A Study of Effective Control Policy and Wireless Networks

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Abstract – Wireless network systems are becoming increasingly popular in recent years. As the wireless resources are scarce, it is important to allocate resources efficiently and carefully in order to achieve maximum output. The call admission control scheme; play a significant role in providing the desired quality of service by judiciously assigning the radio channels that are available in a micro cell. With the rapid growing applications of multimedia, it has become desirable for wireless network systems to deliver broad-band services for integrated traffic which includes voice calls, data calls and images. In this survey article we discuss various aspects of wireless network system.

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INTRODUCTION

The next-generation wireless networks need to support a wide range of multimedia applications with limited radio resources like bandwidth. In order to guarantee quality of/service (QoS) of existing users and to optimize the overall system resource utilization, call admission control (CAC) along with efficient resource reservation scheme plays an important role in next generation wireless networks. Call admission control is a key element in the provision of guaranteed quality of service in wireless networks. The design of call admission control schemes for mobile cellular networks is especially challenging given the limited and highly variable resources, and the ability of users encountered in such networks. This article provides a survey of admission control schemes for cellular networks and the research in this area. Our main objective of this survey article is to provide a broad classification and thorough discussion of existing call admission control schemes. In addition to this, we present some modeling and analysis basics to help in better understanding the performance and efficiency of admission control schemes in cellular networks. We describe several admission control schemes and compare them in terms of performance and complexity. Handoff prioritization is the common characteristic of these schemes.

We survey different approaches proposed for achieving handoff prioritization with a -focus on reservation schemes.

Starting in 1921 in the United States, police department experimental mobile radios began operating just above the present AM radio broadcast band. On June 17, 1946 in Saint Louis, AT&T and Southwestern Bell introduced the first American commercial mobile telephone service (typically in automobiles). Installed high above Southwestern Bell's headquarters, a centrally located antenna paged mobiles and provided radio-telephone traffic on the downlink. In the mid-1960s, the Bell System introduced the Improved Mobile Telephone Services (IMTS), which markedly improved the mobile telephone systems. As early as 1947, it was realized that small cells with frequency reuse could increase traffic capacity substantially and the basic cellular concept was developed. However, the technology did not exist. In the late 19608 and early 1970s, the cellular concept was conceived and was then used to improve the system capacity and frequency efficiency.

Each cell in a cellular network is equipped with a base station and with a number of radio channels assigned according to the transmission power constraints and availability of spectrum. A channel can be a frequency, a time slot or a code sequence. The motivation for studying wireless network system comes from the numerous applications such as computer and communication networks, client server communication (CSC), digital communication system (DeS), and carrier sense multiple access with collision detection (CSMA/CD), mobile switching center (MSC) and many others. For this purpose, we cite an example of mobile switching center (MSC). Any terminal residing in a cell can communicate through a radio link with the base station located in the cell, which communicates with the mobile switching center (MSC), which is in turn connected to the public switched telephone networks (PSTN) as shown in fig. 1. When a user initiates or receives a call, the user may roam around the area covered by the network. If the mobile user moves from one ceil to another, and the call from/to the user has not finished, the network has to hand off the call from one cell to another at the cell boundary crossing without user's awareness of handoff and without much degradation of the service quality.

With the advancement of new technology, the telecommunication deregulation has restructured the communication industry all over the world which has led to business competition in the wireless services market. The telecommunication networks need utilization of their channels to achieve a desired goal. The problem of allocating the channels in an efficient manner in order to get maximum output is of vital importance. In every region, there are many multiple wireless users who have the freedom to choose the provider for their service. More and more operators are looking for cellular technology to provide service to thousands of new subscribers with high quality telephone service at a reasonable price. To increase efficiency and capacity, the service area is divided into many numbers of micro cells which are overlaid by macro cells. To cope up with such issues, various channel allocation schemes have been provided time to time. The design efforts of traffic and mobility modeling in cellular architecture of wireless network system aim to improve the system performance while fulfilling certain constraints. In wireless networks, the traffic is dependent on both time and space.

