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EVOLUTION OF CALL ADMISSION CONTROL SCHEMES IN WIRELESS NETWORK – A SURVEY

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Abstract –

The Next generation wireless networks (NGWN) will be heterogeneous which will able to have different radio access technologies (RATs) operating together. The Radio Resource Management (RRM) is one of the key challenges in NGWN. The Call admission control (CAC) mechanism is one of the Radio Resource Management technique plays most important role for ensuring the desired QoS to the users working on different applications which are having the diversified nature of QoS requirements to be fulfilled by the wireless networks. One of the key challenges to be addressed in this prevailing scenario is the distribution of the available channel capacity among the multiple traffic with different bandwidth requirements so as to guarantee the QoS requirements of the traffic. The call blocking probability is one of the QoS parameter for the wireless network and for better QoS it is desirable to reduce the call blocking probability. Provision of quality-of-service (QoS) guarantees is an important and challenging issue in the design of integrated services packet networks. Call admission control (CAC) is an integral part of the problem. Without call admission control, providing quality-of-service (QoS) guarantees will be impossible. The issue of call admission control is closely related to other aspects of a network, such as service models, scheduling disciplines, traffic characterization and QoS specification. Call admission control (CAC) with statistical quality-of-service (QoS) guarantees is a particularly important and challenging problem. One of the most important challenges is that of providing call admission control (CAC) for a heterogeneous mixture of applications which have differing quality-of-service (QoS) requirements. The advances in multimedia applications over a wide area network have directed considerable research into the quality of service. A comprehensive exposition of the specifications and management of quality of service (QoS) in wireless networks and in distributed computing systems, supporting multimedia applications, are important for both service providers and end users. This article is a survey to explore issues concerning the quality of service in the current and next generation wireless networks.

Keywords – Call admission control (CAC), Radio resource management (RRM), and Quality of service (QoS)

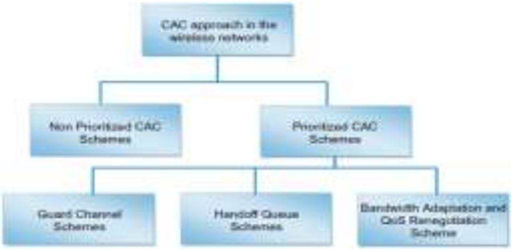
I INTRODUCTION

Call admission control (CAC) is a mechanism to provide quality-of-service (QoS) in a wireless network by restricting the access to network resources. An admission control is a technique which accepts a new call request provided there are adequate free resources to fulfill the quality-of-service (QoS) requirements of the new call request without violating the committed quality-of-service (QoS) of already accepted calls. There is a exchange 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. We assume that available bandwidth in each cell is channelized and focus on call-level quality-of-service (QoS) measures. Hence, the call blocking probability (Pb) and the call dropping probability (Pd) are the relevant terms quality-of-service (QoS) parameters.

Compared to wired networks, the fluctuation in resource accessibility in wireless networks is much more severe and it results from inherent features such as fading and mobility. The current and next generation wireless networks are expected to provide multimedia services with different QoS requirements. Since multimedia services having different traffic behaviors, their QoS requirements may also differ in terms of bandwidth, delay, and dropping probabilities. The radio resource management unit is responsible for the fair and efficient allocation of network resources among different users. The large demand for high capacity has put to the use of micro and pico sized cells. As a consequence, the handoff rate significantly increases and the handoff procedure becomes a more crucial issue for ensuring seamless connectivity and satisfactory QoS. Also from the user’s point of view, handoff attempt failure is less desirable in comparison to blocking a new call. Due to the limited resources in wireless multimedia systems, efficient call admission control schemes and resource reservation schemes are needed to maintain the desired QoS.

II CAC SCHEME CLASSIFICATION

CAC schemes can be classified into general categories primarily based either on the criteria considered in the decision part of the CAC scheme or on specific design characteristics. The admission criteria considered by CAC schemes are usually related to various QoS parameters. Moreover, CAC schemes can be divided into two categories, local and collaborative schemes. The local schemes have been proposed for homogeneous networks. This can be grouped into prioritized schemes and non prioritized schemes. In the non prioritized admission control scheme, all types of calls are equally considered; the scheme is like as first come, first served. A call is denied access only if there is no channel is available. In the prioritized admission control scheme, the policy is based on dropping lower bandwidth calls to serve handover or new call requests of a higher bandwidth class; therefore higher bandwidth calls have a higher priority. This prioritizing policy can be useful in a heterogeneous network where connections with a lower bandwidth requirement can be reallocated to a network, which optimized for a particular data rate and service provisioning and thus leave high-speed connections free for users which demanding high QoS. Following Fig. shows a classification diagram of the CAC algorithms.



