Negotiation of QoS through Service differentiation by CAC for 3G Cellular Network

Miss. Swati Kurkure[1], Prof. Suresh Gawande[2]
Department of E&TC Engineering, Bhabha Engineering Research Institute, RGPV University, Bhopal, Madhya Pradesh, India[1, 2]
swatikurkure12@gmail.com[1], suresh.gawande@rediffmail.com [2]

Abstract—**In the 1G and 2G of wireless cellular systems, CAC has been worked for a single service scenario environment. In the 3G and beyond wireless cellular systems, multimedia services such as video, data, and audio are to be offered with various QoS profiles. Hence, more sophisticated CAC schemes are needed to develop for dealing with these challenges. With the support of higher data transmission rate for mobile users, 3G networks are expected to support different broadband multimedia services. Call admission control is needed for admitting reasonable number of users in the sense that call admission control can satisfy various qualities of service (QoS) requirements and also increase the spectrum efficiency. Voice and data are the basic requirement of every user and also these services are demanded with good quality. The multimedia traffic is controlled by queuing system and this system helps to reduce the congestion in the cellular network due to newly originated and existing calls. In this paper we consider the two types of services voice and data. We assure that our scheme will reduce the probability of dropped calls and will also improve the overall system performance.**

Keywords—**Call Admission Control (CAC), Quality-of-Service (QoS), Universal Mobile Telecommunication System (UMTS), Grade-of-Service (GoS), Successful Call Completion Rates (SCCR), Wide Band Code Division Multiple Access (WCDMA)**

I. INTRODUCTION

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.

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). [12]

Multimedia is the media that uses multiple forms of information content and information processing (e.g. text, audio, graphics, animation, and video) to inform or entertain the user. The evolution of internet has also increased the demand for multimedia content. When any multimedia para meter like text, images etc are transmitted. If the bandwidth is small collision of packets occur, this collision leads to traffic and this whole is called the multimedia traffic.

Allocating radio resources to users with minimum blocking of new calls and dropping of hand-offs has become a vital issue in cellular wireless networks system design. The task of the Admission Control 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 3G mobile cellular network systems and beyond. 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. Complex 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 became a significant strategy used to calculate the performance of 3G wireless cellular network systems and limiting the interference in the system by controlling the number of users in a cell.

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 a keynote of CAC scheme in today's wireless cellular networks along with our proposed work is presented. Section IV presents the obtained results through simulation, as well as the discussion about the results. Finally, we concluded the paper in section V.

II. QUALITY OF SERVICE

A. *Definition of 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.
- **Reliability** The availability of a connection. (Links going up/down)

QoS involves prioritization of network traffic. QoS can be targeted at a network interface, toward a given server or router's performance, or in terms of specific applications. A network monitoring system must typically be deployed as part of QoS, to insure that networks are performing at the desired level.

QoS is sometimes used as a quality measure, with many alternative definitions, rather than referring to the ability to reserve resources. Quality of service sometimes refers to the level of quality of service, i.e. the guaranteed service quality. High QoS is often confused with a high level of performance or achieved service quality, for example high bit rate, low latency and low bit error probability.

B 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. 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

C Various QoS schemes in 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. The renegotiation scheme is a scheme in which the bandwidth allocation is changed dynamically based on the availability. [7, 10]

III. Call Admission Control Scheme

A Overview CAC schemes

Several CAC schemes have been developed in wireless cellular networks. Some of them are based on a predetermined maximum number of users in the system. Many schemes are more CDMA-oriented and consider the SIR as the determinant parameter in accepting or not accepting a new call. Those schemes are commonly called Interference-CAC (I-CAC) and can be further classified into: [3].

1) Wideband Power Based CAC

This scheme computes the increase in the interference (power) caused by the establishment of a new user in the cell and accepts the call only if the total interference does not exceed a predefined threshold. [3]

2) Throughput-Based CAC

A throughput-based CAC scheme computes the increase in the load caused by the establishment of a new user in the cell and accepts the call only if the total load does not exceed a predefined threshold. [3]

3) Signal to Noise Interference Ratio-Based CAC

This scheme computes the minimum required power for new user and accept it if is not below a predefined minimum link quality level. [3]

B Proposed Scheme

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.[6]

Our proposed algorithm or scheme 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 (voice & data), each has its own QoS requirements. The basic need of service is the voice quality and so according to the priorities of the incoming and the existing calls, decisions are taken by CAC scheme so as to avoid the overload and congestion in the network. Our CAC scheme gives preferential treatment to high priority calls, such as handoff calls, by reserving some bandwidth to reduce handoff failures. We have also adopted the queuing mechanism and provided certain limit for the calls in the queue. An admission criterion allows the traffic load for allocation of the spectrum bandwidth and provides the two types of services mainly voice and data and also increase the system capacity and performance.