In wireless networks, mobile users use multi-mode terminals that are equipped with multiple air interfaces and adaptive protocols so that the same terminal can be used for different networks. Using these terminals, mobile users are always connected to the best available network or networks. When users move out of the coverage of the serving network, their terminals automatically switch to another network such that the applications do not experience connection interruption. Therefore, users perceive different wireless networks as a single integrated system. We refer to this integrated system as the next-generation wireless systems (NGWS). The next generation wireless networks face new challenges in the form of increasing volume of traffic with the increase in number of users and the average traffic generated by users.

In this survey article, our main goal is to provide a broad classification channel allocation scheme for cellular radio network. In addition to this, we present some modeling and analysis basics to help in better understanding the performance and efficiency of admission control schemes in cellular networks. By observing this trend, one can be predicted that the next generation of traffic in high speed wireless network will be mostly generated by personal multimedia applications which has wide variety of applications encountered in news-on-demand, video-on demand, WWW browsing, fax etc. and many others. For multimedia traffic, it is necessary to provide the quality of service guarantees between end-users.

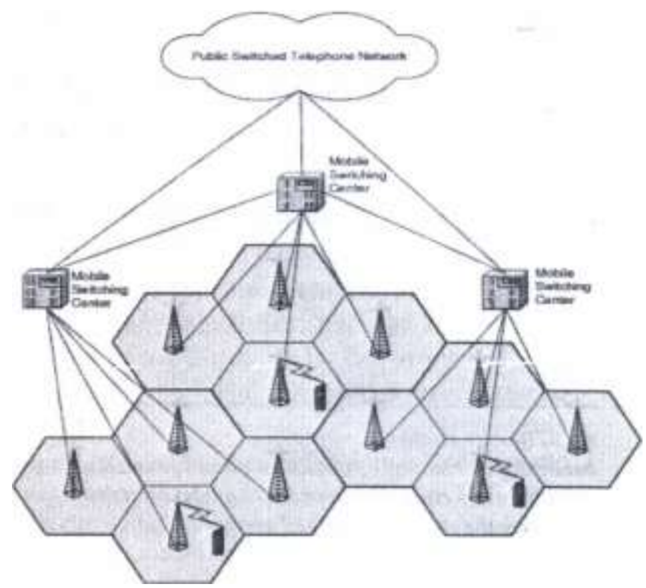

Fig. 1: A Cellular System with Hexagonal Cells

The increasing demand for advanced multimedia services combined with the resource constraints of the wireless networks indicate the need of efficient admission control schemes to achieve a competent resource management combined with adequate quality of service (QoS) levels for end users. QoS provision in wireless networks is closely related to the exploitation of available network resources and the maximization of the number of users. Call admission control (CAC) is one of the key issues in wireless networks like in wireless mobile communication, concentrating great interest in research work about QoS. CAC schemes are employed to ensure that the admission of a new call into a resource limited network does not violate the service level agreements (SLAs) concerning ongoing calls.

CAC scheme for wireless networks have been widely studied-under different network architectures and network administrator polices. The objectives of the manuscript are to present thoroughly the main concepts of CAC design and QoS provision in wireless and mobile networks. The study will focus on system- and traffic analysis employed to model the complexity of communication traffic. CAC schemes handle multiple call stream flows corresponding to different- priority levels providing an efficient mechanism to deal with different QoS necessities. The demanding environment of wireless communication poses numerous challenges in CAC design concerning the resource constraints, the connection quality, QoS requirement, SC prioritization, Mobility characteristics and revenue optimization. Another critical issue in admission control is the performance evaluation:

Analog cellular systems belong to the first generation where the major service provided is voice. Second generation cellular systems use digital technologies to provide better quality of service including voice and limited data with higher system capacity and lower cost. Third generation cellular networks offer multimedia transmission, global roaming across a homogeneous wireless network, and bit rates ranging from 384 Kbps to several Mbps. Worldwide migration to 3G is expected to continue through 2005 [1]. Meanwhile, researchers and vendors are expressing a growing interest in 4G wireless networks that support global roaming across heterogeneous wireless and mobile networks, for example, from a cellular network to a satellite based network to a high-bandwidth wireless LAN [1]-[3].

