New Call Admission Control and Handoff Techniques for 3-G Mobile Networks

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Abstract

In mobile Networks each type of Services has distinct characteristics and QoS requirement. The important issues in 3-G N/W are to prepare a framework for multi-class services to perform call admission and handoff efficiently. The available Call Admission Control (CAC) and Handoff Techniques in mobile network have considered only single class of service or have touched value of few classes but not beyond. In this paper we have considered 8 types of services, which are differentiated according to their Acceptable delay in transmission, Buffering capacity, Transmission mode and Bit rate. In this approach CAC and Handoff issues are resolved by awarding Priority Number to each cal, which will also resolve issue of collision in CAC and handoff. Performance of proposed frame- work for CAC and Handoff is evaluated by calculating Call Dropping probability and Call Completion probability.

1. Introduction

1.1 Evolution of Wireless Services

Wireless communication has experienced an enormous amount of growth during the last two decades. In this work we have reviewed the evolution of wireless communication systems and corresponding changes in CAC mechanisms from generation to generation. The first generation of wireless systems used analog transmission for speech services, which were introduced in early 1980s, they included AMPS, TACS, NMT etc. All of these 1-G systems used FDMA for spectrum sharing among multiple users. Conventional 1-G CAC was fixed guard channel scheme and handoff, call queuing scheme. The second generation wireless systems used digital transmission techniques, which were introduced in late 1980s. Digitization allowed the use of TDMA and CDMA as an alternative method of radio resource sharing. For CAC mechanisms, adaptive guard channel schemes are used besides other methods. The third generation wireless systems have been standardized by the International Tele-communication Union and standard is known as International Mobile Telecommunications-2000. IMT-2000 standard provided a high quality worldwide roaming capability on a small terminal and supports multimedia application such as Internet browsing, e-commerce, e-mail, video conferencing, and access to information stored. Another important feature of third generation networks is more innovative and efficient CAC mechanism, which not only considers different service classes but also take advantage of adaptive nature of multimedia applications in order to minimize call dropping probabilities to provide better QoS to the users.

1.2 Challenges in wireless Multimedia Networks

Providing multimedia services in wireless systems has become a reality due to 3-G technology. To achieve this, many technical challenges are yet to overcome; one of them is radio aspect where higher rate services with high quality will demand more spectrum efficient radio technologies. The issues for radio aspect are radio interface access, Radio transmission technology, and Radio resource management. Another challenge is related to Network Aspect having technical issues like functional architecture, signaling and protocols of 3G wireless multimedia networks. Some key issues in this category are Mobility Management, Signaling and protocol, connection establishment, maintenance and release, etc. The third issue is Security and privacy. Unlike the wired-line telephone system, a cellular system has to consider the impairment of air-interface and the changes due to the mobility of MS.

2. Background

Due to rapid growth of wireless communication technology especially for voice communication over wireless link and multimedia traffic, quality-of-service (QoS) is necessary. The parameters and techniques need extra emphasis for better performance.

2.1 Call admission control and handoffs:

QoS means that traffic should get predictable service from available resources in the communication

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system. QoS techniques for wireless networks are completely different from wired one. In most of the cases QoS requirements are specified by Bandwidth, delay and Reliability.

2.1.1 Call admission control:

In mobile networks, the service area is divided into cells each of which is equipped with a number of channels. Two types of calls share these channels are: New calls and Handoff calls. When call arrives at a cell in which a channel is not available, it may be blocked or queued, depending upon the call admission control schemes used. Some of the quantities which are most significant in determining QoS are New call blocking probability, Handoff call blocking probability and Call dropping probability.

2.1.2 Handoff :

The handoff techniques are design parameters for better performance. The two basic types of handoff are hard hand off and soft hand off.

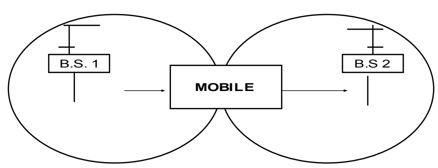

Figure.1 Handoff from B.S.1 to B.S.2

In hard handoff**,** the link to the prior base station is terminated before or as the user is transferred to the new cell's base station. That is to say that the mobile is linked to no more than one base station at a given time. In soft handoff the mobile station is linked and communicating with base station 1 till new base station is not selected else call will drop.

