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QoS Based CAC Scheme for 3G Wireless Cellular Networks-A Review

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***Abstract*-CAC has been extensively studied in wireless networks as an essential tool for congestion control and QoS provisioning. CAC in wireless networks has been receiving a great deal of attention during the last two decades due to the growing popularity of wireless cellular networks and the central role that CAC plays in QoS provisioning in terms of the signal quality, call blocking and dropping probabilities, packet delay and loss rate, and transmission rate.**

***Q*uality-of-service (QoS) plays a major role in wireless cellular networks & it is one of the most important issues from both the users and operators point of view. All the parameters related to QoS are not same important for all users and applications. The satisfaction level of different users also does not depend on same QoS parameters.**

Our proposed CAC scheme gives preferential treatment to higher priority calls, such as handoff calls of all class of service (data, voice & video), by reserving some bandwidth to reduce handoff failures. In addition, queuing is also used to enhance the handoff success probability. The scheme uses the effective load as an admission criterion and applies different thresholds for new and handoff calls. Finally, the scheme considers three types of services: video, voice & data calls. It is expected that our scheme reduces the drop handoff calls and increases the total system capacity; hence the Grade-of-Service (GoS) and the system performance can significantly improve.

***Keywords*-Call Admission Control (CAC), Quality-of-Service (QoS), Universal Mobile Telecommunication System (UMTS), Grade-of-Service (GoS), Successful Call Completion Rates (SCCR).**

I. INTRODUCTION

The 3G wireless cellular mobile systems which are based on WCDMA technology are expected to be interference limited. Soft capacity is one of the main characteristics of 3G (i.e. UMTS) and it requires new radio resource management strategies to serve diverse QoS requirements. [4]

Providing multimedia services with Quality of Service (QoS) guarantees in third generation wireless cellular networks poses great challenges due to bandwidth issue. The QoS provisioning means that the multimedia traffic should get predictable service from the available resources in the communication system. In most cases, QoS requirements are specified by the 3-tuple: (bandwidth, delay & reliability). [13]

In the first generation (1G) and second generation (2G) of wireless cellular systems, CAC has been developed for a single service environment. In the third generation (3G) and beyond wireless cellular systems, multimedia services such as video, voice & data are to be offered with various QoS profiles. Hence, more sophisticated CAC schemes are developed to deal with these changes. [5]

Allocating radio resources to users with minimum blocking of new calls and dropping of handoffs has become a vital issue in wireless networks system design. The task of the Admission Control (AC) is to decide whether or not to assign the radio resources the users request from the system. Admission control strategy will adopt proper admission criterion according to different QoS requirements and overall system performance. Currently, Effective and efficient radio resource management schemes need far more attention in third generation mobile cellular network systems and beyond. Call admission control (CAC) schemes are critical to the success of future generations of wireless networks. On one hand, CAC schemes provide the users with access to a wireless network for services. On the other hand, they are the decision making part of the network carriers with the objectives of providing services to users with guaranteed quality and at the same time, achieving as much as possible resource utilization. It is therefore conceivable that CAC policy is one of the critical design considerations in wireless cellular networks.

Complex call admission control (CAC) is needed for admitting reasonable number of users in the sense that CAC can satisfy various QoS constraints for different services and also maximize the spectrum utilization for systems. CAC schemes play a very important role in the performance of 3G wireless cellular network systems as it directly controls the number of users in a cell and thus limit the interference in the system.

The rest of the paper is organized as follows. In section II the detailed explanation about the need, challenges & schemes of

QoS has been presented. Section III, provides an overview of various aspects of CAC schemes in today's wireless cellular networks along with the proposed scheme is elaborated. Section IV describes the main reasons for using call admission control schemes to guarantee quality-of-service parameters. Finally, we concluded the paper in section V.

II. Quality-Of-Service (QoS)

A. Quality-of-Service (QoS)

Quality-of service (QoS) in wireless 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:

1) Throughput: The rate at which the packets go through the network. Maximum rate is always preferred.

2) Delay: This is the time which a packet takes to travel from one end to the other. Minimum delay is always preferred.

