DEVELOPMENT OF CONGESTION CONTROL SCHEME FOR WIRELESS MOBILE NETWORK

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ABSTRACT

The tremendous growth of wireless networks demands the need to meet different multimedia (such as voice, audio, video, data, etc) applications available over the network. This 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 based on the use of dynamic guard channel allocation scheme. In addition, a buffer will be introduced to store handoff calls if there are no channel available instead of dropping (rejecting) them. The performance analysis of the new scheme will be carried out, especially, the effect of the dynamic threshold and buffer size on call blocking probabilities.

Keywords: *Handoff call, New call, Congestion, Mobile network, Quality of Service (QoS), Buffer, Multimedia*

1. INTRODUCTION

In the past decade, the wireless network has experienced tremendous growth, and this growth is likely to continue in the near future. Apart from an increase in the number of users [1, 2, 3], more demanding applications will appear, resulting in ever greater resource requirements. The design of such a network, which is based on a cellular architecture [4, 5, 6], will give room for adequate use of the available frequency spectrum. A strong network backbone is needed to support connections since high quality of service (QoS) 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 [7,8]. On the other hand, the network resource allocation decides how to accept incoming connection requests [9, 10, 11]. The major call-level qualities of service parameters based on cellular concept are: new call blocking and handoff call blocking probabilities [12]. When a mobile user tries to communicate with another user or a base station, it must first obtain a channel from one of the base stations that hears it. If a channel is available, it is granted to the user otherwise the new call is blocked. The user releases the channel either when the user completes the call or moves to another cell before the call is completed. The procedure of moving from one cell to another while a call is in progress is called handoff. While performing handoff, the mobile unit requires that the base station in the cell that it moves into will allocate it a channel. If no channel is available in the new cell, the handoff call is blocked [12]. Instead of blocking such call, a buffer is introduced which stores the call until a channel is available to transmit the call. This is a motivation for the study. Also, many dynamic channel allocation mechanisms have been proposed [13, 14, 15], but all these mechanisms may improve the performance of the cellular 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. This is an important step forward from the other conventional threshold strategies that may be employed by network operators. In this study, a dynamic guard channel policy is proposed to handle both the new and handoff calls with buffers at various locations in the network to handle the blocked handoff call in order to keep the quality of service of handoff call and the buffer threshold will be determined by the rate at which traffics enter the network. This is an important step forward from other conventional threshold strategies that may be employed by network operators. Data traffic is assumed to be delay-tolerant and the capability of buffering the delay-insensitive data traffic is added. The call admission mechanism will be considered under different scenarios with an estimation of the values of the dynamic threshold and buffers that meet the QoS parameters.

1.1 Statement of the problem

From the users' point of view, it is more frustrating to loose a call that has already begun than to be prevented from establishing a new call. However, most of the proposed channel allocation schemes and call admission control did not take into account the effect of handoff calls in the performance of the system. In general call handoff is affected by the degradation of the radio link, either because there is some change in the environment, or because the user is moving and needs to change base station to keep sufficient transmission power. In effect, users' welfare will consequently be improved (increase) if special care is given to handoff calls; even if it increases the blocking probability of the new calls.

1.2 Research Questions

Mobile wireless network users have the ability to move from one location area to another, which has to be monitored, in order to provide and distribute adequate network resource usage throughout the network over time. However, an in-depth study of the problems of call admission control in relation to buffer management to prevent congestion in mobile wireless networks will be carried out. Key questions that the research will address are:

• What performance parameters call admission control participants exchange?
• Quantitatively, what are the goals of call admission, buffer, and users in mobile wireless networks?
• How is a call quality of service (QoS) maintained?
• How well does the proposed policy evaluate the blocking probabilities of new call and handoff calls?
• How does the proposed policy compare with the existing policies?
• Does the proposed policy provide a stable global acceptability?
• How can the input traffic affect channel allocation in order to lessen the impact of uncertainty?
• How relevant and effective is the proposed policy in shaping users' behavior?

1.3 Objectives of the study

The specific objectives of the research are to:

(i) establish system performance parameters such as new call blocking probability, handoff dropping probability, call holding (dwelling) time and buffer size.
(ii) formulation of a congestion control (mathematical) model using the parameters in (i) above.
(iii) simulation program development to implement the parameters using C++ programming language, and
(iv) develop appropriate documentation for effective deployment of the scheme.

1.4 Significance and beneficiary of the study

Although CAC schemes and buffer management were designed for the same purpose, little or no work has been carried out on their combined effects as a resource manager. The principal study, [23], is more focused on performance analysis and the call admission control scheme it uses is relatively simple. Hence, it does not explore all the possible benefits a well designed CAC scheme has to offer. Therefore, it would be worthwhile and beneficial to explore how different CAC schemes manage to improve the network utilization, and how well they can be combined with buffer. This could permit direct comparison and allow for the determination of the best scheme as well as presenting how buffer could provide even greater results. This is one goal of the research.

With the current trend towards an ever growing use of mobile networks for purposes other than simple voice calls, there is a need to understand how dynamic buffer would behave in the case of packet-based cellular networks, since these may be used in the future. This is the second goal of the research: to explore how incoming traffic properties could impact on network performance, and to seek the best values for key parameters.

1.5 Scope/Delimitation of the study

The research is based on combining call admission control with buffer in controlling congestion in mobile wireless network.

1.6 Expected contribution to knowledge

This study is expected to generate parameters for measuring the performance of call admission control system such as new call blocking probability, handoff call blocking probability, call holding time and buffer size. It will also provide appropriate documentation for the effective deployment of the scheme. In addition, the new scheme will reduce handoff call blocking probability. In general, the result from the work will provide knowledge of how call admission control can be integrated with buffer management to control congestion in wireless mobile network.

2. RELATED WORK

There are several related research work based on call admission control and buffer management for different traffic classes in wireless networks, these are presented below.

[16] proposed a support for multimedia users with dynamic bandwidth requirements. This policy takes 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 which take into consideration neighbouring cells information have been proposed [17, 18, 19]. However, those algorithms only support users with fixed bandwidth requirements. [13] employed the concept of prioritisation of handoff calls over new calls by using buffering technique since it is desirable to complete an ongoing call rather than accepting a new one. [20] developed a class-based admission policy that satisfies the QoS requirements for each traffic class by allocating adequate resources to each type. They introduced the capability of buffering calls that can tolerate delay if no channels are free. The guard channel approach [23,27, 28, 29] offers generic means of increasing the chances of handoff call success, simply by allocating a number of channels exclusively to handoffs. In [21] a threshold-based guard channel policy for a single traffic type was proposed. The policy allocates some channels only to handoff call and if the number of busy channels exceeds a given threshold, new calls are blocked. The number of the required guard channel depends on the required values of the new and handoff call probabilities. [22] introduced a distributed call admission policy where the threshold values vary dynamically depending on the input traffic to the cell to enhance the handoff call blocking probability in case of overloading. [23] proposed an admission control policy based on the well known threshold based guard channel method for two different traffic classes (voice and data) and introduced a buffer to handle handoff data calls if no channels are available rather than rejecting them. They employed two methods (blocking and preemptive) to handle handoff voice calls.

In [32] a detailed survey of the different channel allocation schemes is presented. The channel allocation can be fixed, dynamic or hybrid, depending on how the resources are shared among the different cells in the network. [25, 33] proposed a fixed channel allocation where a set of nominal channels is permanently allocated to each cell for its exclusive use. The total number of available channel is divided into a number of sets and the minimum number of channel sets required to serve the entire coverage area is related to the reuse distance. In [34, 35], a dynamic channel allocation (DCA) 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 [36, 42]. [42] 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. In [37], the number of guard channels is adjusted automatically in real time to minimize the loss probability of handoff calls. [38] 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. [39] proposed a method that involved the introduction of guard channels and the queuing of new calls. The results showed that the blocking of handoff calls decreases much faster than the queuing probability of new calls increases. [40, 41] 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. [43] developed a congestion control game with a linear pricing scheme based on variations in the queueing 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. [19] 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 could meet the QoS requirements of different service classes and achieve reasonably high network utilization.

3. THE PROPOSED SCHEME

This research combines call admission control with buffer to prevent congestion in a wireless mobile network. Effect of the different buffer sizes will be investigated, evaluation of the blocking probabilities of new and handoff calls shall be considered. Performance comparison of both the new policy and the traditional methods will be measured.

3.1 The Model

The proposed scheme considers a multiple class of calls (multimedia system) that differ in their QoS requirements and traffic parameters, allowing for call transitions among classes. The model is structured over users moving along an arbitrary topology of cells. Each cell has the same number of channels, due to the fact that wireless network resources are limited, which give service to classes of call request that is assumed to be generated according to a Poisson distribution with an exponential call holding time. During call establishment, a call is assumed to declare its priority. The call processing entities of the system (e.g. the processing elements of the Base station or Base Station Controller) are able to identify the call type at any moment. The available resources are the maximum number of channels in a cell and the buffer size that is used to queue handoff call in case no channel is available. The buffer size could be adjusted depending on the input traffic rate. A mathematical (analytical) model will be developed to support this. The system model and flowchart is shown in figure 1 and figure 2 respectively.

3.1.1 Traffic Characteristics

To optimize the network resources, a research on the different traffic parameters (requirements) quality of service need will be done. The proposed research includes examining existing CAC applications that could be efficiently implemented; as well as measuring network and computing properties to determine the performance of the proposed scheme. A traffic model is going to be developed. [30, 31] are useful models for this research. The work in this project will involve calculating the new call and handoff call blocking probabilities. It is expected to use common characteristics of all the traffics to simplify as well as strengthen intuition in creating and analysing the effect of buffer size in relation to call blocking probabilities.