OBJECTIVES OF THE STUDY

Wireless network system (WNS) has emerged recently as a promising technology for next-generation wireless networking. In WNS, it is important to provide an efficient handoff scheme, due to the frequent user mobility. The evolution of wireless network technologies had leaded different generations of wireless systems. The main objective of this survey article is to provide the performance analysis and the quality of service especially for wireless network systems. One of the common issues among all these wireless systems are the QoS provisioning, particularly for wireless network which supports multimedia data. The key challenge which needs to be tackled in .the QoS provisioning model for multimedia wireless network is the call admission control (CAC). Efforts are needed on designing a cost-effective CAC scheme as to enable the base station to admit as many calls as possible into the network, with minimum call dropping rates, fast admission (i.e. lower number of bandwidth reallocations) and efficient bandwidth utilization.

In wireless mobile networks, the service area is divided into cells each of which is equipped with a number of channels. Two types of calls are sharing these channels namely (i) the new calls and (ii) the handoff calls [4]. New calls are those initiated by mobile users in the current cell; while the handoff calls are those initiated in other cells and handed over to the current cell. Call admission control (CAC) plays a significant role in providing the desired quality of service in wireless networks. In wireless mobile communication the channel allocation and quality of service are the major factors and important issues to decide the performance of any concerned system. Call dropping and handoff is a key element in wireless cellular networks in order to provide QoS to the users and to support user's mobility. From the user's point of view, the service of a handoff request is more important as the forced termination of an ongoing call is more annoying than the blocking of new calls.

Mobile wireless network has experienced tremendous growth in the last decade, and this growth is likely to continue in the near future. The increasing demand for advanced multimedia services combined with the resources constraints of the wireless networks indicate the need of efficient admission control schemes to achieve a competent resources management combined with adequate quality of service levels for end users.

There are some basic techniques which are commonly used in wireless network system:

HANDOFF SCHEMES

According to the handoff schemes, we can classify the way wherein the new channel is set up and the method according to which the call is handed off from the old base station to the new base station. At call-level, there are two classes of hand off schemes i.e. (i) hard hand off and (ii) soft handoff [5], [6].

ARD HANDOFF:

In hard handoff, the old radio link is broken before the new radio link is established and a mobile terminal communicates at most with one base station at a time. The mobile terminal changes the communication channel to the new base station with the possibility of a short interruption of the call in progress. If the old radio link is disconnected before the network completes the transfer, the call is forced to terminate. Thus, even if idle channels are available in the new cell, a handoff call may fail if the network response time for link transfer is too long [7]. Such type of situations can be seen in the second generation mobile communication systems based on GSM fall in this category.

SOFT HANDOFF

In soft handoff, a mobile terminal may communicate with the network using multiple radio links through different base stations at the same time. The handoff process is initiated in the overlapping area between cells some short time before the actual handoff takes place. When the new channel is successfully assigned to the mobile terminal, the old channel is released. Thus, the handoff procedure is not sensitive to link transfer time [5], [7]. The second and third generation CDMA-based mobile communication systems fall in this category. Soft handoff decreases call dropping at the expense of additional overhead (two busy channels for a single call) and complexity (transmitting through two channels simultaneously) [7]. Two key issues in designing soft handoff schemes are the handoff initiation time and the size of the active set of base stations the mobile is communicating with simultaneously [6]. This study focuses on cellular networks implementing hard handoff schemes.

