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A QoS Provisioning for 3G Wireless Networks Using Call Admission Control

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***Abstract*—Provision of quality-of-service (QoS) guarantees is an important and challenging issue in the design of integrated services packet networks. Call admission control (CAC) is an integral part of the problem. Clearly, without call admission control, providing quality-of-service (QoS) guarantees will be impossible. The task of call admission control (CAC) can be most easily illustrated by considering the following question:**

Given a new call/session that arrives to a network, can it be accepted by the network at its requested quality-of-service (QoS), without violating existing quality-of-service (QoS) guarantees made to on-going calls?

This seemingly simple question turns out to be very complicated, as the issue of call admission control is closely related to other aspects of a network, such as service models, scheduling disciplines, traffic characterization and QoS specification. Call admission control (CAC) with statistical quality-of-service (QoS) guarantees is a particularly important and challenging problem. One of the most important challenges is that of providing call admission control (CAC) for a heterogeneous mixture of applications which have differing quality-of-service (QoS) requirements.

Key Words— **Call admission control, quality-of-service.**

I. INTRODUCTION

The 3G technology is a developing technology for the future mobile communication. Nevertheless, along with the development of the 3G mobile technologies, the development of the consumer electronics will also grow. The 3G services add a valuable mobile dimension to services that have already become an integral part of modem life, such as the internet and intranet access, and video-conferencing. With the support of higher data transmission rate for mobile users, 3G networks are expected to support different broadband multimedia services, and hence, leading to the increasing provision of the products for consumer electronics, like video mobile phones and 3G broadband PCMCIA cards. Apart from the appearance of the products, a key factor that most end users concern is the diverse quality-of-service (QoS) requirement of the system. In other words, the network performance will affect the market of the products in consumer electronics, indirectly. [2]

Provision of Quality-of-Service (QoS) guarantees is an important and challenging issue in the design of integrated services packet networks. Call admission control (CAC) is an integral part of the problem. Clearly, without call admission control, providing quality-of-service (QoS) guarantees will be impossible. The task of call admission control (CAC) can be most easily illustrated by considering the following question:

» Given a new call/session that arrives to a network, can it be accepted by the network at its requested quality-of-service (QoS), without violating existing quality-of-service (QoS) guarantees made to on-going calls?

This seemingly simple question turns out to be very complicated, as the issue of call admission control is closely related to other aspects of a network, such as service models, scheduling disciplines, traffic characterization and QoS specification. Call admission control (CAC) with statistical quality-of-service (QoS) guarantees is a particularly important and challenging problem. One of the most important challenges is that of providing call admission control (CAC) for a heterogeneous mixture of applications which have differing quality-of-service (QoS) requirements. [3] The performance of any wireless cellular network, as well as its revenue (number of customers using the network, and their degree of satisfaction) is determined to a great extent by its call admission control (CAC) scheme/algorithm/protocol. As its name implies, the call admission control (CAC) determine if a new call request is granted, or rejected. [6]

There has been a rapid development in wireless cellular communications, in which the quality-of-service (QoS) guarantee remains one of the most challenging issues. One of the key elements in providing quality-of-service (QoS) guarantees is an effective call admission control (CAC) policy, which not only has to ensure that the network meets the quality-of-service (QoS) of the newly arriving calls if accepted, but also guarantees that the quality-of-service (QoS) of the existing calls does not deteriorate.

There are a number of unique aspects in the next generation of multimedia wireless cellular networks that the design of an effective admission control scheme needs to take into account.

- Smaller cells will be employed (microcells or picocells), thus the number of handoffs during a call's lifetime is likely to be increased; additionally, there is an increased influence from neighboring cells and even next-neighboring cells.
- Possibly different QoS requirements for different calls, and potentially more stringent quality-of-service (QoS) requirements of individual calls mandate a highly precise resource allocation.
- Diversified traffic load requires that admission control has to be adaptive to the changing traffic pattern. Therefore, a dynamic approach is preferred. [7]

Call admission control (CAC) is a very important measure in wireless networks system to guarantee the quality of service (QoS). In future wireless networks multimedia traffic will have different quality-of-service (QoS) requirements. [1]

The main objectives of the call admission control (CAC) are:

1. To guarantee an uninterruptable service for admitted calls as they move from one cell to another.
2. To maximize the network resource utilization by reserving resources only where needed and within the expected residence time interval.

