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Call Admission Control Scheme And The Desire For Prioritization In Mobile Networks

Erua J.B.
Department of Elect/ Elect Engineering,
Ambrose Alli University,
Ekpoma. Nigeria
eruajb@yahoo.com

Ojieabu C.E.
Department of Elect/ Elect Engineering, Ambrose Alli University ,
Ekpoma. Nigeria.
bishopeghosa@yahoo.ca

***Abstract*—The wireless communication system usually called the global system for mobile communication (GSM) has been a great catalyst for the telecommunication industry. Since its inception in Nigeria in the late 1990'.There have been tremendous increase in the number of subscribers to the various network providers available. This increase in demand has led to traffic congestion due to the limited frequency spectrum available. An easy approach to solve this problem is to increase the network capacity, but this is uneconomical because even at their current size, the network are under-utilized during off peak period and very congested at peak period. Call admission control and prioritization of hand off are necessary tools for the effective management of the network for a better quality of service (QOS) to the consumers. This paper provides a survey of admission control scheme and handoff prioritization for cellular network several (CAC) schemes are discussed with handoff prioritization being a common characteristic of these schemes.**

Keywords—Call Admission, Control, Prioritization, Network, Handoff, Scheme.

INTRODUCTION

Since, its inception, the wireless communication market has experienced tremendous growth and is likely to continue. One major drawback for wireless networks is that the available radio frequency spectrum is limited and can no longer support these increasing demands [1].

. The original approach was to increase the capacity of the network using cell splitting, frequency reuse, or overlapping cell layers to reduce congestion.

Since it is no longer possible to make the network capacity fit the demand during peak periods, alternative solution has to be found to achieve a better utilization of this limited capacity, but this is uneconomical because even at their current size, the network are under-utilized during off peak period and very congested at peak period [1,2,3]. This paper suggests that Call Admission Control Mechanism and Prioritization of Handoff can provide an effective management tool for an efficient Quality of Service (QOS) in mobile networks[3,4].

MATERIALS AND METHOD

Classification of CAC Scheme

Third generation radio communication systems are designed to offer multimedia services, including voice and video, telephony and high-speed Internet access. The Interference-based schemes can be classified into[5]:.

Wideband Power-based CAC: This method computes the increase in the interference (power) caused by the establishment of a new user in the cell in uplink and accepts the call only if the total interference does not exceed a predefined threshold[5].

Throughput-base CAC: A throughput-based CAC algorithm computes the increase in the load caused by the establishment of a new user in the cell in uplink and accepts the call only if the total load does not exceed a predefined threshold.

Signal to noise ratio interference-based CAC: This algorithm computes the minimum required power for the new user and accepts it if it is not

below a predefined minimum link quality level One of the ways to reduce the handoff failure rate is to prioritize handoff. Handoff algorithms that try to minimize the number of handoffs give poor performance in heavy traffic situations. In such situations, a significant handoff performance improvement can be
Obtained by prioritizing handoff.

Call Admission Control

Call admission control (CAC) is a technique to provide quality-of-service (QoS) in a network by restricting the access to network resources. Simply stated, an admission control mechanism accepts a new call request provided there are adequate free resources to meet the quality-of-service (QoS) requirements of the new call request without violating the committed quality-of-service (QoS) of already accepted calls[3,4,5]. There is a tradeoff between the quality-of-service (QoS) level perceived by the user (in terms of the call dropping probability) and the utilization of scarce wireless resources. In fact, call admission control (CAC) can be described as an optimization problem. We assume that available bandwidth in each cell is channelized and focus on call-level quality-of-service (QoS) measures. Therefore, the call blocking probability (Pb) and the call dropping probability (Pd) are the relevant quality-of-service (QoS) parameters. Three call admission control (CAC) related problems can be identified based on these two
Quality-of-service (QoS) parameters[5,6]:

MINO: Minimizing a linear objective function of the two probabilities

MINB: For a given number of channels, minimizing the new call blocking probability subject to a hard constraint on the handoff dropping probability.