CAC Classification

Non prioritized CAC schemes –

In heterogeneous wireless networks, interference poses important constraints regarding mainly to the signal quality. This situation has an effect not only on network conditions but it also on system capacity. In CDMA wireless networks, interference is the dominant role for affecting their performance in terms of capacity and QoS provision for the end users. Therefore, the SINR is an adequate measure of the signal quality. CDMA based air interfaces are mainly affected by interference which caused by other users from the same network instead of gaussian noise, so these effect is usually neglected, focusing mainly on SIR. Therefore, CAC schemes implemented for interference limited networks which employ as admission rules either the interference levels caused by a new incoming call or the signal quality levels achieved. Hence, interference-based CAC schemes admit new calls only if the SNR/SIR values can be maintain a threshold signal quality level. The SNR/SIR levels correspond to predefined QoS levels for new and ongoing users. This simple approach provides a tool to minimize interference in wireless networks, while on the other hand constitutes an efficient admission criterion. In NPS, the BS handles handoff calls in exactly the same way as new calls (i.e., handoff call is blocked immediately if no resources are available). All available resources in the BS are shared by handoff and new calls. However, the disadvantage of this scheme is that it is difficult to guarantee the required dropping probability of handoff calls.

Prioritized CAC schemes -

In these schemes preferential treatment is given to handoff calls, to avoid unwanted call blocking and handoff dropping while increasing channel utilization. Usually handoff calls are assigned higher priority than the new calls. These strategies falls into two categories: Handoff queue and Guard channel schemes.

Handoff queue schemes –

The principal idea of these schemes is that when resources become available, one of the calls in the handoff queue is served. If there are no available resources, call requests are queued until resources become available again. The HQ scheme needs a large of buffers to deal with real-time multimedia traffic and more sophisticated scheduling technique are needed to meet the QoS requirement for delay sensitive calls in order to guarantee that the queued data will not expire before they are transmitted.

Guard channel schemes –

The basic concept of GC-based admission control mechanism is to reserve resources in each cell a priori to deal with handoff requests. To get user's equipment continuous connectivity, the system reserves backup channels called as guard channels which give preferential treatment to priority calls and handoff calls. In such a system, call requests with lower priority are rejected if the number of available resources is less than a certain threshold. GC strategies differ in the number of guard channels which was chosen by a base station.

They are called fixed guard channel and dynamic guard channel, respectively. The fixed guard channel schemes reserve a fixed number of channels for handoff calls. In this scheme, only one traffic class was considered. The advantage of this scheme lies in the simplicity in terms of deployment, because there is no need to exchange control information between the base stations. However, with a small portion of handoff calls, GC schemes result not only in increased blocking probability of new calls, but it also in inefficient resource utilization, because only a few handoff calls are able to use the reserved channels exclusively. On the other hand, with a large number of handoff calls, it is difficult to guarantee the service requirements of the handoff call. All these schemes proposed above are static because such GC schemes cannot adapt to quick variation of the traffic pattern. Dynamic GC schemes, improve the system efficiency while providing the QoS guarantees to priority calls.

Bandwidth adaptation and QoS renegotiation scheme –

Wireless networks support a variety of services which can be classified into rate adaptive applications and constant bit rates (CBR) services. In such services, voice calls, a bandwidth increase beyond the standard requirement will not improve the respective QoS. In case of rate adaptive services, users can specify minimum and maximum bandwidth requirement, at their connection request stage. Apart from specifying the bandwidth range required by each service class, rate variations may originate from the dynamic nature of the wireless environment along with the mobility of user terminals. Thus, in advance wireless networks bandwidth adaptation algorithms are required to improve network utilization and guarantee the QoS of ongoing calls. When the network conditions are favorable and enough resources are available, they can be assigned to ongoing rate adaptive users according to two general strategies based on service class priorities. According to the first strategy, the available resources are fairly assigned to all ongoing users without considering any priorities. According to the second scheme, resources are first assigned to service class calls of high priority, until the resources are exhausted or all high priority service class calls have taken the maximum bandwidth required.

III CAC SURVEY OF DIFFERENT GENRATION

Call Admission control in 2G -

In [1], when a handoff occurs to a cell where there is not enough bandwidth, a channel currently being used is divided into two (equal size) sub channels: one to serve the existing calls that are currently using the channel, and the other to serve the handoff call. This scheme uses fixed-size sub channels, resulting in potential fragmentation and waste of bandwidth when a call rate does not match the bandwidth of the fixed-size channels. Further, this scheme does not apply admission control for guarantee QoS, and it uses information regarding neighboring cells. Such scheme only considers a single type of traffic (voice calls).

In [2], admission control for integrated voice and data traffic in packet radio networks is investigated. The admission control policy is based on a predetermined threshold value of either the mean delay or the packet loss probability for data traffic, and on the long-term blocking probability for voice traffic. This scheme does not reserve bandwidth in neighboring cells, and it does not adapt to variation in network conditions.

In the admission control scheme proposed in [3], different resource-sharing schemes are employed to allocate resources to different classes of traffic. Although this scheme is very interesting and useful, it does not consider reserving bandwidth in advance. It only considers a simple, Poisson traffic model.

A distributed admission control scheme is proposed in [4]. In this scheme, the admission control is based on both the number of existing connections in the cell where a connection request is generated and the number of connections in the adjacent cells. Call admission control process carried out at each base station in a distributed manner. Only a single traffic type is considered. Unlike the proposed scheme, this scheme does not reserve bandwidth, and is not adaptive to changes in network conditions. Therefore, the scheme proposed in [4] may not work well if the network carries diverse types of traffic with varying bandwidth requirements since the number of connections alone may not provide accurate information regarding the network traffic load.

In [5], an admission control based on dynamic channel assignment is proposed. In this scheme, network traffic conditions are first evaluated in the admission control stage, and then channels are assigned to new calls. Although this scheme is adaptive to changes in network conditions, it does not reserve bandwidth in neighboring cells. Therefore, this scheme risks an inability of meeting QoS requirements when handoff occurs.

In [6], a new admission control scheme is proposed to provide high degrees of QoS guarantees for multimedia traffic carried in microcellular, high-speed wireless networks. The proposed scheme combines call admission control and bandwidth reservation to guarantee QoS requirements. The proposed scheme considers both local information (the amount of unused bandwidth in the cell where the user is currently resides) and remote information (e.g., the amount of unused bandwidth in the neighboring cells) to determine whether to accept or reject a connection. Since a mobile user is free to move anywhere, an admission control scheme that relies solely on local information cannot guarantee QoS requirements of a connection throughout its lifetime. The proposed scheme thus uses both local and remote information, and allocates bandwidth in the cell where a connection request originates and reserves bandwidth in all neighboring cells. When a user moves to a new cell necessitating a call handoff, the reserved bandwidth in the cell that the user is moving into is used to support the handoff connection. In addition, every time a user moves to a new cell, bandwidth is reserved in the new neighboring cells, and the reserved bandwidth in the cells which are no longer neighboring to the new cell is released. Further, the proposed scheme distinguishes real-time traffic and non real-time traffic, and reduces the bandwidth assigned to non real-time connections to provide higher quality of service to real-time connections if necessary. The proposed scheme can also adjust the amount of reserved bandwidth based on the current network conditions. This is done by measuring the average connection-dropping probability (i.e., the probability that handoff connections are dropped due to lack of bandwidth) and the reserved bandwidth usage (i.e., how much of the reserved bandwidth is actually being used) and adjusting the amount of reserved bandwidth accordingly. Therefore, the proposed scheme adapts to various network load conditions. It is also noteworthy that the proposed scheme is performed in each base station in a distributed manner and that no central coordination is necessary.

Call Admission control in 3G -

A user's access to a cellular system consists of two stages; calls set up and call maintenance. During the call set up stage, the system has to decide if there is sufficient resource is available to accommodate the requesting user. Once the system grants access to the user, it enters the call maintenance stage during which it has the responsibility of the system to provide acceptable quality of service. The decision process to whether or not to grant access to a call request is called call admission control. A good admission control scheme should admit as many users as possible to maximize revenue of the system while maintaining the quality of service for ongoing calls.

In [7], Leong et al. proposed a call admission control (CAC) policy, where a limited fractional guard channel is used to reserve resources only for potential handoff calls to maintain service quality for admitted users. The voice and data users share cell capacity. The voice users have priority access to the cell capacity whereas time variant residue capacity is available for data services. The channel holding time distribution for data users depends upon the allocated bandwidth. The authors exploit the statistical multiplexing among on/off voice calls and between voice and data traffic for high resource utilization. However, the authors assumed that the overall system is homogeneous and in statistical equilibrium.

In [8], Epstein and Schwartz proposes, predictive QoS-based admission control algorithm. In this distributed call admission control algorithm, information is exchanged among neighboring cells for resource reservation and admission control, while the admission control decision is made locally. The maximum number of ongoing calls is estimated depending upon the new call blocking and handoff call dropping probability. However, this scheme has huge signaling overheads and did not guarantee high resource utilization.

In [9], Zhang et al. proposes an adaptive threshold-based call admission control algorithm where a new call is admitted if the available resource is greater than a threshold. Otherwise, it is rejected or queued. This algorithm adjusts the threshold dynamically. The scheme has fewer signals overhead than [8] but works successfully under moderate traffic condition only.

In [10], Fang and Zhang proposes, three call admission control strategies. In the first scheme, a new call will be blocked if the number of new calls in a cell exceeds a threshold. The handoff call is rejected only when all channels in the cell are busy. This scheme works well when the call arrivals are burst in nature. However when a big burst of calls arrive in a cell, the network may not be able to handle the resulting handoff traffic, which may lead to severe call dropping. In the second scheme proposed by the authors, a new call is accepted if the number of busy channels is less than a threshold. The handoff calls are always accepted if channels are available. This scheme works well if the average channel holding time of new and handoff calls is equal. Finally, the authors proposed a new call thinning scheme where a new call is admitted with certain probability. Thus, when the network is congested, the number of admitted new call reduces.

In [11], Wu et al. proposes a call admission control scheme, in this scheme each BS estimates the number of handoff calls for each class of traffic separately. Each BS uses such estimation to maintain a target handoff call dropping probability. But the implementation complexity of this scheme is very high due to probabilistic estimation for the potential number of handoff calls from neighboring cells.

Call admission control in 4G -

Efficient call admission control algorithm is required for 4G wireless networks due to the diverse QoS requirements for multimedia applications and the presence of different wireless access technologies. The call admission control algorithm must be able to handle vertical handoff. It must be able to accommodate different types of users and applications with different QoS requirements. The system utilization and QoS performance can be improved for multimedia applications by adjusting the bandwidth allocation depending on the state of the network and users QoS requirements. At both call-level and packet-level, QoS needs to be considered to design call admission control algorithms so that not only the call dropping and call blocking probabilities, but also the packet delay and packet dropping probabilities can be maintained at the target level.

In [12], Niyato and Hossain proposed a novel call admission control scheme for 4G wireless networks. This scheme is divided into two sub-modules, one for the wireless part and the other for the wired part. In the wireless part, the call admission control needs to handle multiple classes of calls as well as calls due to vertical handoff from other types of networks. If the call is used for data transfer, adaptive bandwidth allocation (ABA) can be applied to increase resource utilization. Moreover, call admission control in the wireless part must consider the nature of capacity (soft or hard) so that resource reservation and admission control can be performed optimally. The call admission control sub-module for the wired part and inter-network with the DiffServ domain is important to reduce the dropping probability for the packets already transmitted. Since the wireless resources are limited in the system, the call admission control sub-module in the wired part must ensure that the wired network can maintain the QoS of traffic from wireless users at the desired level. Both the call and packet levels performance requirements need to be satisfied in the wireless part. In the wired part, packet level QoS performance can be maintained through ABA and proper scheduling mechanisms, whereas the call level performance depends on the resource reservation and admission control strategy. However, in the wired part, only packet level QoS requirements need to be satisfied.