CHANNEL ALLOCATION SCHEMES

Using the channel allocation schemes, channels are managed at each cell based on co-channel reuse constraints. Under such constraints, three classes of channel assignment schemes have been widely investigated [8]-[10]:

(i) Fixed channel allocation (FCA)

(ii) Dynamic channel allocation (DCA)

(iii) Hybrid channel allocation (HCA)

FIXED CHANNEL ALLOCATION

In FCA schemes, a set of channels is permanently assigned to each base station. A new call can only be served if there is a free channel available in the cell. Due to non-uniform traffic distribution among cells, FCA schemes suffer from low channel utilization.

DYNAMIC CHANNEL ALLOCATION

In DCA, all channels are kept in a central pool to be shared among the calls in all cells. A channel is eligible for use in any cell provided the co-channel reuse constraint is satisfied. DCA was proposed to overcome this problem at the expense of increased complexity and signaling overhead. Although DCA provides flexibility, it has less efficiency than FCA under high load conditions [10]; To overcome this drawback, hybrid allocation techniques, which are a combination of FCA and DCA, were proposed.

HYBRID CHANNEL ALLOCATION

In HCA each cell has a static set of channels and can dynamically borrow additional channels. For comprehensive survey on channel assignment schemes, the reader is referred to [8].

DROPPING AND HANDOFF FAILURE

When a mobile user called mobile terminal requests for the service, it may either be granted or denied. This denial of service is known as call blocking, and the corresponding probability known as call blocking probability. In a cellular network, an active terminal may move from one cell to another. The continuity of service to the mobile terminal in the new cell requires a successful handoff from the previous cell to the new cell. A handoff is successful if the required resources are available and allocated for the mobile terminal. The probability of a handoff failure is called handoff failure probability. During the life of a call, a mobile user may cross several cell boundaries and hence may require several successful handoffs. Failure to get a successful handoff at any cell in the path forces the network to discontinue service to the user. This is known as call dropping or forced termination of the call and the probability of such an event is known as call dropping probability. In general, dropping a call in progress is considered to have a more negative impact from the user's perspective than blocking a newly requested call.

QUEUEING HANDOFF SCHEMES

In handoff prioritization, handoff queuing schemes are the further techniques. This scheme delays handoff, instead of denying access, until sufficient resources are available in the new cell. As long as there are queued handoff requests, no new calls are admitted. In this way handoff requests receive higher priority than new call requests. For describing the handoff schemes, we cite an example of "code division multiple access". In handoff prioritization, handoff queuing schemes are the further techniques. This scheme delays handoff, instead of denying access, until sufficient resources are available in the new cell. As long as there are queued handoff requests, no new calls are admitted. In this way handoff requests receive higher priority than new call requests. For describing the handoff schemes, we cite an example of "code division multiple access"

FIRST IN FIRST OUT (FIFO) SCHEME

FIFO queue based handoff scheme is a simple static scheme, where the handoff requests from MS's are queued, if a free channel is not available with the target BS. When a channel is released in the cell, it is assigned to the hand off call waiting in the queue in a first come first out manner. The FIFO queuing strategy reduces, the probability of handoff failure to a great extent, but it is not the best scheme because due to varying speeds and directions of mobiles, the first mobile to enter handoff area may not be the first to leave it. Essentially its weakness is, it does not use all the information concerning the MS's in the queue. An improvement over this scheme is the - dynamic queuing schemes which serve handoff on priority basis.

MEASUREMENT BASED PRIORITIZATION SCHEMES (MBPS)

The handoff queuing approach in Measurement Based Prioritization Scheme [11] is a non-preemptive dynamic priority policy. The priority of the queued MS is defined by the power level that the MS receives from the BS of the source cell, when it is moving towards the destination cell. The highest priority level is assigned to the handoff attempt associated with the MS whose power level is closest to the receiver threshold. The MS's waiting for a channel in the queue is sorted continuously according to their priorities. When a channel is released, it is granted to the MS with the highest priority. The algorithm of prioritized queuing handoff scheme is shown in fig. 2.