MINC: Minimizing the number of channels subject to hard constraints on the new and handoff calls blocking/dropping probabilities. Channels could be frequencies, time slots or codes depending on the radio technology used. Each base station is assigned a set of channels and this assignment can be static or dynamic. MINO tries to minimize penalties associated with blocking new and handoff calls. Thus, MINO appeals to the network provider since minimizing penalties results in maximizing the net revenue. MINB places a hard constraint on handoff call blocking thereby guaranteeing a particular level of service to already admitted users while trying to maximize the net revenue[6]. MINC is more of a network design Problem where resources need to be allocated appropriately based on, for example, traffic and mobility characteristics. Since dropping a call in progress is more annoying than blocking a new call request, handoff calls are typically given higher priority than new calls in access to the wireless resources. This preferential treatment of handoffs increases the blocking of new calls and hence degrades the bandwidth utilization. The most popular approach to prioritize handoff calls over new calls is by reserving a portion of available bandwidth in each cell to be used exclusively for handoffs. In general there are two categories of call admission control (CAC) schemes in cellular networks.

CHANNEL ALLOCATION

There are different channel allocation schemes which are used in real mobile networks. They have direct consequences on the overall performance[5,10], which explains why so much effort was put into researching better resource allocation techniques in the past.

Two types of calls shares the channel allocated to a cell: the new calls and handoff calls. New calls are initiated by mobile users in the current cell; while handoff calls are initiated in other cells but handed over to the current cell. The major quality of service metrics for cellular networks, the call blocking probability and the call dropping probability, depends on how the number of channels is shared between these two types of calls,. That is the call admission control schemes.

G. Megha and A.Sachan[14], in their work presents detailed survey of the different channel allocation schemes. It can either be fixed, dynamic or hybrid. However, whatever scheme is used, we must try to avoid interference between calls and the same frequency cannot be reused in another cell within a **"CO-CHANNEL REUSE DISTANCE"σ^2**

FIXED CHANNEL ALLOCATION

The fixed channel allocation (FCA), a set of nominal channels is permanently allocated to each cell for its exclusive use. The total number of available channels is divided into a number of sets; the minimum number of channels set (N) required to serve the entire coverage area is related to the reuse distance σ[14].

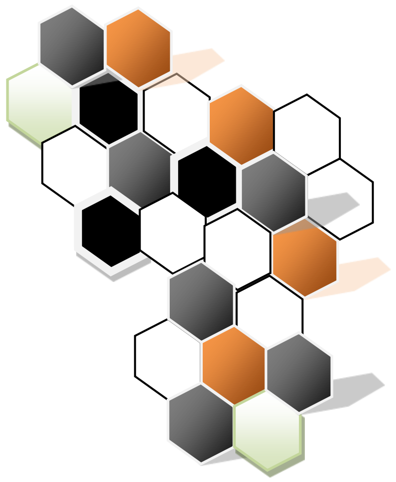


Fig 1 Channel Allocation for N=3 and N=7

In the basic FCA scheme, the total number of channels allocated to each cell is the same. It is therefore possible to avoid traffic congestion using historical data to allocate channels. But poor performance is easily obtained if the traffic congestion changes over time.

DYNAMIC CHANNEL ALLOCATION

Because of variations of traffic in cellular system, FCA schemes do not attain high efficiency. To overcome this, Dynamic channel allocation (DCA) has been researched. For the DCA, there is no fixed relationship between channels and cells. All channels are kept in a central pool and assigned dynamically to radio cells as new calls arrive in the system. The channel is returned to the central pool once the call is terminated.

In DCA, a channel is eligible for use in any cell, provided the signal interference constraints are satisfied. The major differences between the strategies are related to how this choice is made because more than one channel might be available in the central pool to be assigned at a particular time.

HYBRID CHANNEL ALLOCATION

Combining both FCA and DCA, hybrid channel allocation was proposed by Joe Sin and Nicholas Georganas in their work **"A SIMULATION STUDY OF A HYBRID CHANNEL ASSIGNMENT SCHEME FOR CELLULAR LANDMOBILE RADIO SYSTEM".** In HCA scheme, the available channels are spitted into fixed and dynamic sets[6,14]. The fixed contains a number of nominal channels assigned to cells and preferred for use in their respective cells. The second set of channels is shared by all users in the system to increase flexibility. When a call requires services from a cell where all nominal channels are busy, a channel from the dynamic set is then used.

HANDOFF PRIORITIZATION

One of the ways to reduce the handoff failure rate is to prioritize handoff. Handoff algorithms that try to minimize the number of handoffs give poor performance in heavy traffic situations[6,8,9]. In such situations, a significant handoff performance improvement can be obtained by prioritizing handoff. Channel assignment strategies with handoff prioritization have been proposed to reduce the probability of forced termination. Two basic methods of handoff prioritization are guard channels and queuing.

Guard Channels — Guard channels improve the probability of successful handoffs by reserving a fixed or dynamically adjustable number of channels exclusively for handoffs. For example, priority can be given to handoff by reserving *N* channels for handoffs among *C* channels in the cell. The remaining (*C* – *N*) channels are shared by both new calls and handoff calls[8,9,10]. A new call is blocked if the number of channels available is less than (*C* – *N*). Handoff fails if no channel is available in the candidate cell. However, this concept has the risk of underutilizing spectrum. An adaptive number of guard channels can help reduce this problem. Efficient usage of guard channels requires the determination of an optimum number of guard channels, knowledge of the traffic pattern of the area, and estimation of the channel occupancy time distributions.

Queuing of Handoff — Queuing is a way of delaying handoff; the MSC queues the handoff requests instead of denying access if the candidate BS is busy. Queuing new calls results in increased handoff blocking probability[8]. The probability of a successful handoff can be improved by queuing handoff requests at the cost of increased new call blocking probability and a decrease in the ratio of carried-to-admitted traffic since new calls are not assigned a channel until all the handoff requests in the queue are served. Queuing is possible due to the overlap region between the adjacent cells in which MS can communicate with more than one BS. If handoff requests occur uniformly, queuing is not needed; queuing is effective only when handoff requests arrive in groups and traffic is low for two reasons. First, if there is a lot of traffic, it is highly unlikely that a queued handoff request will be entertained. Second, when there is moderate traffic and traffic arrives in bundles, a queued handoff request is likely to be entertained due to potential availability of resources in the near future and the lower probability of new handoff requests in the same period. Queuing is very beneficial in macro cells since the MS can wait for handoff before signal quality drops to an unacceptable level. However, the effectiveness of queuing decreases for micro cells due to stricter time requirements. The combination of queuing and channel reservation can be employed to obtain better performance. Joint optimization of queuing and handoff parameters may be better due to the following reasons.

• When handoff algorithms are designed to minimize the number of unnecessary handoffs, excessive call drops may occur during high traffic intensities. These strategies minimize the number of handoff attempts per boundary crossing, and sufficient time may not be available for entertaining handoff requests under heavy traffic conditions. For example, if a large amount of hysteresis is used to minimize handoffs, call quality may become unacceptable by the time a handoff request is entertained[7,9].

• Different handoff algorithms introduce different delays in handoff requests. Hence, the delay associated with handoff queuing may not be acceptable for some handoff algorithms. The performance improvement achievable with handoff queuing is variable and dependent on handoff algorithms.

• Some handoff requests may demand higher priority in a queue to save the call. This can be investigated properly by noting both the traffic and transmission characteristics.

Handoff Schemes-The handoff schemes can be classified according to the way the new channel is set up and the method with which the call is handed off from the old base station to the new one. At call-level, there are two classes of handoff schemes, namely hard handoff and soft handoff.

1) **Hard handoff**- In hard handoff, the old radio link is broken before the new radio link is established and a mobile terminal communicates at most with one base station at a time. The mobile terminal changes the communication channel to the new base station with the possibility of a short interruption of the call in progress. If the old radio link is disconnected before the network completes the transfer, the call is forced to terminate. Thus, even if idle

channels are available in the new cell, a handoff call may fail if the network response time for link transfer is too long. Second generation mobile communication systems based on GSM fall in this category.

