



**UNIVERSITI PUTRA MALAYSIA**

**ADAPTIVE QUALITY OF SERVICE CALL ADMISSION CONTROL  
WITH USER MOBILITY PREDICTION FOR MULTIMEDIA TRAFFIC  
OVER WIRELESS NETWORKS**

**PRIHANDOKO**

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OVER WIRELESS NETWORKS**

**By**

**PRIHANDOKO**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra  
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Philosophy**

**April 2003**



## **To All I Love**

*My Mother*

**Ibu Siti Maryatun**

*My Father*

**Bapak Katimin Hadisutopo**

*My Wife and the Mother of My Children*

**Desy Hertinsyana**

*My Lovely Children*

**Muhammad Umar Abdul Aziz**

**Khairina Azmi Zahidah**

**Muhammad Salman Alfarisi**



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Doctor of Philosophy

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

**Faculty: Engineering**

Multimedia traffic is expected to be supported in the next generation wireless networks. As in wireline networks, the wireless network must also be capable of providing guaranteed quality of service (QoS) over the lifetime of mobile connections. Some challenging problems that appear in multimedia wireless networks, such as user mobility and shortage of bandwidth, influence the QoS provisioning for the users.

In this thesis, we propose a new framework called Adaptive quality of service (AdQoS) to guarantee the QoS of multimedia traffic. The objectives that AdQoS framework tries to accomplish are minimum new call blocking and handoff dropping rates. The key feature of this framework is the bandwidth



reallocation scheme. This scheme is developed to control the bandwidth operation of ongoing connections when the system is overloaded.

The other key feature is the bandwidth reservation scheme incorporating a user mobility prediction to manage the QoS of the networks. Based on the mobility prediction, bandwidth is reserved to guarantee the uninterrupted handoff process. A comparison between existing user mobility prediction and the proposed scheme is also presented.

An integrated system, which combines the Bandwidth Allocation Level technique and the user mobility prediction, is also proposed. The proposed user mobility prediction algorithm integrates the Received Signal Strength (RSS) measurements for the mobile terminal's intra-cell movement and aggregate history of mobile terminals for inter-cell movement.

When compared with the conventional scheme proposed in the literature, the simulation results show that our proposed scheme reduces the new call blocking probabilities, the handoff dropping probabilities and reduces significantly the probability of terminating calls while still maintaining efficient bandwidth usage.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia  
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**KAWALAN PENERIMAAN PANGGILAN MUTU PERKHIDMATAN  
ADAPTIF DENGAN TELAHAN KEMUDAHALIHAN PENGGUNA  
UNTUK TRAFIK MULTIMEDIA DALAM RANGKAIAN WAYARLES**

By

**PRIHANDOKO**

April 2003

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

**Faculti: Kejuruteraan**

Trafik multimedia dijangkakan akan disokong ke dalam rangkaian wayarles generasi masa depan. Sebagaimana dalam rangkaian berwayar, rangkaian wayarles juga harus berupaya untuk menyediakan Kualiti Perkhidmatan terjamin sepanjang hayat penyambungan mudahalih. Beberapa masalah yang mencabar di dalam rangkaian berwayar seperti kemudahalihan pengguna dan kekurangan lebar jalur mempengaruhi penyediaan Kualiti Perkhidmatan kepada pengguna.

Dalam tesis ini, kami mencadangkan satu kerangka kerja yang baru, dinamakan Kualiti Perkhidmatan Boleh Adaptasi (AdQoS). Ia bertujuan

menjamin Kualiti Perkhidmatan bagi trafik multimedia yang secara umumnya diklasifikasikan sebagai trafik masa nyata dan bukan masa nyata.

Tujuan yang ingin dicapai oleh kerangka kerja AdQoS adalah mendapatkan halangan panggilan baru dan kadar pengguguran pindah-sel yang minimum. Ciri utama kerangka kerja ini ialah skim pengagihan semula lebar jalur. Skim ini dibangunkan untuk mengawal operasi lebar jalur panggilan semasa apabila sistem mengalami lebihan beban. Satu skim rizab lebar jalur yang mengambil kira ramalan kemudahalihan pengguna juga dicadangkan dalam tesis ini untuk menguruskan Kualiti Perkhidmatan rangkaian. Skim ramalan kemudahalihan dibangunkan berasaskan sejarah terkumpul pengguna mudahalih. Berasaskan ramalan kemudahalihan, lebar jalur dirizabkan untuk menjamin proses pemindahan-sel yang licin.