2.2 Approaches for CAC and handoffs

In CAC mechanism proposed in [1], each station independently reserves number of handoff channels in order to guarantee a specified probability of handoff. The number of reserved handoff call channels change dynamically in order to respond to the varying traffic conditions. The Threshold Access sharing policy [2] has three level of call admission the lowest level, when the wireless channel is highly underutilized all incoming calls that can be satisfied are admitted. After a certain threshold, when channel allocation has become more highly utilized, all calls are still admitted, but lower priority calls are admitted conditionally, theses calls are aware that the channel is heavily used and they may loose their connection or have their service reduced if more traffic arrives. An adaptive algorithm for CAC in wireless networks is proposed in [3]. This algorithm is built upon the concept of guard channels, and it imposes a hard constraint on the handoff call blocking probability. In [4] call admission control algorithms for a cellular or microcellular systems are evaluated based on two QoS metrics: The new call blocking probability and the forced-termination probability. In [5] it has been shown that the Hybrid Control Scheme yields the best performance, particularly during periods when load differs from the expected level. A call admission policy, based on the fractional guard channel scheme is proposed in [6], which additionally considers the blocking of new calls.

Multimedia traffic typically consists of streams of text, video, and voice. This traffic may result from applications like streaming, interactive or non-real time. Interactive applications, such as voice over IP, have stringent QoS requirements needing rate, delay, and jitter guarantees. Round-trip delays have to be low, and jitter has to be small as well while packet losses can be tolerated to an extent. Techniques dealing with Real time and Non-real time classes, CAC issues in multimedia CDMA systems by illustrating the basic principles have been discussed in [7]. SIR as a measure of QoS has been introduced and described, which is relatively simple to administer CAC [8],[9]. With undifferentiated services complete sharing would work fine by maintaining the SIR for each user. However, with multiple classes of service, the required minimum SIR depends on the user class. Various schemes have been proposed to address the issue of traffic type differentiation in the call admission process. In [12], the traffic has been classified into four types as per QoS requirement and channels are partitioned into three independent groups. The next generation wireless and mobile networks are designed to support a true combination of both real-time and non-real time services [10][11].

2.3 Channel allocation scheme:

We focus on a single cell as a reference cell in an integrated wireless and mobile network and use to represent the environment. The traffic arrival at the base station of the reference cell is categorized in either of four types. The system model for the reference cell is shown in figure no. 2. The total channels S of the cell are divided into three independent parts, i.e., real-time channels (RCs), nonreal-time channels **(**NCs**),** and shared channels (SCs). Type 1 call can be served only if there are channels available in RC part. Similarly, type 3 calls can be served only if there are idle channels in NC part. Type 1 (or type 3) call is blocked if there is no available channel in RC (or NC) part.

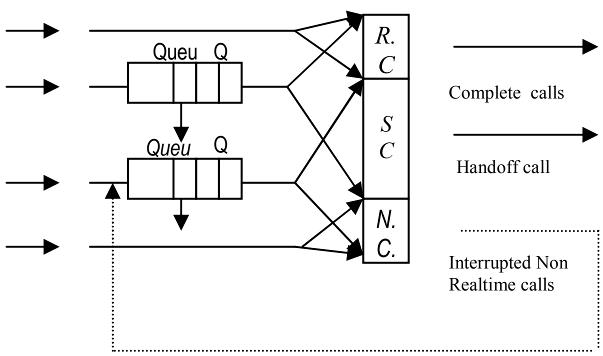

Figure 2 System model for 4 services

A type 4 call can be served in NC part if there is any channel available in NC part. If the channels in NC part are busy, type 4 calls can be served if there are free channels in SC part. If none of the channels in NC and SC parts are available, it will be put into Q_N. Otherwise, type 4 call will be blocked if Q_N is full. Type 4 call in Q_N can be transferred from the current cell to one of the next adjacent cells when the mobile user moves out of the cell before it gets a channel in the current cell. The maximum possible waiting time of type 4 calls in *QN* is the dwell time of nonreal-time user in a cell. The NCs are used by nonreal-time originating and handoff calls (type 3 and type 4) only. As type 2 and type 4 traffic have more stringent QoS requirement than type 1 and type 2, the SCs are reserved for the overflowed traffic of type 2 and type 4 from RC or NC parts. Type 2 and type 4 traffic have their own waiting queues in the base station, Q_R and Q_N, which have finite capacity M_R and M_N. There is no queue for the originating call. The number of RCs, SCs, and NCs are represented by S_R, S_C, and S_N.

2.4 Estimation method for optimal partitioning of channels:

In our QoS requirement criterion set, the forced termination Probability P_{hf} and the blocking probability B_{OR} to judge the real-time service performance. The following code shows how to get the near optimal channel assignment using our analytical model.