These two objectives may conflict with each other, as guaranteeing uninterruptable service requires reserving resources in a large number of cells while maximizing resource utilization requires limiting resource reservation to those cells which are expected to be visited by the mobile unit. [8]

Call admission control (CAC) techniques must he introduced to guarantee that ail traffic types meet their quality-of-service (QoS) requirements. These are techniques that control the acceptance of different types of calls into the system. The necessary quality-of-service (QoS) is guaranteed in term of both call dropping and call blocking probabilities. A call admission control (CAC) strategy may block additional calls even if there are enough resources for the service in order to improve the system's fairness. Call admission control (CAC) is based on the knowledge of the statistical characteristics of ongoing and arriving calls. The decision to accept an additional call involves the calculation or estimation of the consequences of the call acceptance on blocking and delay of itself and other incoming calls.

Arriving (new and handoff) calls are granted/denied access to the network by the call admission scheme (CAC) based on predefined criteria, taking the network loading conditions into consideration. Call admission control (CAC) in wireless cellular networks has been receiving a great deal of attention during the last two decades due to the growing popularity of wireless communications and the central role that call admission control (CAC) plays in quality-of-service (QoS) provisioning in terms of the signal quality, call blocking and dropping probabilities, packet delay and loss rate, and transmission rate. In the first and second generation of wireless systems, call admission control (CAC) has been developed for a single service environment. In the third generation and beyond wireless systems, multimedia services such as voice, video, data, and audio are to be offered with various quality-of-service (QoS) profiles. Hence, more sophisticated call admission control (CAC) schemes are developed to cope with these changes. This paper provides a comprehensive survey of call admission control (CAC) schemes in modern wireless cellular networks.

II. System Design

2.1 Main Reasons for Using Call Admission Control (CAC) Schemes

2.1.1 Signal Quality

Call admission control (CAC) is essential to guarantee the signal quality in interference-limited wireless networks. For instance, CDMA wireless cellular networks have a soft capacity limit so that the more loaded the network is, the more deteriorated is the signal quality for users in terms of the interference level or the signal to interference ratio (SIR). Hence, call admission control (CAC) schemes admit users only if it can maintain a minimum signal quality to admitted users (including the new call and existing calls). In this case, the admission criterion can be the number of users (per cell and/or per group of neighbor cells), interference level or SIR, total transmitted power by BS, or received power by either BS or the mobile station.

2.1.2 Call Dropping Probability

Since dropping an active call is usually more annoying than blocking a new call, call admission control (CAC) is employed in bandwidth-limited wireless networks to control the handoff failure probability (PHF). This can be implemented by reserving some resources for handoff calls exclusively.

2.1.3 Packet-Level Parameters

When packet-oriented services are provided by wireless networks, network overloading can cause unacceptable excessive packet delay and/or delay jitter. The throughput level at the network or user level can also be dropped to unbearable levels. Therefore, call admission control (CAC) should be used to limit the network level to guarantee packet-level quality-of-service (QoS) parameters (packet delay, delay jitter, and throughput).

2.1.4 Transmission Rate

Call admission control (CAC) schemes are used in wireless cellular networks offering data services to guarantee a minimum transmission rate. The use of call admission control (CAC) to ensure a minimum transmission rate has been studied extensively in wire line networks. The problem, however, is more complicated in wireless networks because of user mobility (implying handoff and link quality variations), limited bandwidth, and mutual co channel interference.

2.2 Call Admission Control (CAC)

Call admission control (CAC) is a technique to provide quality-of-service (QoS) in a network by restricting the access to network resources. Simply stated, an admission control mechanism accepts a new call request provided there are adequate free resources to meet the quality-of-service (QoS) requirements of the new call request without violating the committed quality-of-service (QoS) of already accepted calls. There is a tradeoff between the quality-of-service (QoS) level perceived by the user (in terms of the call dropping probability) and the utilization of scarce wireless resources. In fact, call admission control (CAC) can be described as an optimization problem.

We assume that available bandwidth in each cell is channelized and focus on call-level quality-of-service (QoS) measures. Therefore, the call blocking probability (Pb) and the call dropping probability (Pd) are the relevant quality-of-service (QoS) parameters.

