains the network structure design, the distribution of functionalities, the air interface design and its protocol stack, and the design of the internetworking functions to interconnect to the ATM transport network. The distribution of the functional blocks in the wireless network is based on the network control strategy to determine the capabilities for user-to-network and network-to-network access. The air interface design delivers the requirement of the reliable radio connectivities for information transport and signalling control based on the characteristics of the wireless environment. The internetworking functions convert the information elements in the wireless network to standard formats of the ATM network. In addition, it also connects the wireless signalling control elements to the signalling network for settlement of the end-to-end connection.

Raychaudhuri and Wilson Proposal for WATM Architecture

Raychaudhuri [1] provides an updated review of the wireless ATM network architecture proposed in earlier work [3, 5, 6, 7]. Below, we give a brief description of this proposal.

Basic Concept

The reference architecture for WATM systems as is shown in Figure 1 consists of two major components: