Development of Prioritized Handoff Scheme for Congestion Control in Multimedia Wireless Network

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Abstract - **The rapid increase in the use of mobile devices demand the need to meet different multimedia application requirements of the users. However, the application demand and allocation could lead to congestion if the network has to maintain such high resources for the quality of service (QoS) requirements of the applications. In this paper, a new admission control policy for wireless mobile multimedia networks is being proposed. Two kinds of traffics are assumed to compete for the access to the limited number of frequency channels available in each cell: Real-time and non-real-time calls. The calls are further categorized as new real-time and non-real-time calls or real-time and non-real-time handoff calls. Hot spot calls are given priority over cold spot calls if the cold spot request is non-real-time. Call of the same cell and priority are served using ticket scheduling. Blocked new real-time and non-real-time calls are lost, while blocked real-time and non-real-time handoff calls can wait in the handoff buffer for channel to be available. The system is modelled by a multi-dimensional Markov chain, and a numerical analysis would be presented to calculate the blocking probabilities of the calls. The scheme would also be simulated using extensive runs to investigate its performance.**

Index Terms - Channel, Hot spot, Cold spot, Buffer, Real-time call, Non-real-time call

I. INTRODUCTION

Mobile wireless network has experienced tremendous growth in the last decade, and this growth is likely to continue in the near future. Apart from an increase in the number of users [30] [8] more demanding applications will appear, resulting in ever-greater resource requirements. The design of such a network, which is based on a cellular architecture [12], will give room for adequate use of the available frequency spectrum. A strong network backbone is needed to support[1] connections since high quality of service without fully coordinated channel and network access is achievable. The wireless channel must be kept from reaching the congestion point, since it will cause an overall channel quality to degrade and loss rates to rise, leads to buffer drops and increased delays, and tends to be grossly unfair toward calls which has to traverse a larger number of radio hops.

Call admission control (CAC) and network resource allocation are the key issues of concern. CAC determines the condition for accepting or rejecting a new call based on the availability of sufficient network resources to guarantee the QoS parameters without affecting the existing calls [5]. On the other hand, the network resource allocation decides how to accept incoming connection requests [38][10] to avoid congestion. This is where the proposed scheme will be operational (at the base station subsystem). The major call-level qualities of service parameters based on cellular concept are: new call blocking and handoff call blocking probabilities.

Many dynamic channel allocation mechanisms have been proposed [11] [29], but all these mechanisms may improve the performance of the mobile wireless networks. However, for practical reasons, the channel allocation is usually done in a static manner. The use of dynamic threshold to manage the buffer at various locations in the network will reduce drastically all these problems, since the buffer threshold will be determined by the rate at which traffics enter the network. The buffer will be located at the access point to specifically assist the mobile terminal to perform active scanning. Implementing buffering functionality on the access point itself also provides better control on the buffering period and buffer size. This is an important step forward from the other conventional threshold strategies that may be employed by network operators.

In this paper, a centralized dynamic allocation is employed with ticket scheduling technique of handling calls of the same priority. Buffers at various locations in the network, is introduced to handle the blocked real-time and non-real-time handoff in order to keep the quality of service of handoff calls. Before allocating channels to calls, if call request for channel arrive at the same time, the scheme gives priority to hot spot calls before cold spot calls if the cold spot call is non-real-time. However, if call comes from the same cell and of the same type, ticket scheduling is also invoked to serve the calls. This is an important step forward from other conventional static strategies that may be employed by network operators. New non-real-time traffic is assumed to be delay-tolerant and the capability of buffering the delay-insensitive real-time and non-real-time traffic is added. The scheme prevents traffic congestion because of its implementation at the base station subsystem of the network.

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The call admission mechanism will be considered under different scenarios with an estimation of the values of the call blocking probabilities.

A Statement of the Problem

User mobility in mobile wireless networks always suffers fluctuation/unavailability of network resources due to congestion. This leads to inefficient or low utilization of network resources. The aim of this research is to develop a system that employs the use of dynamic channel allocation with buffering technique to address this problem

B Scope of the Research

The project is tailored towards combining channel allocation technique with buffer in controlling congestion (prevention) in mobile wireless network.