APPLICATIONS OF QOS

There are several applications that require service guarantees in order to function properly. These applications are described as follows:

QOS FOR AUDIO AND VIDEO

First, and probably foremost, service guarantees are required to properly transmit 'audio and video'. In recent years, several providers have started offering audio and video services, such as telephony and video, over packet-switched networks. One motivation behind these offerings is that there is unused bandwidth in the IP network that can be utilized for a fraction of the cost of a dedicated, circuit-switched network. Another motivation is that the free-form nature of a packet-switched network makes it very versatile arid allows for new forms of services, such as video on demand. A particular challenge of audio/video transmission is that, for maximum efficiency, some compression methods encode the streams at a variable bit rate (VBR). While throughput guarantees can be made at the highest possible bit rates for such streams, doing so is wasteful and a more useful QoS scheme would make throughput guarantees at the average bit rate and allow for busty traffic with minimal additional delay and loss.

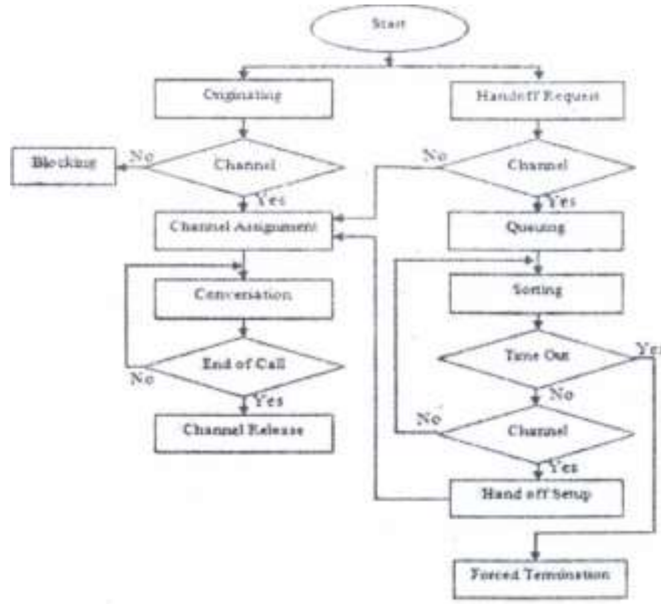

Figure 2: Handoff Scheme for Prioritized Queue

QOS FOR NETWORK

Second, real-time systems that are connected to a network require a constant stream of data which matches or exceeds their throughput rate. For this purpose, we consider 'an automated system' in a factory that makes cuts in a piece of metal based on data it receives from a network. If the network cannot keep pace with the cutting machine, then there is a chance that materials can be wasted. Another example of a real-time system is 'a military vehicle' wherein requiring service guarantees that is connected to a network. If it takes too long for data to arrive at the vehicle, or if enough data is lost, then the situational awareness of the vehicle's operators can become degraded. This problem is amplified when non-human system components, such as guided weapons, require information from the network to support their situational awareness.

QOS FOR INTERNET SERVICE PROVIDERS

Nowadays, QoS plays a vital role for 'Internet service providers' (ISPs). ISPs are expected to make service guarantees to their clients. In some cases, the clients have an application that requires such service and they buy a package from the ISP that meets the needs of that application, in other cases, the client has no such requirement, but still expects the ISP to meet all service guarantees because they are specified in the contract.

CONCLUSION

In this survey article, we have provided an extensive survey of wireless networks including queuing handoff, soft handoff prioritization schemes, call admission control, quality of service for wireless network systems. A broad and detailed categorization for these features is presented. For each category we explained the main idea and identified their distinguishing features. We believe that this survey article can help system designer and developer for developing any concerned wireless network system. CAC schemes discussed in this survey article are important in wireless networks not only for providing the QoS requirements but also for maintaining the network consistency and prevent congestion. There are many variables and performance indicators involved, and it is often not clear what is optimal for a particular system. Moreover many assumptions about mobility and traffic characteristics are not practical. Therefore most of the soft handoff prioritization schemes proposed in the literature is difficult to deploy in current and future wireless networks. With the help of this survey article, we help for the researchers for providing the desired level of QoS with the maximization of the network resources exploitation.

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