As mentioned before, channels could be frequencies, time slots or codes depending on the radio technology used. Each base station is assigned a set of channels and this assignment can be static or dynamic.

MINO tries to minimize penalties associated with blocking new and handoff calls. Thus, MINO appeals to the network provider since minimizing penalties results in maximizing the net revenue. MINB places a hard constraint on handoff call blocking thereby guaranteeing a particular level of service to already admitted users while trying to maximize the net revenue. MINC is more of a network design problem where resources need to be allocated apriority based on, for example, traffic and mobility characteristics.

Since dropping a call in progress is more annoying than blocking a new call request, handoff calls are typically given higher priority than new calls in access to the wireless resources. This preferential treatment of handoffs increases the blocking of new calls and hence degrades the bandwidth utilization. The most popular approach to prioritize handoff calls over new calls is by reserving a portion of available bandwidth in each cell to be used exclusively for handoffs. In general there are two categories of call admission control (CAC) schemes in cellular networks:

1. Deterministic Call Admission Control (CAC): Quality-of-service (QoS) parameters are guaranteed with 100% confidence. Typically, these schemes require extensive knowledge of the system parameters such as user mobility which is not practical, or sacrifice the scarce radio resources to satisfy the deterministic quality-of-service (QoS) bounds.
2. Stochastic Call Admission Control (CAC): Quality-of-service (QoS) parameters are guaranteed with some probabilistic confidence. By relaxing quality-of-service (QoS) guarantees, these schemes can achieve a higher utilization than deterministic approaches.

Most of the call admission control (CAC) schemes which are investigated fall in the stochastic category. Figure depicts a classification of stochastic call admission control (CAC) schemes proposed for cellular networks.

Call admission control (CAC) schemes can be classified based upon the number of services/classes. Single-class call admission control (CAC) has been dominant in first and second generation (2G) wireless cellular networks when voice service was the main (and sometime the only) offered service. With the growing interest of data and multimedia services, single-class call admission control (CAC) schemes are no longer sufficient and as a result multiple-service/class call admission control (CAC) schemes are more relevant, especially in the enhanced second generation (2.5G) and third generations and beyond (3G/4G). The design of multiple-service/class call admission control (CAC) schemes is more challenging since some critical issues, such as service prioritization, fairness, and resource sharing policy, must be considered.

Optimal call admission control (CAC) schemes are always preferred, but they are not necessarily attainable, particularly in realistic scenarios with a large problem size and complicated system parameter interdependence. As such, heuristics and intelligent techniques are widely used to find suboptimal call admission control (CAC) scheme.

Call admission control (CAC) schemes can be classified as proactive (parameter based) or reactive (measurement-based). In proactive call admission control (CAC) schemes, the incoming call is admitted/denied based on some predictive/analytical assessment of the quality-of-service (QoS) constraints. In reactive call admission control (CAC) schemes, the incoming call might start transmission (by transmitting some probing packets or using reduced power). Then the reactive call admission control (CAC) scheme decides to admit/reject the call based on the QoS measurements during the transmission attempt at the beginning.

Call admission control (CAC) can also be classified based on the information needed in the call admission control (CAC) process. Some CAC schemes use the cell occupancy information. This class of call admission control (CAC) schemes requires a model or some assumption for the cell occupancy. Alternatively, call admission control (CAC) schemes might use mobility information (or estimation) in making the admission decision. The use of mobility information, however, is more complicated and requires more signaling.

The information granularity used in call admission control (CAC) schemes can be considered at the cell level or at the user level. If a uniform traffic model is assumed, information of one cell is enough to represent the whole network condition. In a non-uniform traffic model, however, information from different cells is required to model the network status, which increases the information size. The third case, in which information of each individual user is considered, of course leads to a huge information size.