C Objectives of the Research

The specific objectives of the research are to:

(i) Develop an improved channel allocation system that will achieve efficient resource allocation (utilization) across the network
(ii) Simulate the system using measuring parameters.
(iii) Implement a system prototype.
(iv) Evaluate the performance of the model
(iv) Develop appropriate documentations for effective deployment of the scheme.

D Methodology of the Research

(i) Extensive literature review on the problems of existing call admission control schemes
(ii) Measuring parameters for the model will be specified.
(iii) Mathematical model will be developed.
(iv) Simulation program development using C++ programming language.
(v) Development of system prototype using Java programming language.
(vi) Model will be evaluated to determine its performance.

E Expected Contribution to Knowledge

Most of the works in the existing literature deals separately with buffer management and call admission control in mobile wireless multimedia networks. The most important contribution of this work is the integration of buffer with call admission control at the base station subsystem, combining various novel approaches of channel allocation and a new scheduling technique of improving spectrum utilization called ticket scheduling. The dynamic nature of network traffic necessitates such algorithm.

One of the important motivations behind the new scheme is to provide guaranteed quality of service for handoff calls, due to user mobility and efficient utilization of network resources at the base station to the two classes of wireless multimedia traffic- those generated respectively by real-time (delay sensitive) and non-real-time (delay tolerant) applications. This is achieved through scheduling of real-time new and handoff calls and priority techniques, as required. The performance of the new scheme is captured through various analytical models and simulation experiments. Analytical models compare the new scheme with an existing scheme proposed in the literature. Significant improvement is predicted which would be validated with simulation experiments. The analytical model would estimate the carried traffic and the size of the buffer requirements for the handoff calls.

II. LITERATURE REVIEW

The study of channel allocation is not a new topic in wireless communication world. Strategies to handle calls have been widely considered. The simplest way of giving priority to handoff requests is to reserve a fixed number of channels for them, which is called “Guard channel” [23]. In [14], queues are allowed only for the originating voice calls. Both the originating calls and handoff requests are allowed to be queued in [42]. In [43], handoff schemes with two-level priority reservation have been proposed. Cellular systems that support a mixture type of platform are considered in [33]). However, all of the above researches is based on voice cellular system only and multiple types of services have not been taken into consideration.

With the development of integrated wireless mobile system, non-real-time service has to be incorporated and its effect needs to be taken into consideration [13]. In order to support wider range of traffic, the handoff strategy need to take different features of different types of service into account. On the other hand, transmission delay of non-real-time service does not have much impact on the performance of non-real-time service (delay insensitive). Therefore, a successful handoff without interruption is very important to real time services, but not so critical for non-real-time service. [32] proposed a special two-dimensional model for cellular mobile systems with pre-emptive priority to real time service calls. However, no distinction was made between originating and handoff requests. Since forced termination of ongoing real time services calls is more annoying than blocking of originating calls from the users’ point of view, higher priority should be given to real time service handoff calls. In [44], a priority handoff scheme for the integrated voice/data wireless network has been studied but only data service handoff requests are allowed to be queued. [18] employed the concept of prioritization of handoff calls over new calls since it is desirable to complete an ongoing call rather than accepting a new one. They developed a channel assignment policy as well as using the idea of buffering handoff calls in case there are no available channels. [25] presented a comprehensive survey of different call admission control techniques. [11] proposed a support for multimedia users with dynamic bandwidth requirements. These policies take only local information in the admission decision process, and therefore will have a high call dropping probability. To reduce the call dropping probability, few other CAC algorithms that take into consideration neighbouring cells information have been proposed [5] [22] [24]. However, those algorithms only support users with fixed bandwidth requirements.