$S_R = S_R'$, $S_C = 1$, $S_N = S_N'$
While ($B_{OR} <= B_{OR}^*$ || $B_{ON} <= B_{ON}^*$ || $T_N <= T_D^*$ || $P_{hf} <= P_{hf}^*$)
{ *if* ($P_{hf} <= P_{hf}^*$) S_C++
Calculate new B_{OR}^* , B_{ON}^* , P_{hf}^* and T^*_D
if ($B_{OR} <= B_{OR}^*$) S_R++
if ($B_{ON} <= B_{ON}^*$ || $T_N <= T_D^*$) S_N++ }
Calculate new B_{OR}^* , B_{ON}^* , P_{hf}^* and T^*_D
}

3. Proposed Work

The main idea of this work is to consider the issue of handoff and CAC, which takes care of both issues simultaneously. Other aim is to provide a framework in which all inputs are differentiated according to their classes in which they fall, to satisfy most of the QoS issues involved in services offered, to provide fair amount of attention to all type of calls whether low priority or high priority. In this work a framework is proposed where different 3-G user categories have been considered and are handled according to their priority and their QoS requirements and have been achieved by allocating channel accordingly. These services can be divided into 4 categories which are: Conversational, Streaming, Interactive and Background.

3.1 Proposed System Model

All the services have been divided into 8 parts according to their QoS requirements and then priorities have been allotted to all services. Higher priority services will be entertained first whenever there is collision in accessing channel. These services have been categorized according to the QoS parameters: Delay Requirement and Buffering Capacity.

3.1.1 Assumptions involved in Proposed Model :

All the services have been given priorities and have three different categories. With priority 0 (P-0) will be given all the authorities to use channel first and services with priority 7 (P-7) will have least authorities. The offered services in this model are:

1. Real time conservational Hand-off calls (P-0)
2. Real time Streaming Hand-off calls (P-1)
3. Real time conservational calls originating from the base cell (P-2)
4. Real time Streaming calls originating from the base cell (P-3)
5. Non- Real time Interactive Hand-off calls (P-4)
6. Non- Real time Background Hand-off calls (P-5)
7. Non- Real time Interactive calls originating from the base cell (P-6)
8. Non- Real time Background calls originating from the base cell (P-7)

The services have 4 types, which are as follows:

Type 1: Real time conservational originating from the base cell and Real time Streaming calls originating from the base cell.

Type 2: Real time conservational Handoff calls and Real time Streaming Handoff calls.

Type 3: Non- Real time Interactive calls originating from the base cell and Non- Real time Background calls originating from the base cell.

Type 4: Non- Real time Interactive Handoff calls and N.R.T. Background Handoff calls.

Handoff calls are given more attention as compared with those calls which are being originated from the cell with real time calls getting higher priority as compared to Non- real ones, which causes the Type 2 services to be served first. Real time calls whose delay requirements are strict have the highest priority to get hold of the recourses. Real time category includes Conversational and Streaming services. Non- real time category includes Interactive and Background service.

4. Results

All the simulation work has been divided in to three modules named input, waiting Queue and channel and result comprises of plot between various traffic rate and call completion probability and call dropping probability.

4.1 Assumptions in Simulation:

4.1.1 Input module Assumptions:

1) Input has been categorized in 8 priorities from 0-7.
2) Number of calls in Handoff group is less as compared to originating ones.
3) Number of conversational calls is highest.
4) All I/P's have been taken as a Poisson traffic with arrival rate
5) Some threshold has been set on the basics of which origination of call will be decided.
6) Call duration for originating call is decided by Exponential distribution.

4.1.2 Waiting Queue module Assumptions:

1) Size of waiting Queue is varied from 30 to 60.
2) They store call priority number and time which of arrival into Queue.
3) If for 5 min. call is not served then call will go to call dropped array.

4.1.3 Channel module Assumptions:

1) Channels are represented by array.
2) Size of array is equal to 100. i.e. 100 channels are available for communication.
3) Each channel contains information of status and priority number.

4.2 Implementation Results:

4.2.1 Call Dropping Probability:

Figure no.3 shows the variation of Call Dropping Probability against increasing arrival rate with different Queue size. It is evident from the graph that as the traffic rate is increasing call dropping probability will also increase because recourses available are fixed. Figure 4 shows the variation of Call Dropping Probability against increasing arrival rate measured for each priority of services. Here it is clearly visible that services with Priority 0,1 has the lowest call blocking probabilities as compared to other services. From fig. no. 5 we can say that as the traffic rate has increased the Completion call probability has dropped even after the increase in traffic resources, this will lead to the less number of completed calls.