Call admission control (CAC) schemes have been designed either for the uplink or the downlink. In the uplink, transmit power constraint is more serious than in the downlink since the MS is battery operated. On the other hand, call admission control (CAC) in the downlink needs information feedback from MSs to the BSs for efficient resource utilization. Applying call admission control (CAC) for both links jointly is crucial since some calls might be admissible in one of the links and non-admissible in the other, particularly for asymmetrical traffic. Jeon and Jeong have proposed a joint call admission control (CAC) scheme for both the uplink and downlink. The call request is admitted only if it is admissible in both uplink and downlink. The asymmetry between uplink and downlink traffic, which is one of the characteristics of some multimedia services such as Web browsing, has been taken into account by adjusting the allocated bandwidth to each link in the call admission control (CAC) based on the traffic characteristics in each link. It has been shown that this asymmetric allocation enhances resource utilization and other quality-of-service (QoS) parameters such as Pb and Phf. This work has been extended to investigate the same problem in CDMA networks. The impact of the bandwidth allocation between UL and DL on QoS parameters (Pb, Phf and outage probability (Pout)) has been analyzed using a SIR-based call admission control (CAC) scheme for voice and data (asymmetric) services. It has been shown that there is an optimum bandwidth allocation that minimizes the Pb, Phf and Pout. [4]

2.3 Call Admission Control (CAC) Scheme

In the CAC algorithm new call arrival rates are estimated continuously and if they are higher than a predetermined level some calls are blocked irrespective of whether a channel is available or not. The objective of this scheme is to maintain the new call arrival rate lesser than a predetermined level. In this scheme a comparison is made with the existing two schemes namely pre-request scheme and the guard channel scheme and various advantages and disadvantages are given for the two schemes and then a CAC algorithm is developed which provides a better QoS than the existing two schemes. The two metrics used for QoS in this algorithm are Forced Termination Probability (FTP) which is defined as the ratio of the number of calls which are forced to terminate because of failed handoff to the number of calls that successfully entered the network. Another metric is the Successful Call Completion Rate (SCCR) which is defined as the number of calls which are completed successfully in a unit time by each cell. So lower FTP and higher SCCR is what ideal algorithms will try to achieve and this algorithm achieves that.

2.3.1 Call Admission Algorithm (CAC)

In the CAC algorithm the acceptable load is calculated based on simulation results and this value is used for comparison purpose. The estimated load is also calculated and it is checked with the acceptable load. If the estimated load is lesser than or equal to the acceptable load, then attempts are made to allocate channels for all the incoming calls. If the estimated load is greater than the acceptable load then only a fraction of the incoming calls will be allocated channels and the remaining fraction of the calls will be discarded even if there are available channels. This is called pre-blocking of channels and this scheme improves the FTP and SCCR of the profiled users.

2.3.2 Different QoS Schemes in Cellular Networks

There are many QoS schemes which have been deployed for cellular networks and each scheme has its own advantages and disadvantages. In this section we are going to look into some of the fundamental and effective QoS schemes which are used for providing voice and data services. Fault Tolerant Dynamic Allocation scheme looks into methods of reusing the channels effectively between two cells, which are separated by a minimum distance so that they do not interfere with each other. The channels are allocated dynamically as opposed to static allocation where the channels are allocated and reserved beforehand.

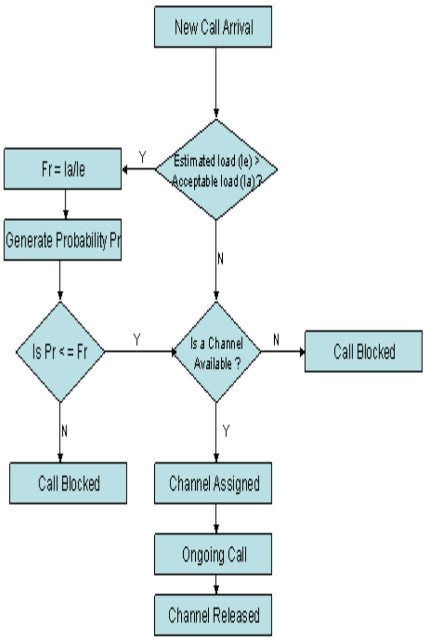

Figure 2.3.1.1: Flow Chart for CAC Algorithm

The next scheme is the Call Admission Control (CAC) which employs pre-blocking of calls based on the available bandwidth for handling calls. This algorithm is based on two schemes which were used earlier namely Pre request scheme and the guard channel scheme. CAC algorithm utilizes both the schemes and gives better performance in terms of successful call completion rates (SCCR) and provides guaranteed QoS for profiled users. In the Mobility prediction techniques hand off losses are reduced and due to which the blocking and the dropping probabilities are significantly reduced. In this mobility prediction scheme road topology information is gathered and stored in a database and the path or the trajectory of the mobile host is calculated. No assumption about the shape of the cell is assumed. The renegotiation scheme is a scheme in which the bandwidth allocation is changed dynamically based on the availability. If a low priority service has been admitted with a bandwidth less than what it had asked and after sometime extra bandwidth is available due to completion of a high priority service then the remaining bandwidth is given to the low priority service and thus increases the QoS of the lower priority service. This scheme also ensures that the higher priority services get their requested bandwidth and they are not affected in any way.