2) **Soft handoff**- In soft handoff, a mobile terminal may communicate with the network using multiple radio links through different base stations at the same time. The handoff process is initiated in the overlapping area between cells some short time before the actual handoff takes place. When the new channel is successfully assigned to the mobile terminal, the old channel is released. Thus, the handoff procedure is not sensitive to link transfer time. The second and third generation CDMA-based mobile communication systems fall in this category[7,9,11].

Soft handoff decreases call dropping at the expense of additional overhead (two busy channels for a single call) and complexity (transmitting through two channels simultaneously). Two key issues in designing soft handoff schemes are the handoff initiation time and the size of the active set of base stations the mobile is communicating with simultaneously. This study focuses on cellular networks implementing hard handoff schemes.

GUARD CHANNEL SCHEME

This scheme is the nearest to a standard, it is commonly used for experiments and subjected to numerous studies. The approach offers a means of increasing the chance of handoff call success. This is done by allocating a number of channels exclusively for them. This means that, if there are N channels of communication in the cell from which G are guard channels. A new call will be accepted only if the number of available channels is superior to G, whereas handoff calls will be accepted as long as at lease one channel is available10,11].

If all channels are guard channels, it is impossible to start a new call, but the probability that a handoff call will be blocked is very low. On the other hand, if no channel is allocated exclusively for handoff calls, both types of calls will be treated equally, neglecting the importance of handoff calls. This is solved automatically by adjusting the number of guard channels in real time to minimize loss of probability of handoff calls.

QUEUING SCHEMES

The queuing of calls is the second major scheme for handoff prioritization. Different queuing schemes exist.

- **QUEUING OF HANDOFF CALLS**

Here, handoff calls are queued and no new calls are handled before the handoff calls in the queue are dealt with. This scheme is stricter; it is of course not possible for a caller to wait indefinitely. It is therefore necessary to impose a time limit, determined by analysis of the average time that a user stays in the overlapping area. Handoff calls can be blocked before being queued because; the size of the buffers for queuing is limited.

- **QUEUING OF NEW CALLS**

it seems more natural to queue new calls given the fact that they are almost insensitive to delay. A method of introducing guard channels and queuing new calls shows that the blocking of handoff calls decreases much faster than the queuing probability of new calls increase.

- **QUEUING BOTH TYPES OF CALL**

We can also decide to queue both type of call and then give a higher priority rate to handof calls present in the queue[8,9,11].

1. **Deterministic Call Admission Contro (CAC):**

Quality-of-service (QoS) parameters ar guaranteed with 100% confidence. Typically these schemes require extensive knowledge o the system parameters such as user mobilit which is not practical, or sacrifice the scarc radio resources to satisfy the deterministi quality-of-service (QoS) bounds.

2. **Stochastic Call Admission Contro (CAC):**

Quality-of-service (QoS) parameters are guaranteed with some probabilistic confidence. By relaxing Quality-of-service (QoS) guarantees, these schemes can achieve a higher utilization than deterministic Approaches.