Bila dibandingkan dengan skim yang dicadangkan dalam literatur, keputusan simulasi kami menunjukkan bahawa skim yang dicadangkan berjaya mengurangkan kebarangkalian halangan panggilan baru dan kebarangkalian pengguguran pindah-sel. Ia juga berjaya mengurangkan secara jelas kebarangkalian penamatan panggilan disamping mengekalkan penggunaan lebar jalur yang efisien.

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## LIST OF ABBREVIATIONS

ABR	Available Bit Rate
AdQoS	Adaptive Quality of Service
ATM	Asynchronous Transfer Mode
BS	Base Station
CAC	Call Admission Control
CBR	Constant Bit Rate
HCDP	Handoff Call Dropping Probability
ITU-T	International Telecommunications Union Telecommunications
MT	Mobile Terminal
NCBP	New Call Blocking Probability
PCS	Personal Communications System
QoS	Quality of Service
RSS	Received Signal Strength
UBR	Unspecified Bit Rate
UMP	User Mobility Pattern
VBR	Variable Bit Rate
WATM	Wireless Asynchronous Transfer Mode



# CHAPTER 1

## QUALITY OF SERVICE FOR MULTIMEDIA WIRELESS NETWORK

### 1.1 Introduction

A broadband wireless network, such as wireless ATM, is capable of providing adequate multimedia service support for mobile users anywhere at any time. This implies that wireless networks should provide packet-based transport and bandwidth on demand, as well as support multimedia applications. However, the integration of wireline and wireless networks poses significant challenges. This is due to user mobility, limited radio frequency spectrum, radio channel impairment, and so on in the wireless segment [32], [37], [49], [50]. Hence, as what has been achieved in wireline networks, wireless network is also expected to have some mechanisms to provide Quality of Service (QoS) guarantee to the system.



## 1.2 Motivations and Objectives

Mobile users are expected to operate in an environment in which the quality of service (QoS) can vary significantly within and across different types of wireless networks, ranging from high speed indoor wireless LANs to very low speed outdoor wireless WANs. The continuous support of minimum QoS guarantees of multimedia applications poses a major challenge in heterogeneous wireless environments [15], [16]. Such a support requires the development of a flexible and adaptable network resource management framework. The framework must provide efficient mechanisms to bridge the heterogeneity gap between different types of networks, resolve potential QoS mismatch as mobile units move from one coverage to another, and dynamically accommodate applications with different QoS requirements in response to network performance degradation.

The existing proposals for QoS guarantee over multimedia wireless networks, show some drawbacks, such as inability to adapt to the fluctuating network resources, lack of mechanisms to predict future mobile terminal (MT) movements, and partitioning of the call admission control and bandwidth reservation scheme into two different entities that are isolated from each other.

In cellular networks, an important QoS parameter is the new call blocking probability (NCBP), i.e., the probability that a new connection request will be denied admission



into the network. A similar situation arises when an established connection in one cell attempts to move to a neighbouring cell. If the new cell cannot support the level of resources required by the connection, the handoff attempt is denied and the connection is dropped. The handoff call dropping probability (HCDDP) states the probability that an ongoing connection will be forcibly terminated during a handoff between cells due to the lack of resources in the target cell.

The NCBP and HCDDP together are used as a good indication of a network's quality of service. Another important parameter is the degree to which the network makes an effective use of bandwidth, due to its most limited resources. This parameter, referred to as the bandwidth usage, expresses the ratio of the amount of bandwidth used by various applications admitted into the network to the total bandwidth capacity of the network. Keeping the NCBP and HCDDP low while at the same time make use of bandwidth efficiently is one of the most challenging tasks facing wireless protocol designers [4-8].

In this thesis, call admission control and bandwidth reservation scheme have been developed to assure guaranteed QoS for heterogeneous traffic while maintaining efficient resource usage. To achieve this, a base station must strike a balance between the two conflicting requirements, allowing a maximum number of calls to be admitted into the network, and minimizing the handoff call-dropping rate.



In order to overcome the above problems, this thesis has defined its objectives as follows.

- (i) To study the approaches of current research in dealing with maintaining the QoS guarantees for multimedia wireless networks in the open literature.
- (ii) To design a system model that comprises call admission control and bandwidth reservation scheme that can manage QoS guarantees.
- (iii) To propose novel techniques to be incorporated into the system model to improve the overall network performance.
- (iv) To evaluate the performance of the proposed system in comparison with the current proposals.

In order to meet the objectives, we propose a framework called AdQoS (Adaptive QoS) system. The work conducted in this thesis differs from previous published work in the following ways:

- (i) The proposed system offers a comprehensive solution for multimedia wireless networks by combining the call admission control and the bandwidth reservation scheme into one framework to manage the QoS provisioning.
- (ii) The proposed system is developed to handle different types of traffic instead of only one as proposed in most of the current research.