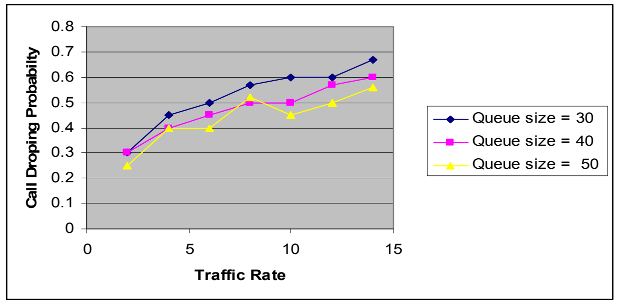

Fig. no. 3 call dropping with diff queue size

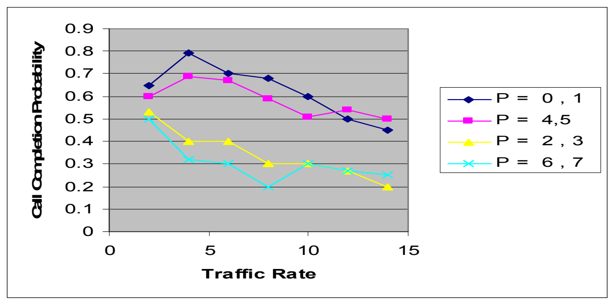

Fig. no. 4: call dropping with priority

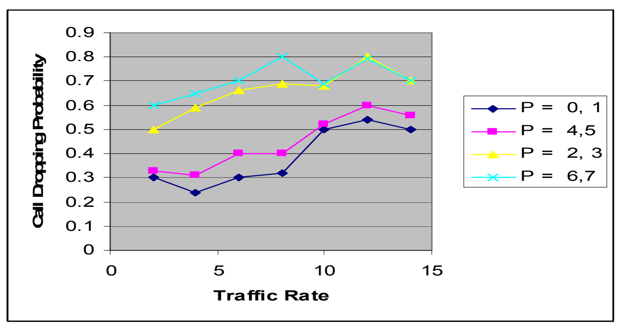

Fig no. 5 call dropping with diff services

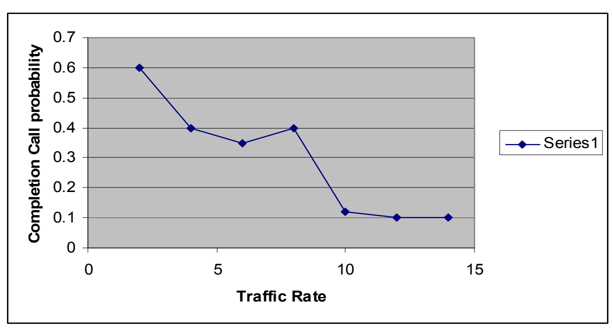

Fig. no. 6 call completion with traffic rates

4.2.2 Call completion Probability:

Here all type of services with their priority has been considered and plotted for various arrival rate. As we can observe that there is quite a significant change between the plots of various priorities. Variation of services with priority 0,1 and 4,5 with respect to arrival rate is quite large as compared to those with priority 2,3 and 6,7 . Completed calls from priority 0,1 and 4,5 will be more and Completed calls from priority 2,3 and 6,7 will be less. so, there is significant change in shape of these priorities .

5. CONCLUSION:

Objective of upgrading the existing framework for CAC and handoff to all services available in 3-G has been achieved by raising the services from 4 to 8. Most of the major issues in CAC and handoffs like collision to access the channel, to give fair amount of attention to lower priority calls and to maintain performance of framework by maintaining call dropping probability and call completion probability has been resolved successfully by giving each call its own identity in the from of priority number and reserving some channels for lower priority calls. It has been shown from the graph that services have successfully been divided into 8 categories which were the formulated as per the requirement of UMTS (3-G) networks. Values of various plot shows that both CAC issues and handoff issues has been achieved as all type of services has been handled fairly that is all services have respectable values of call blocking probability and call completion rate. Highest value of Call Dropping probability for topmost (0) priority call is 0.2 which is acceptable and highest value of Call Completion probability for lowest (7) priority call is 0.86 which is acceptable under all conditions. Another issue of call collision in CAC and Handoff part was carefully dealt with the help of allotting priority to each type of call. So, This CAC and Handoff technique is suitable for 8 type of services which were categorized according to the requirement of 3-G Network and Channels are borrowed from lower service class by preempting them which is the demand of new generation network .

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