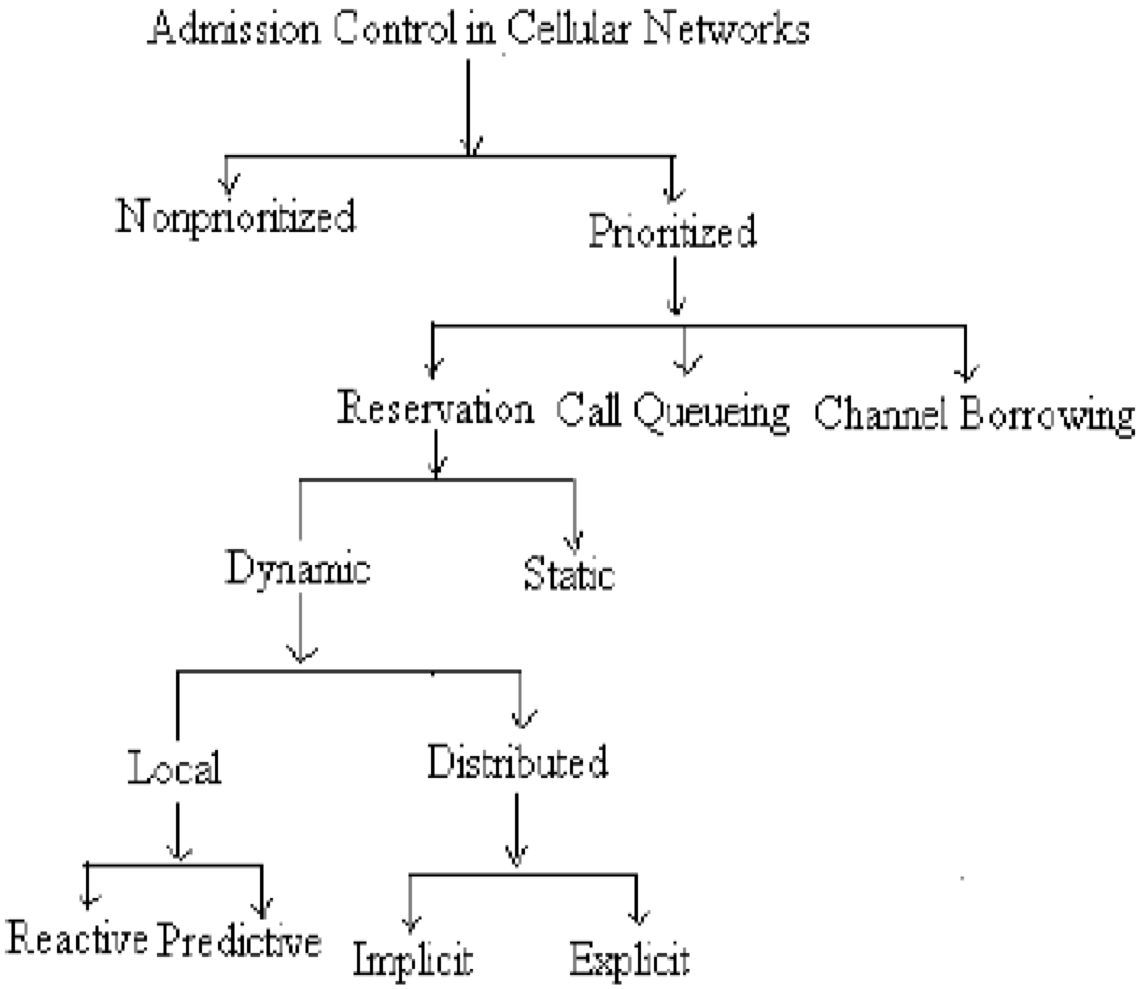


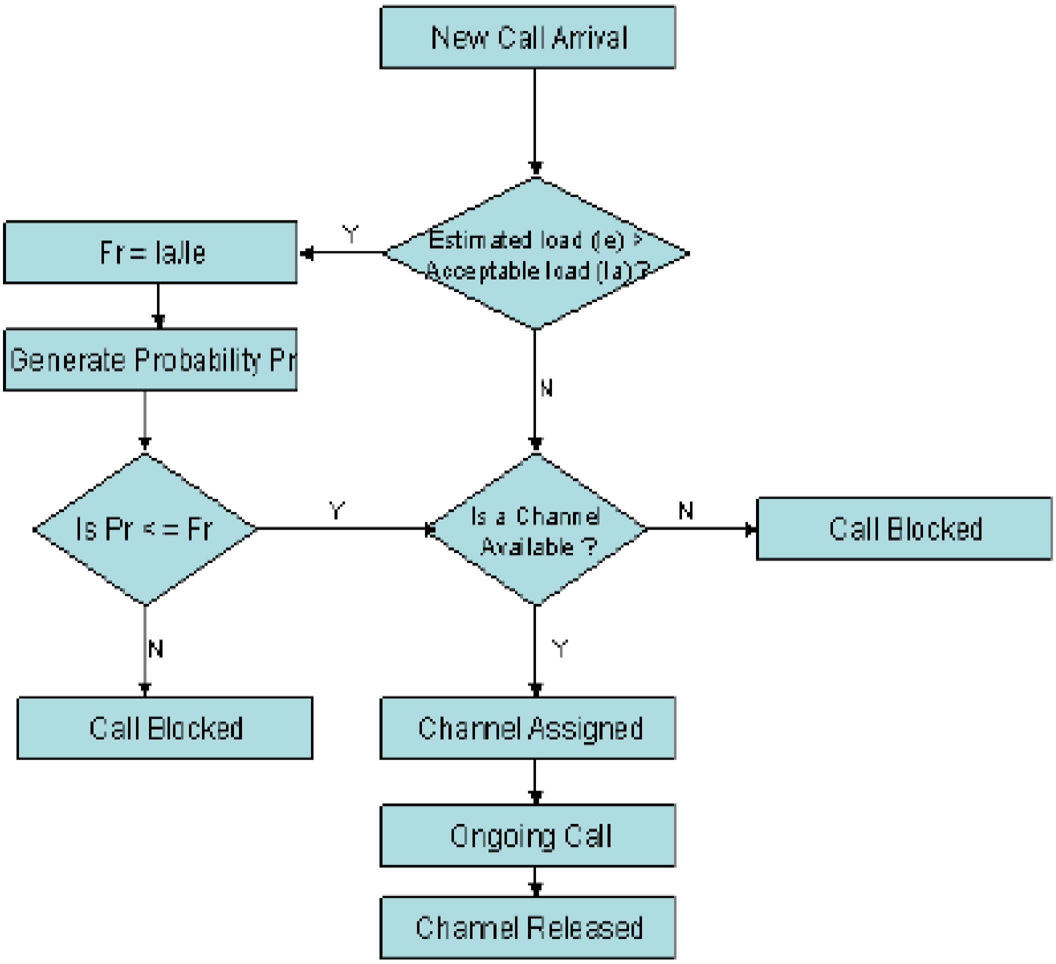
Fig 2. Stochastic call admission control schemes in cellular networks[6]

Most of the call admission control (CAC) schemes which are investigated fall in the stochastic category. Figure depicts a classification of stochastic call admission control (CAC) schemes proposed for cellular networks. Call admission control (CAC) schemes can be classified based upon the number of services/classes. Single-class call admission control (CAC) has been dominant in first and second generation (2G) wireless cellular networks when voice service was the main (and sometime the only) offered service. With the growing interest of data and multimedia services, single-class call admission control (CAC) schemes are no longer sufficient and as a result multiple-service/class call admission control (CAC) schemes are more relevant, especially in the enhanced second generation (2.5G) and third generations and beyond (3G/4G). The design of multiple-service/class call admission control (CAC) schemes is more challenging since some critical issues, such as service prioritization, fairness, and resource sharing policy, must be considered. Optimal call admission control (CAC) schemes are always preferred, but they are not necessarily attainable, particularly in realistic scenarios with a large problem size and complicated system parameter interdependence. As such, heuristics and intelligent techniques are widely used to find suboptimal call admission control (CAC) scheme. Call admission control (CAC) schemes can be classified as proactive (parameter based) or reactive (measurement based). In proactive call admission control (CAC) schemes, the incoming call is admitted/denied based on some predictive/analytical assessment of the quality-of-service (QoS) constraints. In reactive call admission control (CAC) schemes, the incoming call might start transmission (by transmitting some probing packets or using reduced power). Then the reactive call admission control (CAC) scheme decides to admit/reject the call based on the QoS measurements during the transmission attempt at the beginning[6,9,10].