2.4 Call Admission for Voice and Data Traffic

The two most important services voice and data are considered in this section. Voice traffic is delay sensitive and requires real - time transmission. It can tolerate some data losses. On the other hand data traffic is not so delay sensitive but they are very sensitive to packet loss and error rates. Voice calls are always given priority over data traffic in cellular networks, as voice calls are more delay sensitive and also cellular networks provide better QoS which is needed for voice services. On the other hand data traffic will most likely end in WLAN coverage as it gets better bandwidth in that region.

An area with only cellular coverage is called as cellular - only area and an area with WLAN and cellular coverage is called double - coverage area. For voice calls, it has got two choices. It can either try cellular area or WLAN coverage area. If a voice call is rejected in a cellular coverage area the it tries in WLAN area. The request is rejected if there is not enough bandwidth to accommodate the voice call in this area. A data call has only one option which is the WLAN area. If it is rejected there it wont try the cellular area as the data traffic overflow in cellular area will degrade the QoS of voice traffic. To provide a priority to voice calls in cellular - only area limited fractional guard channel (LFG) policy is used.

2.5 Call admission Control in Cellular Networks

Extensive research work has been done on the call admission control (CAC) schemes in homogeneous wireless cellular networks. They can be classified based on various design focuses and algorithms, and each algorithm has its own advantages and disadvantages. Generally, call admission control (CAC) in 3G wireless cellular networks give higher priority for voice service than data services for resource allocation, and higher priority for handoff calls than new call requests. We classify previous work on call admission control (CAC) into five major categories: signal quality based call admission control (CAC), guard channel reservation based schemes, queuing methods, quality-of-service (QoS) estimation methods, and bandwidth degradation approaches.

2.5.1Signal quality based Call Admission Control (CAC)

Signal quality in the physical layer is used as a criterion of admission control. Some research work use power level of received signals or signal-to-noise-ratio (SIR) threshold as call admission requirements. An optimal call admission control (CAC) scheme is proposed to minimize the blocking

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probability while keeping a good signal quality to reduce the packet error. However, all the above schemes only check the signal characteristics in the physical layer without considering technical features in other layers and service priorities. Furthermore, there are different criteria for the measurement of signal quality in integrated networks. So it is difficult for implement a call admission control (CAC) in an interworking environment based on a uniform criterion.

2.5.2Guard channel reservation based schemes

To prioritize handoff calls over new calls, a number of channels, guard channels, in each cell are reserved for exclusive use by handoff calls, while the remaining channels are shared by both new calls and handoff calls. To decrease the handoff call dropping probability, which is at the cost of increasing the new call blocking probability, the guard channel must be chosen carefully and dynamically adjusted so that the dropping probability of handoff call is minimized and the network can support as many new call requests as possible. However, the intensities of new call requests and handoff requests are time-variant, and it is difficult to assign appropriate guard channel timely. So the guard channel will reduce the efficiency of system resource utilization, and may not be suitable for heterogeneous network environment.

2.5.3Queuing methods

When there is no channel for incoming call requests, either handoff call requests are put into a queue while new call requests are blocked, or new call requests are put into a queue while handoff calls are dropped. Although queuing schemes can avoid high blocking probability or dropping probability due to increased call intensity for a short period, it is not realistic in a practical system in which a handoff call may not hold in a queue for a long time because of fast signal fading, and new calls will leave the queue system due to users' impatience.