In [13], Song et al. proposed voice and interactive data service. The restricted access mechanism in [8] is used to share the total bandwidth between voice and data services in each network. The priority of voice traffic is considered higher than that of data traffic and occupies up to a certain amount of bandwidth to meet its strict QoS requirements. The remaining bandwidth is dedicated only for data traffic. Moreover, to achieve higher resource utilization, all unused bandwidth is shared equally by ongoing data flows. The number of admitted data calls is restricted to satisfy the mean data transfer time. The voice calls are admitted with a preference to the cellular network to minimize the impact of latency and processing overhead by frequent vertical handoff. On the other hand, data traffic has a better rate adaptation capability. The data calls are admitted to the WLAN and because of the larger bandwidth of WLAN, transmission of the data packets will finish sooner, consuming the allocated resources for less time.

In [14], proposed a dynamic resource management scheme for next generation all-IP wireless network, this scheme uses route selection algorithm, route modification algorithm and network initiated vertical handoff algorithm for the selection of most appropriate route for the transmission or reception of data packets which will help to perform load balancing, to maximize battery power life time of a mobile node, to minimizing power consumption, system delay and loss of packet and lastly to maximize the throughput of the network.

In [15], a novel resource allocation scheme is proposed to retain throughput of mobile users during mobility. The scheme divides the coverage area into smaller concentric regions R1, R2 and R3 where each of the regions uses a fixed Adaptive Modulation and Coding (AMC) scheme. It reserves resources for new calls and RT calls in migration by limiting number of calls. The remaining resources are fairly shared among NRT calls. This scheme ensures each mobile user accepted by the system maintains its throughput. However, it increases call blocking and dropping probabilities when the number of limited calls is high.

In [16], a Preemption and Congestion Control scheme is proposed for reducing call blocking and dropping. This scheme first arranges the bearers according to priority. Then, the bearers with the lowest priorities are fully preempted one at a time by employing load reduction technique to get targeted resources. This scheme significantly improves the dropping and blocking probabilities but is unfair means because lower priorities bearers may be fully preempted while others are still over provisioned.

In [17], a fairness-based preemption scheme is proposed to provide fairness to lowest priority bearers. The scheme operates in two phases: partial and full. In partial preemption, this scheme adopts a form of Cobb-Douglas production function by utilizing factors a and b as tuning factors to achieve a contributing metric (target load) which represent the priorities and extra allocated resources, respectively. While in full preemption, the preempt able calls are completely preempted one by one from the lowest to highest till the target load is to obtained. This scheme improves fairness on the lowest priority bearers but wastage of resources due to unused preempted resources.

In [18], An Efficient Call Admission Control Scheme is proposed to increase utilization of resources and decrease the call dropping probability. This scheme classifies calls into HC and NC. The scheme accept HCs based on latency and resource blocks availability. While NCs are also accepted based on latency and resource blocks availability and if the length of HC queues is less than the threshold size of its queue. This scheme performs well in terms of dropping probabilities and resource utilization ratio. However, the NCs suffer from an increase in NCBP when threshold size of HC queue is large.

In [19], a Delay Aware and User Categorizations Adaptive Resource Reservation-based Call Admission Control (DAUCARR-CAC) is proposed to increase utilization of network resource. The DA-UCARR- CAC classifies users into Gold and Silver and flows to RT and NRT, which transforms into four types of bearers namely: Golden users with real-time flows (G-RT), Silver users with real time flows (S-RT), Golden users with non-real time flows (G-NRT) and Silver users with non-real time flows (SNRT) bearers and reserves virtually predefined RBs for each class. It accepts request if the resources required are less than the available RBs otherwise it accept the requests into a queue if resources are in sufficient. The queued requests are accepted according to their computed AP when RBs are available. This scheme utilizes available RBs, delay tolerance, user categorization and flow type to evaluate the AP of a request. This scheme achieves a better balance between system utilization and QoS provisioning but calls with highest AP experience a higher blocking probability.