This CAC scheme has the following steps: when a call arrives, load factor threshold for new and hand-off 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 hand-off calls can be accepted if sufficient bandwidth gets available, or can be terminated due to timeout. [1-2]

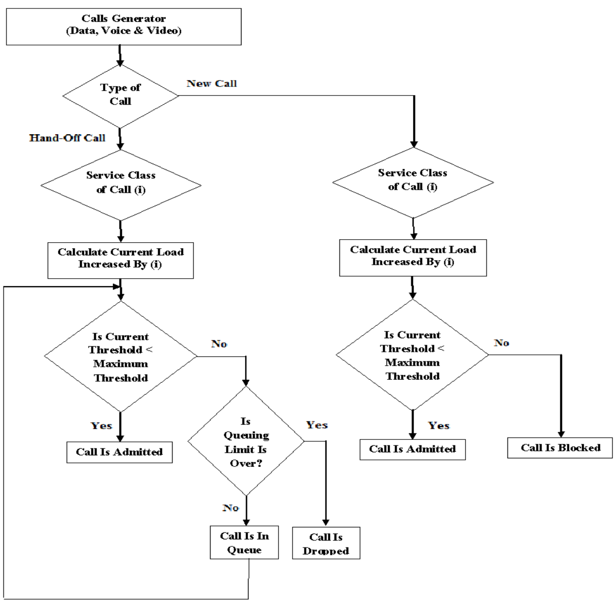

Fig. 2. Proposed Call Admission Control Scheme

IV. DISCUSSION OF RESULTS THROUGH SIMULATION

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:

A) Scenario1

All call services classes (new calls and handoff calls) are treated equally where they have the same load threshold and no queuing is used.

B) Scenario2

Same as scenario 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.

C) Scenario3 (proposed algorithm)

Same as scenario 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. [1, 2]

TABLE I. KEYNOTES SOR SIMULATION

Parameter	**Value**
Access Mode	W-CDMA (FDD)
Bandwidth	5 MHz
Chip Rare	3.84 Mcps
Service classes	Voice, Data
Bit rates	Voice: 12.2kbps, Data: 144 kbps
E_b/N_o	Voice :5.6dB, Data: 3.2 dB
Activity	Voice : 0.4, Data: 1
Fractional load	60-65%
Interference factor (f)	0.5
Arrival rate	Poisson (0.2-2 calls/sec)
Channel holding time	180 Seconds
Queue limit	Max. 5
Queuing time	15 Seconds