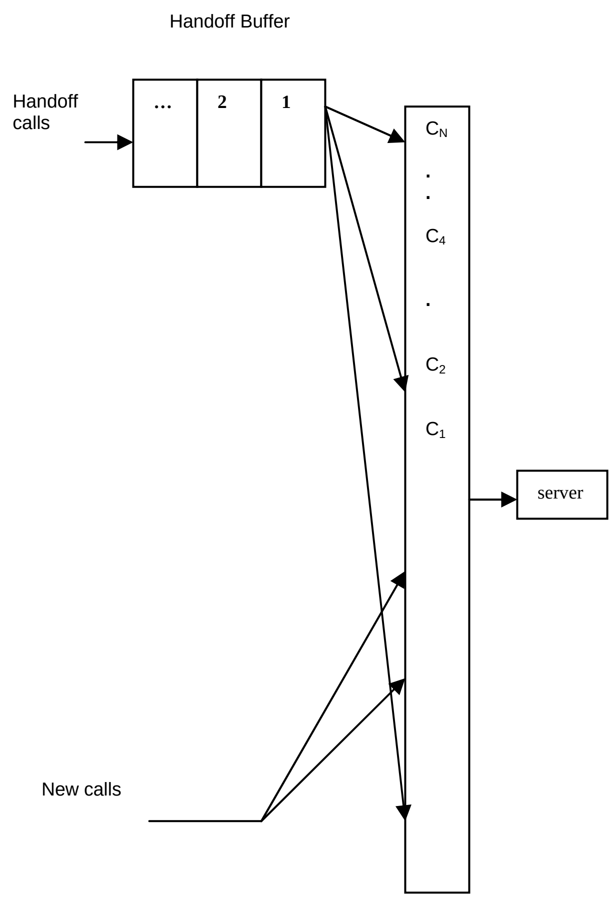

Figure 1: *System model*

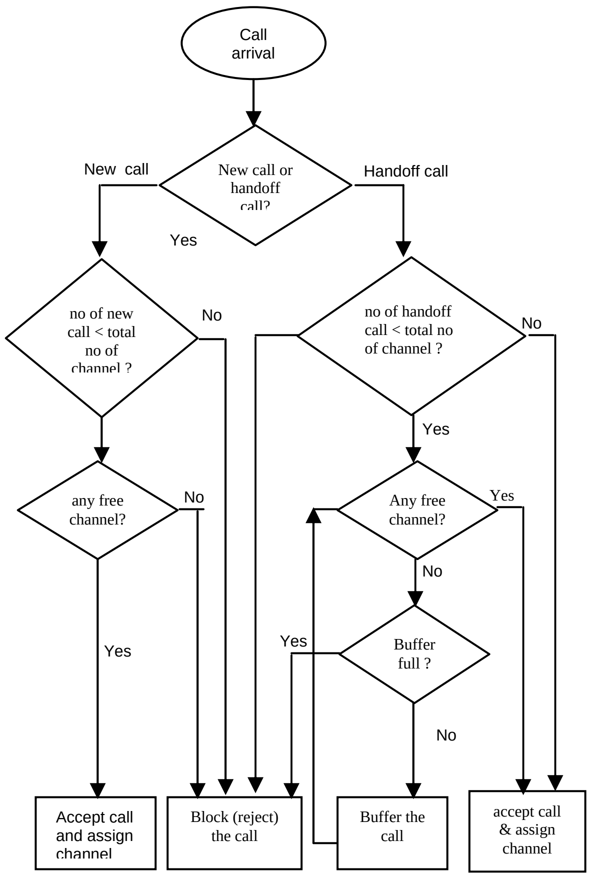

Figure 2: *Flowchart of the proposed scheme*

3.1.2 Channel Allocation

There are many ways to allocate channels to call requests in cellular networks. This research proposal focuses on the use of dynamic channel allocation method [15, 26] which is adjusted depending on the input rate. The algorithm is shown in figure 3.

3.1.3 Buffer Management

Typically a customer waits in a queue with other customers awaiting service, but it is possible for the seller to provide higher priority to certain, presumably higher spending customers. Computational resources could be done in the same manner. Handoff call would be buffered if no free channel is available rather than rejecting them. This would be allocated channel any time either of the following occurs: (i) user completes the call (ii) the user moves to another cell before the call is completed where is believed to be allocated its own channel. However, what determines the handoff that will be allocated channel first depends on the priority attached to it. This policy makes us determine whether delay sensitive handoff should be buffered, or allowed to be initiated again based on its dwelling time.

```
If (incoming request is new call or handoff call)
   If (there is a free channel) then
      allocate the free channel
  else
       If (handoff call)
         put in a buffer
          If (there is free channel again)
            allocate the free channel to handoff call
          else
             Ignore request
          endif
       else
         Ignore request
       endif
   ignore request
  endif
endif
End.
```

Figure 3: *Algorithm of the proposed model.*

4. PROPOSED IMPLEMENTATION

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 be the programming language used to implement the research or alternatively, any network simulators available where an interface will accept all the necessary QoS parameters to determine the various blocking probabilities.

4.1 Performance Evaluation

Part of any policy design is performance analysis. After the new CAC in relation to buffer management policy have been developed for congestion control in wireless mobile network, it will be necessary to measure the performance of the systems under which the policy operate as well as standard models for comparison. Performance metrics include the new call and handoff call blocking probabilities, buffer size. These metrics would represent the number of new calls and handoff calls blocked by the system. Network resource utilization is often a good indicator of

efficiency in systems where resources may become congested even though others are ignored. The effect of buffer size on handoff call blocking probability will be investigated also.

5. CONCLUSION

This research proposal presents the analysis of a new policy of congestion control in wireless mobile networks. Although research efforts have been trying to address this issue, but most of them did not put into consideration buffering handoff calls as a way of reducing the number of handoff call block. 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 throughout of the network will increase considerably. The proposed scheme the implementation of which is being carried out would provide 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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