In [20], a Hybrid Call Admission Control (HCAC) Scheme is proposed to reduce the handoff dropping probability. The HCAC employs the resource block strategy to allocate resources based on call type. This scheme determines the maximum number of RBs required (RBmax), minimum number of RBs required (RBmin) , number of required RBs (RBreq) and tolerable maximum delay (Dmax_i). The new and handoff RT calls are accepted based on RBreq and its latency otherwise the calls are denied if they exceed Dmax_i. Similarly, the new NRT call is accepted based on its RBreq while the handoff NRT is accepted based on its RBmin otherwise the call is denied if it exceeds its Dmax_i. The scheme reduces the call dropping probability. However, it has large new call blocking probability when large number of users.

In [21], a Connection Admission Control and RBs reservation scheme is proposed to minimize call dropping probability. This scheme employs RB reservation algorithm to allocate the maximum number of RBs to all calls when possible. And if the cell is over-loaded, few of the calls in the cell might receive RBs lower than the requested RBs. It degrades NC with largest allocated resources allocated resources and lower priority (NRT) calls to minimum RB required admitting HC when resources are insufficient. Similarly, this scheme admits NC which has not exceeds its latency by degrading NRT calls. This scheme denied both HC and NC calls if resources obtained from degradation are insufficient. This scheme reduces handoff dropping probability, and maintains lower new call blocking probabilities and ensures efficient resource utilization. However, this scheme unlike because of NRT calls degradation.

In [22], a Fair Intelligent Admission Control scheme (FIAC) is proposed for ensuring fair bandwidth allocation among different priority of classes and the flows among at the same priority level. The LTE-FIAC scheme employs complete sharing to share the common pool of available resources to multiple class users. It uses virtual portioning to differentiate among multiclass users. It utilizes a stepwise degradation technique to degrade calls of lower priority to GBR using the Allocation and Retention Priority (ARP) index when resources are insufficient. This scheme achieves a lower call blocking probability and guarantees fair share of bandwidth. However, this scheme increases blocking probability. But, it may experience QoS degradation during call when channel fluctuate.

In [23], a call admission control with reservation scheme is proposed for minimizing call QoS degradation. This scheme classified in terms of two types of traffic namely narrow band and wide band applications. It reserves extra needed resources at the time of admission to maintain call QoS in case of channel condition change due to mobility. This scheme enhances QoS but it wastage resources when the reserved resources are unused.

In [24], a Downlink Call Admission Control scheme with Look-Ahead Calls is proposed to handle advance resource utilization. This scheme classifies requests in terms of new immediate calls, handoff calls and advance calls. It accepts first a new immediate call if the sum of the new call and the aggregated ongoing calls are below the new call capacity threshold, otherwise the call is denied. Then it accepts the handoff calls if the sum of the handoff calls and the ongoing calls are below the handoff calls threshold, and then the calls are queued. Whenever an occupied sub channel is released, the first handoff call in queue is accepted to the network. If more than one handoff call is waiting in the queue, then the handoff calls are served in according to FIFO discipline. Finally, this scheme uses a control factor called book-ahead time to identify the advanced calls. A minimum book-ahead time differentiates new immediate calls from advanced calls while calls above the maximum book-ahead time are rejected. It accepts new advanced call if the sum of the new advanced call and the total advanced calls are below the advanced call threshold; otherwise the new advanced call is denied. Calls above the maximum book-ahead time are denied. This scheme utilizes resources efficiently but experiences an increasing call blocking probability under high offered load.

In [25], an extensive dynamic bandwidth adaption CAC is proposed to reduce call dropping which ensure QoS. This scheme employs a load balancing technique to prioritize HCs over NCs. It uses a Dynamic Bandwidth Adaptation (DBA) method to predict the resources to reserve based on behavior of call history. The DBA utilizes arrival and departure to arrange NRT calls in descending order and assign large number of resources to RT users for ensuring system utilization and user satisfaction respectively. This scheme degrades ongoing NRT call to serve the RT new and handoff calls when resources are insufficient. This scheme achieves a low new call blocking probability, reduces call dropping and improves resource utilization but is unfair to NRT calls due to degradation.

In [26], an Adaptive Connection Admission Control is proposed for heterogeneous network. This scheme adaptively adjust transmission guard interval with respect to the QoS requirements to give high priority to RT call approaching deadline. It assigns resources to RT call based on QoS. This scheme accepts NRT calls in the absence of handover calls and in presence of low network load. This scheme maintains a low call blocking ratio of the ongoing calls of different classes under small number of users. However, this scheme is unfair because NRT calls may be degraded during temporary overload to admit handover calls.