[41] investigated the call admission control strategies for the wireless networks where the average channel holding times for new calls and handoff calls are significantly different, the traditional one-dimensional Markov chain

model may not be suitable, two-dimensional Markov chain theory must be applied. They proposed a new approximation approach to reduce the computational complexity. It seems that the new approximation performs much better than the traditional approach. [37] developed a congestion control game with a linear pricing scheme based on variations in the queuing delay experienced by the users. They used a network model based on fluid approximations, and established the existence of a unique equilibrium and the global stability of the equilibrium point for a general network topology. [21] proposed an adaptive QoS management system in wireless multimedia networks. The proposed system was based on a service model designed for both connection- and application-level QoS. Wireless multimedia applications are classified into different service classes in the service model by their application profiles. Based on the service model, adaptive resource allocation is performed for each service class by employing the appropriate CAC and RR schemes tailored to the QoS requirements of the service class. Through analysis and simulations, it was demonstrated that the proposed system can meet the QoS requirements of different service classes and achieve reasonably high network utilization.

In [19][34], a dynamic channel allocation was proposed where there is no fixed channel among the cells. All channels are kept in a central pool and are assigned dynamically to radio cells as new calls arrive in the system. After a call is terminated, the channel is returned to the common pool. In DCA, a channel is available for use in any cell provided that signal interference constraints are satisfied. Since generally more than one channel may be available in the central pool to be assigned to a cell that requires a channel, some strategy must be applied to select the assigned channel [7]. [41] investigated the call admission control strategies for the wireless networks where the average channel holding times for new calls and handoff calls are significantly different, the traditional one-dimensional Markov chain model may not be suitable, two-dimensional Markov chain theory must be applied. They proposed a new approximation approach to reduce the computational complexity. It seems that the new approximation performs much better than the traditional approach. [36] presented a situation where the handoff calls are queued and no new calls are handled before the handoff calls in the queue are. Hence, this is a stricter scheme than the guard channel ones. [17] achieved better performance by combing guard channel and queue schemes. However, it is important to bear in mind that the more complex and efficient a scheme is, the more computational power and time it requires to be applied. [28] developed a non-preemptive prioritization scheme for access control in cellular networks. [9] proposed the use of dynamic buffering to minimize congestion in mobile network. [39] presented an actual call connection time characterization for wireless mobile networks under a general channel allocation scheme. [45] proposed a new adaptive channel reservation scheme for handoff calls in wireless cellular networks. [27] developed a distributed dynamic channel allocation algorithm for cellular network. [31] demonstrated the use of multi-agent approach for dynamic channel allocation. In [20] a dynamic channel allocation mechanism for ubiquitous environment based on time constraint was developed. [4] developed a centralized channel assignment and routing algorithms for multi-channel wireless mesh networks. [26] is a non-cooperative multi-radio channel allocation in wireless networks. [3] proposed an improved random early detection (DRED) gateway for congestion avoidance. [2] develops a new buffer management scheme for asynchronous transfer mode (ATM) network. However, these schemes only perform better in a light traffic condition. In a heavy traffic situation, the schemes may not perform very well which can lead to degradation in quality of service.

III. SYSTEM DESCRIPTION

This research combines call admission control with buffer to prevent congestion in a mobile wireless network. The effect of buffer size under several scenarios will be investigated to evaluate the blocking probabilities of new and handoff calls. Performance comparison of both the new policy and the traditional methods will be measured.

A System Algorithm

Dynamic channel allocation algorithms assign channels to users dynamically based on traffic conditions of cells. DCA alleviates hot spot traffic, and improves spectrum efficiency. DCA can be centralized or distributed. In centralized DCA, all channels are placed in a common pool and dynamically assigned according to some strategy. It provides an optimum solution for channel assignment. However, in distributed DCA, channels are assigned to users by their base station. Centralized approach is employed in the proposed scheme because of its advantages (best performance) under heavy traffic. Since arriving calls can be bursty, a ticket scheduling is employed. In ticket scheduling, each call is given a ticket and decision is made by choosing ticket at random and the call holding that ticket gets the channel.

The available resources are the maximum number of channels in the cell and the buffer capacity that is used to queue real-time and non-real time handoff calls in case no channels are available. It is assumed that the number of channels in a cell is constant due to the fact that wireless resources are limited. The buffer capacity can be changed depending on the input traffic.

The basic steps of the proposed algorithm are presented next. When user calls arrive and calls are from different cells, calls are served between lines 3 and 10. However, if the calls are from same cell, ticket scheduling assists in serving the calls. In cases where no channel is free, since handoff calls are considered critical, real-time and non-real time handoff calls are buffered until channel to serve the call is available (lines 19-23). Handoff calls will only be blocked when the buffer is full, while new calls are blocked when no channel is idle. The algorithm is illustrated in figure 1.