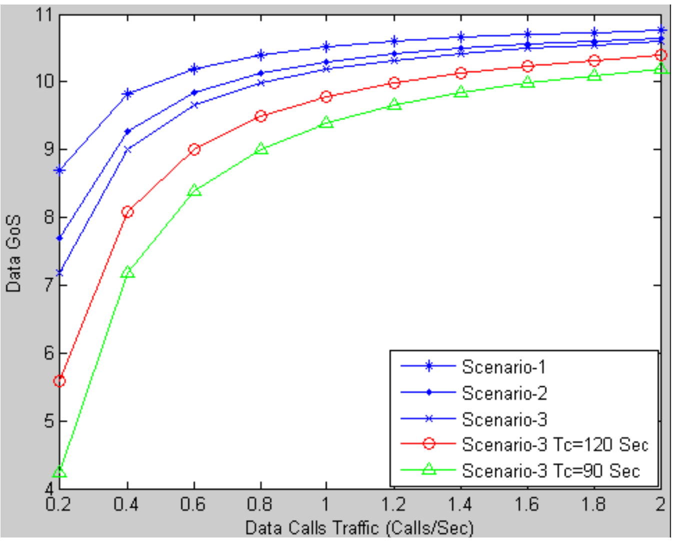

Fig. 3 GoS for Data Calls

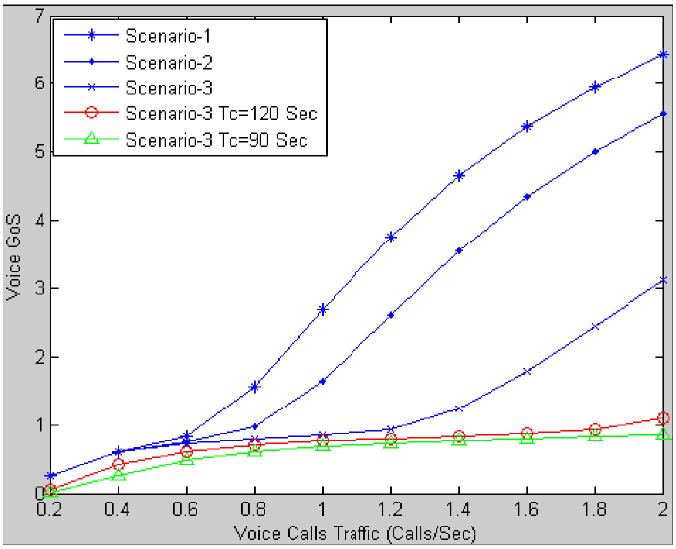

Fig. 4 GoS for voice calls

The arrival of new and hand-off calls is using poisson arrival process. Average service time for all services is 180 seconds. Arriving rates of all services are changed. Scenario-3 is repeated using different service times 120 sec and 90sec respectively. Fig. 3 represents the data GoS vs. offered data calls, Fig. 4 represents the voice GoS vs. offered voice calls. From these figures, it is clear that the performance improves as we use the queuing technique. Also, as the channel holding time decreases the system performance increases. So as the service time decreases the waiting/queued calls will have better chance to get the channel before they timed out. Smaller GoS means will get better system performance & hence the system performance is improved due to smaller GoS as the service time decreases shown in Fig. 3 and Fig.4respectively.

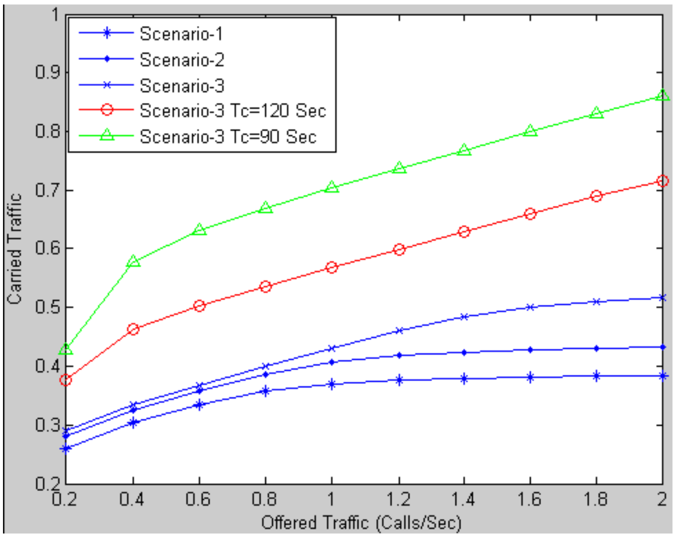

Fig. 5 System Carried Traffic

Fig. 5 represents the system carried traffic vs. the offered traffic. The system has less carried traffic in Scenario-1. But it is significantly increases in Scenario-2 and Scenario-3 as the channel holding time decreases shown in Fig. 5. So as the carried traffic increases the system capacity in term of supporting more calls increases. It is clear that our proposed scheme has better system capacity and this improvements increase as channel holding time decreases. In general as shown in these figures, the system has a better performance by reducing the blocking & dropping probability of new & hand-off calls & increases the total system carried capacity under this proposed scheme.

V. Conclusion

Our proposed scheme deals with improving QoS for the multimedia traffic in wireless cellular network. QoS negotiation has been employed due to the problems facing regarding the bandwidth issues and also because of the unsatisfactory level of the customers need. Negotiation helps to allocate the proper resources and bandwidth required for the maintenance of the call (voice and data) and also prevents the wastage of resources available in the network. We are proposing our scheme in order to provide multimedia applications to mobiles users with quality of service (QoS) guarantees and efficient resource utilization.

The unique features of the proposed scheme are that the maximum spectrum utilization can be achieved and congestion can be reduced to greater extent by adopting queuing techniques .We are providing good QoS with the consideration of GoS for the voice and data traffic. The system capacity increases as the GoS decreases and so the performance of system significantly is improved. So by reducing the GoS for voice and data traffic respectively, QoS increases .Our proposed scheme will reduces the call dropping probability and will maximize new call admission rate, and able to simultaneously provide satisfactory QoS to both voice and data users and maintain a relatively high resource utilization in a dynamic traffic load environment.

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