In [27], a Priority-Scaled (PS) Preemption Handling Scheme is proposed for ensuring fairness to low priority preempt able active bearers (LP PABs). This scheme evaluates the amount of resource needed by reconfiguring all LP PABs to minimum QoS (*R-Min*) or by total preemption of all LP PABs (*R-Total*). This scheme executes Priority-Scaled (PS) Minimum QoS Preemption Algorithm (PS-MQPA) if R-Min can satisfy a request and runs Total Preemption Algorithm (TPA), if R-Min is insufficient but R-Total can satisfy the request. It denied a request if R-Total is insufficient. The PS preemption handling scheme minimizes call dropping of LP PABs. However, the LP PABs suffers from high dropping rate due to preemption under large number of higher priority requests.

In [28], This CAC algorithm for high speed vehicular communication systems is proposed to minimize call blocking and call dropping. This scheme employs throughput estimation to evaluate the required resources by users. It accepts a call when the requested resources are equal or less than the available resources. Otherwise the call will denied when the required resources are greater than the available resources. Then, this scheme reserves the available resources for subsequent call. The subsequent call is accepted if the required resources are less than or equal to the total available resources (reserved resources and available resources) else the call will be denied. This scheme reduces the call dropping and call locking probabilities but it has poor resource utilization due to the reserved resources may not be fully used.

In [29], Resource Estimated Call Admission Control (RECAC) scheme is proposed to guarantee QoS. The RECAC utilizes the type of service request, modulation and coding schemes (MCS) and physical resource block (PRB) usage of the ongoing calls to evaluate the PRBs requirement to a call request. It accepts a call when the total number of available PRBs is more than the requested PRBs else a call will denied. This scheme improves resource utilization and guarantees QoS. However, this scheme has a higher call dropping probability due to insufficient resources required by modulation and coding schemes (MCS) at the time call request.

In [30], an Adaptive call admission control is proposed to reduce call dropping probability and guarantee of QoS. This scheme employs an adaptive resource reservation algorithm that gives a threshold resources block for each class of service. These thresholds are dynamically tuned with the cell state and level of the blocking calls type to prioritize between different classes of service. This scheme admits HCs then NCs. and put NCs in a queue when resources are insufficient. It serves NCs based on their latency. In addition, this scheme degrades NCs with largest allocated bandwidth greater than their minimum required resources and the lowest priority NRT to their minimum required resources under insufficient resources in order to accept HC.

In [31], a Delay-Aware CAC scheme (DA-CAC) is proposed to provide QoS for different services. The DA-CAC employs a moving window average method to compute two thresholds level (TH1 and TH2) using packet delay information and PRB utilization. This scheme accepts a call when its service arrival time is less than or equal to TH1 and rejects the call when its service arrival time is greater than or equal to TH2. Similarly, when the service arrival time is greater than TH1 and less than TH2, then this scheme accepts the call if the call is a HC and denied if the call is NC to prevent network congestion. The DA-CAC scheme guarantees QoS for various types of services. However, this scheme experiences high new call blocking probability and poor resource utilization due to call rejection to prevent network congestion.

In [32], an adaptive CAC scheme based on higher order Markov chains was proposed to handle call blocking probability. This scheme formulates the resource allocation problem as a Markov chain model and uses the PRB allocation algorithm to adjust the allocation of resources. It dynamically reserves resources for HCs based on traffic condition and uses remaining resources to accept all calls. This scheme degrades low priority calls when the system is overloaded to accept more number of calls. This scheme reduces call blocking probability for each class of traffic and ensures network resource utilization. However, it is unfair to calls with low priority due to degradation employed.

In [33], a utility based scheduling and CAC scheme (UBS-CAC) is proposed to allocate resources based on utility function. The UBS-CAC scheme classifies calls as RT and NRT and evaluates channel quality based on RSS. It calculates utility function according to channel condition when allocating resources. This scheme accepts RT and NRT calls based on traffic density and tolerance limit, respectively. It degrades resources of calls with bad channel to accept more number of calls. This scheme reduces HCDP and improves resource utilization but unfair to calls with bad channel condition.