3) Packet Loss Rate: The rate at which a packet is lost. This should also be as minimum as possible.

4) Packet Error Rate: This is the errors which are present in a packet due to corrupted bits. This should be as minimum as possible.

5) Reliability: The availability of a connection. (Links going up/down).

It is for these reasons that providing quality-of-service (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. [6]

B. Need of Quality-of-Service (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 paper.

C. Quality-of-Service (QoS) Challenges

In wireless cellular networks QoS refers to the measurement of a system with good transmission quality, service availability and minimum delay. The major challenges when considering QoS in wireless cellular networks are varying rate channel characteristics, bandwidth allocation and handoff support among homogeneous & heterogeneous wireless networks. 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 take 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. [10]

D. Priority in Quality-of-Service (QoS)

In 1G network and 2G networks such as GSM and CDMA there is only one aspect of QoS and it is voice. Providing quality speech is 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.

E. QoS Schemes in Wireless Cellular Networks

There are many QoS schemes which have been deployed for wireless cellular networks and each scheme has its own advantages and disadvantages. In this paper we are going to look into some of the fundamental and effective QoS schemes which are used for providing video, voice & 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.

The next scheme is the call admission control (CAC) which employs pre-blocking of calls based on the available bandwidth for handling calls. This scheme is based on two schemes namely pre request scheme and the guard channel scheme. CAC scheme 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. [7-10]

III. Call Admission Control (CAC)

This section provides a comprehensive survey of call admission control (CAC) schemes with QoS provisioning in modern wireless cellular networks.

A. Call Admission Control (CAC) in Wireless Cellular Networks

Extensive research work has been done on the call admission control (CAC) schemes in wireless cellular networks. They can be classified based on various design focuses and schemes, and each scheme 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 work on call admission control (CAC) into five major categories:

1) Signal 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 CAC scheme is proposed to minimize the blocking probability while keeping a good signal quality to reduce the packet error. However, all the 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 CAC in an interworking environment based on a uniform criterion.

2) Guard 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.

3) Queuing 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.

4) QoS estimation based approaches: CAC in wireless 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 QoS level in the system.

5) Bandwidth 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.

B. 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 scheme is developed which provides a better quality-of-service (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. [8]

In the CAC scheme 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. [8]

Our proposed algorithm differs from those algorithms in terms of using the cell load as an admission criteria and also using queuing as an additional priority techniques for handoff calls. Also, the handoff calls is divided into three classes (video, voice & data), each has its own QoS requirements. Our CAC scheme gives preferential treatment to high priority calls, such as handoff calls, by reserving some bandwidth to reduce handoff failures. In addition, queuing is also used to enhance the handoff success probability. The algorithm uses the effective load as an admission criterion and applies different thresholds for new and handoff calls. Finally, the study considers three types of services: data, voice and video calls.

This CAC scheme has the following steps: when a call arrives, load factor threshold for new and handoff calls and QoS requirements are determined firstly. Then the load increase of the arrived call and the current cell load factor before accepting the arrived call are calculated. After calculating the current load of the target cell i, it is compared with the load factor threshold of the arrived call of type i. If the current cell load factor plus the load increase is less than or equal the required load factor threshold for the arrived call, then the arrived call can be admitted to enter the target cell. Otherwise, the arrived call is queued or rejected based on queue availability. Queued soft handoff calls can be accepted if sufficient bandwidth gets available, or can be terminated due to timeout. [3]