Call admission control (CAC) can also be classified based on the information needed in the call admission control (CAC) process. Some CAC schemes use the cell occupancy information. This class of call admission control (CAC) schemes requires a model or some assumption for the cell occupancy. Alternatively, call admission control (CAC) schemes might use mobility information (or estimation) in making the admission decision. The use of mobility information, however, is more complicated and requires more signaling. The information granularity used in call admission control (CAC) schemes can be considered at the cell level or at the user level. If a uniform traffic model is assumed, information of one cell is enough to represent the whole network condition. In a non-uniform traffic model, however, information from different cells is required to model the network status, which increases the information size. The third case, in which information of each individual user is considered, of course leads to a huge information size. Call admission control (CAC) schemes have been designed either for the uplink or the downlink. In the uplink, transmit power constraint is more serious than in the downlink since the MS is battery operated. On the other hand, call admission control (CAC) in the downlink needs information feedback from MSs to the BSs for efficient resource utilization. Applying call admission control (CAC) for both links jointly is crucial since some calls might be admissible in one of the links and non-admissible in the other, particularly for asymmetrical traffic. Jeon and Jeong have proposed a joint call admission control (CAC) scheme for both the uplink and downlink. The call request is admitted only if it is admissible in both uplink and downlink. The asymmetry between uplink and downlink traffic, which is one of the characteristics of some multimedia services such as Web browsing, has been taken into account by adjusting the allocated bandwidth to each link in the call admission control (CAC) based on the traffic characteristics in each link[5,7].