In [34], an Adaptive Call Admission Control with Bandwidth Reservation scheme is proposed to avoid starvation of user traffic and enhance resource utilization. This scheme introduces an adaptive threshold value, which is dynamically adjusted according to the traffic intensity. It also employs degradation mode to accept more number of users into a network when resources are insufficient. This scheme prevents starvation of low priority calls and improves efficient resource utilization. However, it wastes network resources due to fixed degradation mechanism applied. In addition, the scheme has poor QoS to delay sensitive applications due to it uses only bandwidth for admitting connections into a network.

Next Generation CAC in 5G -

In heterogeneous wireless networks, mobile users will be able to communicate through any of the available radio access technologies and to roam from one RAT to another, using multiple modes of terminals. In the prevailing scenario the collaborative admission control decision should be based on multiple criteria such that the optimization user satisfaction level and choosing of optimal RAT is achieved.

In [35], this CAC scheme is based on the IEEE 802.21 Media Independent Handover (MIH), to seamlessly hand over mobile users between heterogeneous wireless networks for load balancing purpose. This network involves call admission control technique and a handoff scheme to maximize system reward for network providers and to guarantee QoS-aware seamless handoff for mobile users. The load balancing strategies are required to efficiently utilize the available radio resources and avoid the unwanted congestion due to overloaded wireless networks. Such schemes should control the accessibility of users between available networks based on current loads, predicted traffic profiles and the optimality of a network connection to a particular service request.

In [36], for heterogeneous networks, a joint call admission control (J-CAC) algorithm is required to decide whether a call will be accepted or not, and to select the most appropriate RAT for each admitted call. This J-CAC scheme is envisioned as user-centric in that user's preferences are considered in decision making for RAT selection.

Moreover, lots of literature has been dedicated to the signal to interference ratio (SIR) based call admission control algorithms in the heterogeneous networks [37]. The concept of residual capacity is introduced as the additional number of calls a base station can accept such that the system wide outage probability will be guaranteed to remain below a certain level. This residual capacity is dynamically updated at each cell according to the reverse link SIR measurements at each base station.

In [38], this paper presents a fuzzy logic-based CAC scheme using preemption in 5G C-RAN. The fuzzy logic avoids uncertainties caused in traditional CAC schemes in distributed RAN systems. A cloud bursting technique is proposed where low priority delay tolerant NRT connections are preempted during congestion and outsourced to a public cloud at a certain price of penalty to accommodate the RT connections. It is assumed that the public cloud is of infinite processing capacity as such it cannot get congested; as such it will not be captured in the simulation.

At present, the majority classes of traffic offloading studies, such as licensed assisted access (LAA), LTE in the unlicensed band (LTE-U), and LWA, are focusing on the use of unlicensed spectrum to leverage an overloaded LTE network with its free and abundant bands. However, the unlicensed bands below 6 GHz are already crowded by WLAN user equipment units (UEs). When other coexisting technologies along with LWA come into action, it will be more congested. For incumbent WLAN UEs, the network will be highly congested and it will waste most of its time in contending for the channel. On the other hand, LWA UEs face high latency due to bottlenecks at WLAN APs. Therefore, these conditions lead to performance degradation for both standards, hurting system-level quality of service (QoS). So that, LWA should wisely consider steering the UEs' traffic, scrutinizing network loads, and improving WLAN utilization when it is available and not congested. Moreover, LWA should contribute for increasing the intra-cellular fairness between UEs. This means that the LWA opportunities must be given to UEs that makes the best use of it (proportional fairness). Inspired by the above challenges with LWA, we present a framework of mode selection for LWA-preferred UEs, taking into account the QoS of both WLAN and LTE UEs.

In [39], proposed algorithm, for smartly assigning LWA service to needy UEs, and guarantees an enhanced user experience for LWA UEs without degrading the QoS of existing WLAN UEs. In addition with, this algorithm contributes for maximizing network throughput and performance.

IV CONCLUSION

Call admission control is a most important measure unit for next generation wireless system for ensuring guarantee of quality of the communicating links. The designing of new call admission control schemes/algorithms for a mobile cellular wireless networks are especially challenging for the limited and highly variable resources, and the mobility of users encountered in such networks.

In next generation wireless networks, multimedia traffic will have different QoS requirements. In this paper, we provided extensive survey on most of the major call admission control approaches and related issues for designing highly 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.

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