B. System Model

A good channel allocation scheme should be able to provide different QoS guarantee for different traffic types, while at the same time has to fully maximize (utilize) the scarce wireless resources available in the network. A call is assumed to declare itself either as real-time or non-real-time call. These calls are further classified as: new real-time call

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Begin
1.   While (n calls arrive for connection) do
2.     if (there exist free channel) then
3.     if (calls are from both cells) then
4.      if (cold spot call is non-real time) then
5.        compare and serve hot spot calls before cold spot calls
6.      else
7.        assign ticket to each call
8.         randomly pick any ticket and allocate channel to call with that ticket
9.              endif
10                  endif
11.  elseif (calls are from same cell) then
12      if (same call type) then
13       repeat steps 7 and 8
14      else
15        allocate channel to real-time  calls before non-real time call
16      endif
17   endif
18    if ( no channel is free) then
19      if (call is real time or non-real time handoff) then
20             is buffer full?
21               if No then
22                 put call in buffer
23                 repeat steps 7 and 8
24               else
25                 block the call
26              endif
27      else
28             block the call
29       endif
30    endif
31 end while
   End
```

Figure 1: Channel allocation algorithm

or real-time handoff call and new non-real-time call or non-real-time handoff call. The call processing entities of the system (e.g the processing elements in the base station, the base station controller or the mobile switching centre) are capable of identifying the call type at any moment.

Assume users, representing requests of connection to the base station, arrive at the same time, the system first check where the requests come from (i.e hot spot cell or cold spot cell). Hot spot calls are given priority over cold spot calls in channel allocation. If the requests are from both cells, hot spot cell request is allocated channel before cold spot request if the cold spot request is non-real time, otherwise ticket scheduling is used to serve the calls. Since real-time and non-real time handoff calls are delay sensitive but not loss sensitive, they are given same priority. However, if the requests are from the same cell type, ticket scheduling algorithm is employed and channel is allocated using centralized dynamic technique. Channels are released to the central pool if: user calls are completed, and when a mobile user crosses cell boundary. Blocked real-time and non-real-time new calls are lost, while blocked real-time and non-real-time handoff calls can wait in the handoff buffer (queue) for channel to be available. The queuing scheme is briefly described as follows. No real-time and non-real-time new calls are queued when there is no channel. Real-time and non-real-time handoff calls are sent to the