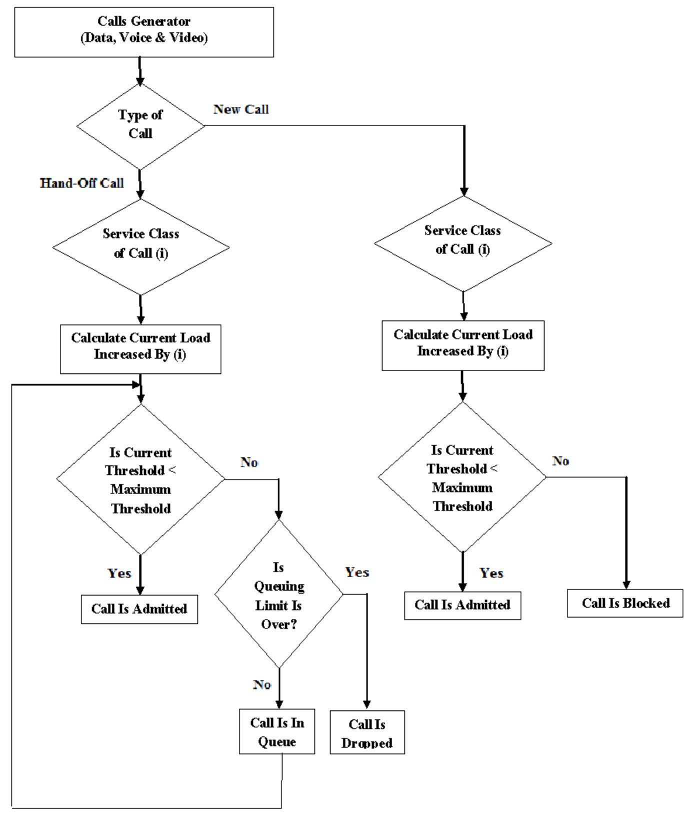

Fig. 1 Call Admission Control (CAC) Scheme (Proposed)

Proposed Algorithm is evaluated based on three QoS metrics: The blocking probability for newly originating calls, the forced termination probability and the total system carried traffic.

New calls and handoff calls are treated differently. Handoff calls are given higher priority to new calls, and load factor threshold for handoff calls and new calls are also different. Handoff calls share residual capacity exclusively besides sharing available capacity with new calls. In simulation we consider the following three scenarios:

1) Scenario1: All call services classes (new calls and hand-off calls) are treated equally where they have the same load threshold and no queuing is used.

2) Scenario2: Same as 1, and in addition to that, the handoff calls are allowed to be queued till the resource is available or the time out is reached.

3) Scenario3 (proposed algorithm): Same as 2, and in addition to that, the handoff calls have higher load threshold than new calls. This scenario is repeated using different channel holding times. [3]

IV. Main Reasons For Using Call Admission Control (CAC) Schemes To Guarantee Quality-Of-Service (QoS) Parameters

A. 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, 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. [25]

B. Call Dropping Probability

Since dropping an active call is usually more annoying than blocking a new call, CAC is employed in bandwidth-limited wireless cellular networks to control the handoff failure probability (PHF). This can be implemented by reserving some resources for handoff calls exclusively. The admission criterion can be either the number of users (per class in a multiple-class system) or an estimate of handoff failure probability. Resources availability can also be used as a criterion for admission. Whatever the used admission criterion, handoff calls receive less stringent admission conditions compared with a new call, which might lead to an increase in the new call blocking rate (PB). [25]

C. 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, CAC should be used to limit the network level to guarantee packet-level QoS parameters (packet delay, delay jitter, and throughput). In this case, the number of users, resource availability and/or an estimate of the packet-level QoS parameters can be utilized as an admission criterion. [25]

D. 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 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. [25]

V. Conclusion

CAC research remains an exciting area. The state of the art in CAC suggests that existing CAC schemes may not handle many of the challenges about multimedia services in wireless cellular networks for the provision of QoS.

Wireless cellular networks will have different QoS requirements because QoS playing a major & important role in wireless cellular networks. In this paper we have seen the various CAC schemes for maintaining the QoS in wireless cellular networks but each one of them has its own advantages and disadvantages.

We propose QoS based call admission control (CAC) scheme for a 3G wireless cellular network for the provision of QoS. Our proposed scheme is prioritized based hence for giving the priority to handoff calls over new calls; we introduce queuing technique because our main focus is to reduce the handoff failures. Also the performance analysis of our scheme with different scenarios is became a keynote of our study. Finally we expect that our scheme reduces the drop handoff calls and increases the total system capacity; hence the GoS/QoS and the system performance can significantly be enhanced.

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