It has been shown that this asymmetric allocation enhances resource utilization and other quality-of-service (QoS) parameters such as Pb and Phf. This work has been extended to investigate the same problem in CDMA networks. The impact of the bandwidth allocation between UL and DL on QoS parameters (Pb, Phf and outage probability (Pout)) has been analyzed using a SIR-based call admission control (CAC) scheme for voice and data (asymmetric) services. It has been shown that there is an optimum bandwidth allocation that minimizes the Pb, Phf and Pout[7].

CALL ADMISSION CONTROL ALGORITHM (CAC)



La- Accepted load
Le- Estimated Load

Fig 3. Flow Chart for CAC Algorithm[4,8]

In the CAC algorithm 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.

CALL ADMISSION CONTROL SCHEMES AND HANDOFF

PRIORITIZATION ALGORITHM

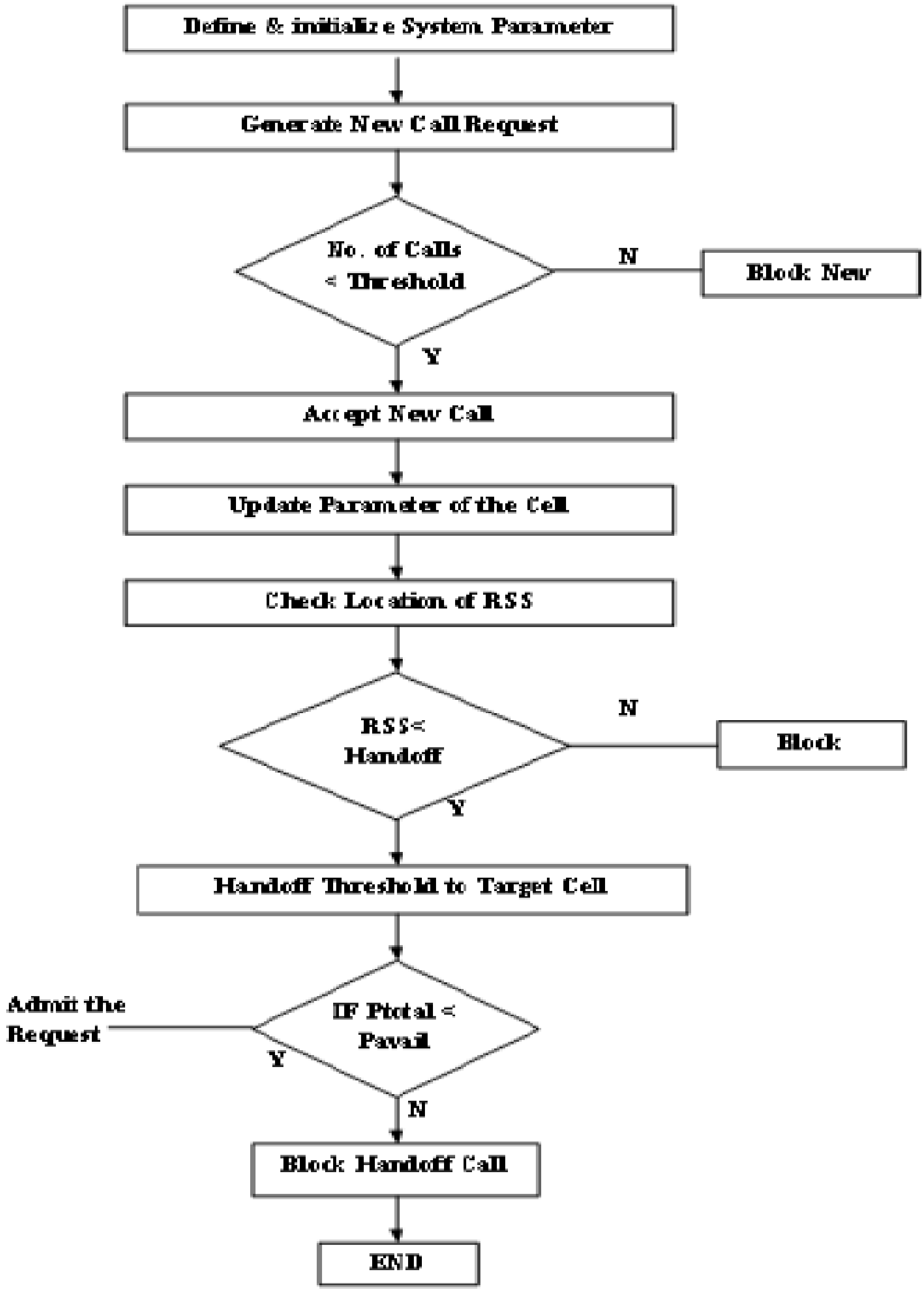


Fig. 3. Flow Chart for CAC Handoff Prioritization Algorithm

The Intelligent System to measure system parameters is developed in Matlab. The system will detect which type of multimedia request is in demand. The multimedia request can be audio, data, images or text. The system will then apply its parameters on the multimedia request. The system parameters are firstly throughput which is nothing but the measurement of the rate of data transfer through a network[7,8,10].

Secondly signal to noise ratio is the ratio which computes the minimum required power for the new user and accepts it if it is not below a predefined minimum link quality level. Thirdly bit error rate which is the frequency of errors that occur when bits are transmitted in a digital system. Fourthly response time which is the time taken by a system or to react to a given input. Then the new call request is generated and the request is send to the base station. The bandwidth of 3G is 3 GHz. The channels available for traffic management are three. The bandwidths divided between these three channels are for audio, it is 2 GHz, for text it is 0.5 GHz and for image it is 0.5 GHz. The allocation of resources to users will depend on the cell size.

PERFORMANCE CRITERIA

In this subsection, we identify some commonly used performance criteria for comparing CAC schemes. Although others exist, we will focus on the following criteria in this survey:

1) Efficiency: Efficiency refers to the achieved utilization level of network capacity given a specific set of QoS requirements.

2) Complexity: Shows the computational complexity of a CAC scheme for a given network configuration, mobility patterns, and traffic parameters.

3) Overhead: Refers to the signaling overhead induced by a CAC scheme on the fixed interconnection network among base stations.

4) Adaptivity: Defined as the ability of a CAC scheme to react to changing network conditions. Those CAC schemes, which are not adaptive, lead to poor resource utilization. Typically, CAC schemes make admission decisions based on some internal control parameters, e.g. reservation threshold, which should be recomputed if the load changes.

5) Stability: Stability is the CAC insensitivity to short term traffic fluctuations. If an adaptive CAC reacts too fast to any load change then it may lead to unstable control.

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)[6,11,12].

CONCLUSION

Call admission control is a very important measure in CDMA system to guarantee the quality of service(QoS) of the communicating links. The design of call admission control schemes/algorithms for mobile cellular wireless networks is especially challenging given the limited and highly variable resources, and the mobility of users encountered in such networks. In future wireless networks multimedia traffic will have different QoS requirement[7,12,13]. In this paper, we provided a survey of the major call admission control approaches and related issues for designing efficient schemes. Call admission control (CAC) is a key element in the provision of guaranteed quality of service (QoS) in cellular wireless networks. One of the key quality-of-service (QoS) measures in wireless cellular networks is the handoff voice call dropping probability as dropping a call-in-progress is generally not considered as acceptable or user-friendly. Handoff prioritization can improve handoff related system performance. Two basic handoff prioritization schemes, guard channels and queuing, are discussed.

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