buffer, if there are no available channels in the destination cell, and remains queued until a channel is found. In the case of high demand for real-time and non-real-time handoff, calls will be denied queuing due to the limited size of the buffer. The queuing device has finite capacity. The buffer of real-time and non-real-time handoff calls lead to relatively low blocking probability. Figures 2 and 3 illustrate the system model and system flowchart respectively.

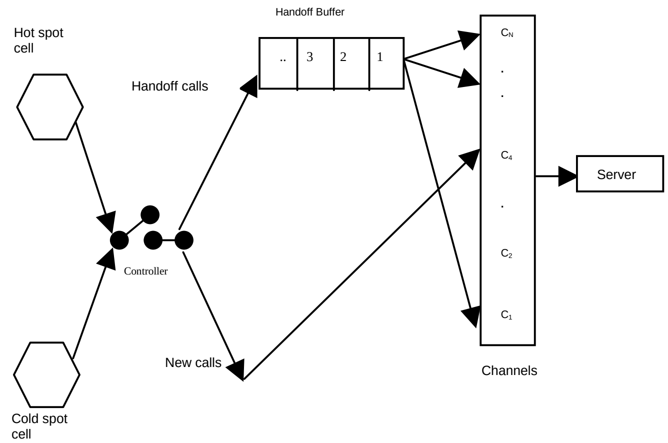

Figure 2: System model

IV RESULTS AND DISCUSSIONS

Simulation is the best method to indicate that a solution is likely to work in an environment where the real-life network is not easily available. This attempts to explain observed behaviour using a set of simple and understandable rules. These rules can be used to predict the outcome of experiment involving the given physical situation. C++ will used to write the simulation program to implement the system characteristics with all the necessary QoS parameters to determine the various blocking probabilities.

The simulator will generate different data, which will act as the rate at which different traffics enter a real life network, an indication of the system state. This would be used in calculating the different probabilities i.e new call blocking probability and handoff call dropping probability.

Part of any policy design is performance analysis. After the new CAC in relation to buffer management policy have been developed, a performance analysis of the system will be carried out, shown in detailed graphs, under different scenarios to test the efficiency of the system. Performance metrics include the new call blocking probability, handoff call dropping probability, and buffer size. These metrics would represent the number of new calls and handoff calls blocked by the system at any point in time. Network resource utilization is often a good indicator of efficiency in systems where resources may become congested even though others are ignored. Finally, the effect of buffer size on handoff call blocking probability will also be investigated with appropriate documentation for effective deployment of the scheme.

V. CONCLUSION

The research paper describes the development of a new congestion control technique in mobile multimedia wireless networks. Most of the existing research works have not considered buffering handoff calls as a way of reducing its force termination probability. Instead of deteriorating the quality of service of handoff calls in the presence of new calls, a buffer is introduced to take care of this and the total throughput of the network will increase considerably.

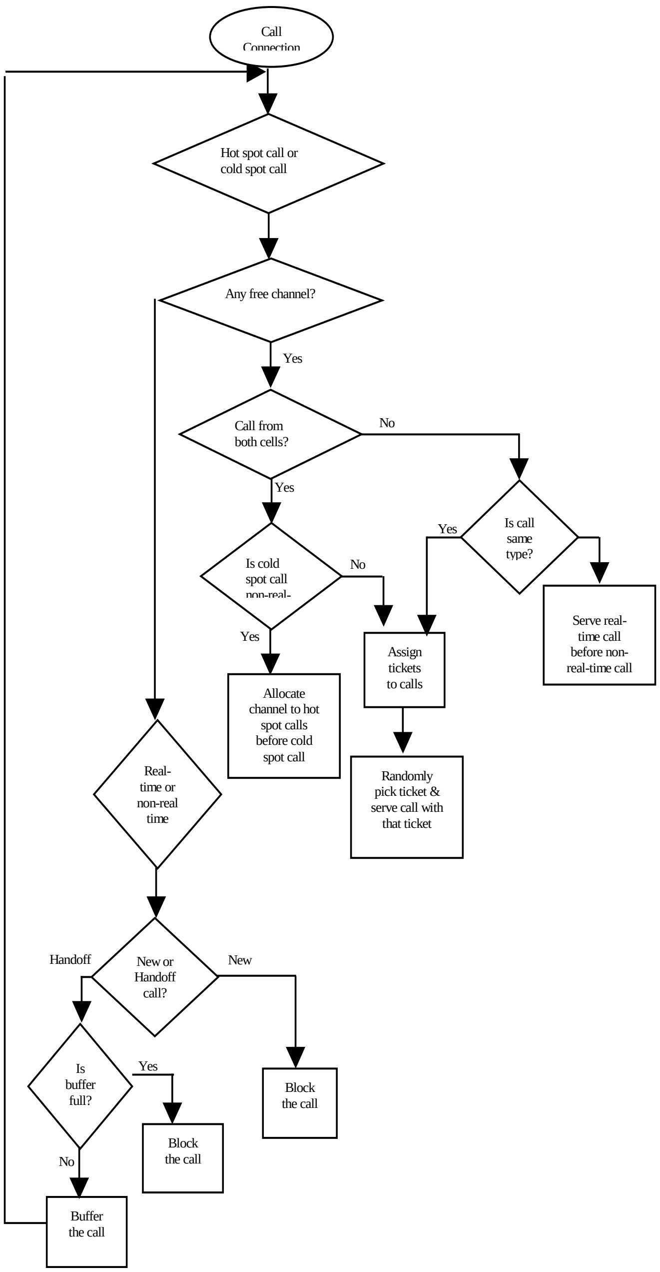

Figure 3: Flowchart of the proposed scheme

The proposed scheme provides a quality of service guarantee to both new and handoff calls and at the same time the exploitation of buffer resources to accommodate blocked handoff in order to improve the performance of the network.

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