2.5.4 Quality-of-Service (QoS) estimation based approaches

Call admission control (CAC) in cellular networks calculates the future resource requirements for new calls and handoff calls based on user mobility and call intensity estimation. A weighted overall handoff failure probability for all cells is calculated as an indicator for long-term statistics of successful call completion. The suggested schemes take the overall weighted handoff failure probability as the criterion for new call admission. Although those schemes can improve the efficiency of admission control and resource utilization, they cause nontrivial calculation complexity, and too many real-time control messages among cells may incur large signaling traffic and communication overhead. Furthermore, rough estimation techniques used in these schemes may cause erroneous decisions for call requests in a real world scenario, which will deteriorate the quality-of-service (QoS) level in the system.

2.5.5Bandwidth degradation Call Admission Control (CAC)

Some methods are proposed to degrade some connections adaptively when there are no more resources available for incoming new calls or handoff calls. For example, longest calls in the system are degraded to free resource for handoff calls. Another proposal includes an algorithm in which each admitted connection degrades to a lower bandwidth level according to weights. Other proposals reduce the bandwidth of latest admitted connections. However, bandwidth degradation can only reduce the bandwidth of varied-bit-rate (VBR) and non-real-time (NRT) services for each individual, and is not suitable for constant-bit-rate (CBR) connections. Furthermore, though these schemes can reduce the blocking probability, the quality-of-service (QoS) level in the network cannot avoid deteriorating after degradation, and the overall utilization ratio may not be improved.

2.6 Call Admission Control (CAC) Flow and Policy

The admission control flow for the integrated networks is classified into two sub-schemes according to the types of call requests, as shown in figure. If the call request is a new call and mobile terminal is out of the WLAN service area, the mobile terminal will send the new call request to the UMTS base station directly. On the other hand, if the call is a new call and mobile terminal is in the WLAN area, the mobile terminal will first send a new call request to the WLAN as the first choice, since the WLAN is much less expensive per call. The new call request will be handled by the call admission control (CAC) in the WLAN. If the WLAN cannot accommodate the new call request, the request will be forwarded to the UMTS base station.

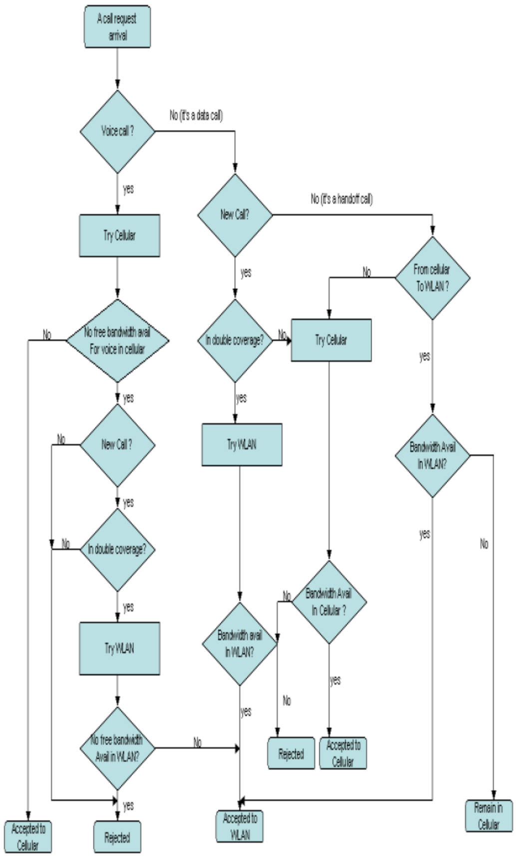

Figure 3.4.1: Call admission procedure for cellular/WLAN interworking

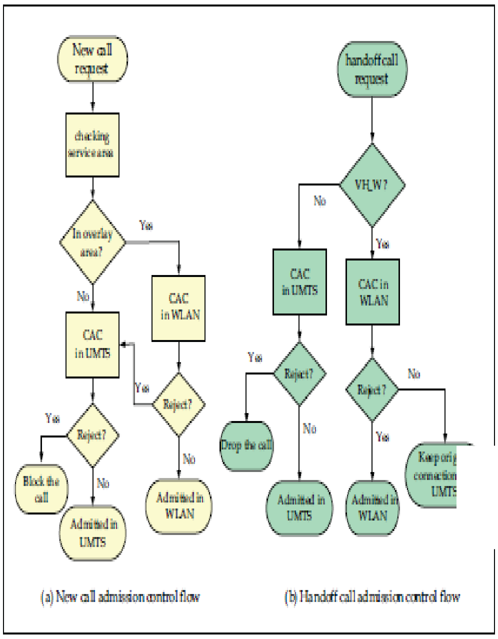

Figure3.6.1 Call Admission Control (CAC) Flow

The situation becomes complex when we consider vertical handoff call requests. Since voice service is real-time service, a user is much more sensitive to voice dropping than dropping of data service during vertical handoff. So voice vertical handoff from WLAN to UMTS cellular network should be assigned a higher priority than new call requests and data vertical handoff from WLAN to UMTS, to avoid possible voice dropping in the cellular service area. Here, we adopt guard channel scheme to reserve some bandwidth for voice VH_U handoff. However, for any data VH_U handoff, no matter how high data rate it gets in WLAN, it become best-effort service when the user move from WLAN to wireless cellular network. So data VH_U is assigned same priority as any new call requests is in wireless cellular network. [12]

Notations :
Vw: number of admitted voice calls in WLAN;
Vc: number of admitted voice calls in cellular network;
Bw: total bandwidth of WLAN;
Bc: total bandwidth of cellular network;
Gc: Guard channel reserved for handoff in cellular network;
D_i: number of admitted data calls of service i in cellular network;
T_i: minimum throughput requirement of data service i;
t_i: current throughput of data service i in WLAN;
Rv: maximum ratio of bandwidth assigned to voice in WLAN;
Rc: maximum ratio of bandwidth assigned to data services in cellular;
bv: average voice generation rate;

Admission Policy:
Switch (Call request type in WLAN)
Case (voice new call or voice handoff from cellular)
if ($(Vw+1)\cdot bv \le Bw \cdot Rv$) & ($t_i \ge T_i$ for all Data classes)
admit the call; ***else*** *transfer call to cellular;*
Case (data new call | data handoff from cellular)
if ($t_i \ge T_i$)
admit the call; ***else*** *transfer call to cellular;*
end

Switch (Call request type in cellular network)
Case (data new call in cell | data handoff from WLAN)
if ($\sum_i (D_i+1)\cdot T_i \le Bc \cdot Rc$) & ($Vc \cdot bv + \sum_i (D_i+1)\cdot T_i \le (Bc - Gc)$)
admit the call; ***else*** *reject the call request;*
Case (voice new call in cell)
if ($(Vc+1)\cdot bv + \sum_i D_i \cdot T_i \le (Bc - Gc)$)
admit the call; ***else*** *reject the call request;*
Case (voice handoff call from WLAN)
if ($(Vc+1)\cdot bv \le Bc$)
admit the call; ***else*** *transfer call to cellular;*
end

Figure3.6.2 Call admission control policy

2.7 Different Call Admission Schemes

For the purposes of review the Admission schemes in existence can be classified as either Interactive or Non-Interactive schemes.

2.7.1 Interactive Call Admission Schemes

Ideally a Call Admission scheme accepts a new call only if the closed-loop Power Control mechanism is able to reach a new equilibrium where all connections observe a target SIR to ensure good quality. Interactive Call Admission scheme behavior is very close to ideal Admission Control because it allows new connections to transmit for a trial period during which it takes measurements to determine weather the connection can be tolerated.

Unfortunately the procedure required for such a scheme is
68 ex considering that during the trial period the
ist ensure the new call does not affect the quality
68 oing calls. Also taking measurements and making decisions with Interactive Admission schemes can be very time consuming. The other drawback is its inability to work with inactive connections. Interactive schemes can only work with always active connections and cannot exploit discontinuous transmission, which is very important in UMTS.

2.7.2 Non-Interactive Call Admission Schemes

Unlike Interactive schemes, Non-Interactive schemes only estimate the network load by measuring a few system parameters. The decisions on call admission are based on the estimates. The total interference measured at the base station is generally considered a good load index since the ability of the power control mechanism to keep SIR at the target level depends on the interference level.

The measured interference includes both intra-cellular and inter-cellular interference. Therefore the admission decision can be based on interference experienced in the cell of the base station as well as in neighboring cells. The measured values are compared with a threshold and is only accepted if the threshold is not exceeded.

The acceptance thresholds are tuned to limit the dropping probability. The simple Receive Power based Admission Control schemes do not consider the additional load due to the new call. The threshold tuning must take into account that the load increase is highly varying depending on mobile terminal position and propagation conditions towards its Base Station and others. The acceptance threshold must be kept low in order to tolerate the worst possible scenarios and to minimize dropping probability. As a result the acceptance probability will be much lower in Non-interactive schemes than those of near ideal schemes.

2.7.3Predictive Receive Power Based Call Admission Control (CAC)

The safety margin of admission thresholds used by Non-Interactive schemes can be reduced by using a scheme to estimate the additional interference due to the new call. Predictive schemes discriminate between calls requested by mobile terminals with different propagation conditions. This approach produces a non-uniform accepted traffic distribution where terminals close to the base station are more likely to be accepted. This is similar to ideal call admission, which exploits this effect to increase accepted traffic.

2.8 Quality of Service (QoS)

Quality of Service (QoS) in cellular networks is defined as the capability of the cellular service providers to provide a satisfactory service which includes voice quality, signal strength, low call blocking and dropping probability, high data rates for multimedia and data applications etc. For network based services QoS depends on the following factors:

- Throughput The rate at which the packets go through the network. Maximum rate is always preferred.
- Delay This is the time which a packet takes to travel from one end to the other. Minimum delay is always preferred.
- Packet Loss Rate The rate at which a packet is lost. This should also be as minimum as possible.
- Packet Error Rate This is the errors which are present in a packet due to corrupted bits. This should be as minimum as possible
- Reliabilit**y** The availability of a connection. (Links going up/down).

It is for these reasons that providing QoS has been a great challenge in the past and it continues to be a hot topic as there is still a lot of scope to provide better service standards.

2.8.1 Why do we need QoS?

Imagine a situation where you are hardly able to hear what your friend is talking over the phone or the phone gets cut when you are talking something important. These things are highly undesirable and you do not want to get low quality service for paying high monthly bills. Communication plays a major role in today's world and to support it QoS has to be given maximum priority. It is important to differentiate the traffic based on priority level. Some traffic classes should be given higher priority over other classes, Example: voice should be given a higher priority compared to data traffic as voice is still considered as the most important service. It should be noted that more preference has to be given to customers who pay more to get better service, without affecting the remaining customers who pay normal amount. To realize all these things effective QoS schemes are needed. Issues and schemes related to providing better QoS is the main subject of this report.

2.8.2 Quality of Service Challenges

In wireless mobile networks QoS refers to the measurement of a system with good transmission quality, service availability and minimum delay. In 4G it is expected to have a reliability of at least 99.999 referred to as five nine reliability. The major challenges when considering QoS in cellular networks are varying rate channel characteristics, bandwidth allocation, fault tolerance levels and handoff support among heterogeneous wireless networks. It is fortunate that each layer which includes physical, MAC, IP, TCP and application have got their own mechanisms to provide QoS. It is important to guarantee QoS in each layer so that the network is more flexible and tolerant to QoS issues. Some of the other challenges are efficient usage of the spectrum as its availability is limited. Bandwidth allocation plays a major role with respect to this aspect. It must be made sure that bandwidth is allocated in an efficient manner and also the remaining bandwidth should not be wasted. Some schemes like Renegotiation scheme takes care of this issue by allocating the remaining bandwidth to lower priority classes. Things get even more complicated when data and voice service has to be supported. Voice services are very delay sensitive and require real-time service. On the other hand data services are less delay sensitive but are very sensitive to loss of data and also they expect error free packets. So both these factors have to be considered for providing QoS for voice and data services.

2.8.3What has been achieved so far in QoS?

In 1G networks and 2G networks such as GSM and CDMA there was only one aspect of QoS and it is voice. Providing quality speech was the major concern. Now in 3G networks QoS has to be provided for voice as well as data. Still priority is given for voice services as they are considered as the primary service. They are very delay sensitive and require real-time service. Data services are comprised of text and multimedia. These services are less delay sensitive but expect better throughput and less or no loss rate.

IV. CONCLUSION

Call admission control is a very important measure in CDMA system to guarantee the quality of the communicating links. In future wireless networks multimedia traffic will have different QoS requirements. One of the key QoS measures in wireless cellular networks is the handoff voice call dropping probability as dropping a call-in-progress is generally not considered as acceptable or user-friendly. In this paper, we study and compare the performance of two call admission control schemes for a multi-service cellular network.

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