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Call admission control approaches in beyond 3G networks using multi criteria decision making

Ramesh Babu H.S.[1], Gowrishankar[2], Satyanarayana P.S[2]
[1]*Acharya Institute of Technology, Bangalore, INDIA*
[2]*B.M.S. College of Engineering, Bangalore, INDIA*
{rameshbabu@acharya.edu.in, gowrishankar.cse@bmsce.ac.in, pss.ece@bmsce.ac.in}

Abstract - **The next generation wireless networks (NGWN) should cater the varied requirements of the user and applications. The Call admission Control (CAC) is one of the radio resource management (RRM) technique used in the wireless networks. Unlike the CAC in homogeneous wireless networks the CAC in next generation wireless networks is very complex. In the next generation heterogeneous wireless networks, a user with a multi-interface terminal may have network access to different service providers using various technologies. This makes call admission control a challenging task where single criteria based CAC algorithms may not be able handle the decision making process efficiently, to address the heterogeneous architectures which characterize next generation wireless network, it is apparent that the call admission control algorithms should be based on multiple criteria. Various approaches have been proposed to solve the call admission control decision problem using multi criteria decision making (MCDM). This article provides a comprehensive survey of the different approaches for Call admission control using multi criteria decision making (MCDM) for incoming calls in heterogeneous wireless networks. The advantages and disadvantages of each approach are discussed.**

Keywords– **Next generation wireless networks, CAC, MCDM,**

I. INTRODUCTION

It is envisaged that the next generation wireless networks (NGWN) will have heterogeneous Radio access technologies (RAT) Coexists. The mobile terminals with multi interface capabilities to provide high bandwidth access anytime and anywhere for the multimedia applications with different quality of service(QoS) requirements in the presence of diversified wireless access technologies like 3G cellular, WLAN, Bluetooth etc. In such type of networks the users on the move is allowed to enjoy seamless wireless services, irrespective of the geographical location, speed and the time. In this complex scenario The radio resource management, specifically Call admission control, plays a very crucial role in such wireless heterogeneous networks carrying multimedia traffic with different QoS requirements .It is evident that the Next generation networks are user - centric, efficient call admission control is required that has vital role in satisfying the user or application QoS requirements .Call admission control policies denotes the Process of making a decision of whether a call should be either accepted or rejected at the base station and assign the required channel to the admitted call based on the available resources versus 'QoS requirements of the user, and the effect on the already admitted calls in the network. Whenever a new call or and handoff call arrives at the base station (BS), The RRM systems has to make a decision of accepting the Call in to the system or rejecting the call. An algorithm that makes these decisions is called CAC algorithm [1].

Call admission control has been extensively studied for both wired and homogeneous networks [2-4]. The homogeneous architectures are incompetent to provide single solution to heterogeneous network architectures of beyond third generation networks (B3G) [5].this limitation of the traditional CAC algorithms has motivated for development of joint call admission control (JCAC) algorithms for NGWN. JCAC is one of the Joint radio resource management (JRRM) technique used in beyond 3G networks.

The traditional CAC for homogeneous networks are responsible for determining whether the mobile terminal may be admitted into the networks or not. In the heterogeneous networks that characterize next generation networks, the JCAC is additionally responsible for deciding which radio access network is best suited to accommodate the incoming user's QoS requirements[6, 7].

The basic motivation for heterogeneous wireless networks has started from the fact that no single RAT can provide the ubiquitous coverage and constant high QoS level across the network [8].This scenario of coexisting RATs different which vary in service, coverage, bandwidth etc forming the heterogeneous networks require to use Joint radio recourse management (JRRM) to provide the best of the QoS for the users of the NGWN. The CAC Algorithm based on single criteria process may not be able to make best CAC decision in NGWN, so with multiple criteria decision making the CAC would be able enhance the user satisfaction and the selection of RAT. The rest of the paper is organized as follows. The next section discusses the traditional CAC using single criteria .The Challenges in NGWN and JCAC using MCDM and the various works reported are discussed in section 3 and the proposed model neural network based CAC using MCDM model is discussed in section 4.The section 5 makes concluding remarks with direction of our future work .

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II.TRADITIONAL CAC ALGORITHMS

The different conventional approaches of CAC are guard channel CAC, collaborative CAC, non collaborative CAC, mobility based CAC, and pricing based CAC.

In the guard channel approach, The handoff calls are prioritized over new calls, some channels are reserved for handoff calls [9].In this approach, the total number of available channels C and C-K is the number of guard channels, a new call is accepted only when total number of busy channels is less than the threshold K, on the other hand the hand off calls are always assigned a channel if there is an available channel. In this method the threshold value should be such a way that the handoff dropping probability should be minimum and the system should accept as many new users as possible.

The guard channels approach even though simple to implement with static threshold it proves to be inefficient lack of adaptability to the current state of the network. This problem was solved by Fractional guard channel CAC [10]. In this scheme the incoming call is accepted based on certain probability that depends on the numbers of busy channels. The reservation of channel is adaptable.

The second scheme is Collaborative approach based CAC. In this method the admission control is made locally but the information exchange happens between the neighboring cell for resource reservation and admission control. The collaborative approach based CAC is proposed in [11].The estimation of call dropping and call blocking probability is given as follows.

$$Phd = \frac{1}{2} erfc\left(\frac{N-\overline{m}}{\sigma}\right) \qquad (1)$$

The number of calls in the home cell, respectively where $P_{hd\ is}$ the target call dropping probability, and $\overline{m}$ denote the mean and variance σ. The mean and variances are approximated from the number of users in the home cell and neighboring cells. The call blocking probability $P_{nb}(t)$ during time interval $t-1$ to t is estimated locally as follows

$$Pnb(t) = (1-\omega)Pnb(t-1) + \omega\frac{s(t)}{r(t)} \qquad (2)$$

The s (t) and r (t) represents the number of blocked class and the number of calls arrived during the time interval t-1 to t respectively. The ω is the weighted moving average. The decision of accepting the incoming calls is made based on equation 1 and 2.

The non collaborative approach based on prediction solves the problem of collaborative schemes by localizing the CAC which makes the resource reservation is only on local information of the home cell which is used to predict the networks resources required in near future [12].

The mobility based approaches works based on user mobility information. In the microcellular wireless network the user mobility was used for CAC which is termed as *shadow clustering*. Even though this scheme is efficient, the calculation of the incoming traffic for a particular cell would be nontrivial. The exchange of real-time information or message among the cells would a huge communication operating cost

The last method is prizing based approach proposed in [13]. The goal is to increase the resource utilization in the network. Utility is the user's level of satisfaction with perceived QoS. The utility is decreasing function of handoff calling probability (*Phd*) and new call blocking (*Pnb*). Though the utility is increased the revenue to the network operator is not increased. It is apparent that to increase the user satisfaction more resources have to be allotted. To revenue is maximized by allocating resources to more number of users by decreasing the amount of resources to each user. The CAC algorithm is to be designed to meet the optimal operating point. In [13] based on the optimal call arrival rate, the pricing was developed. The prizing is charged based on the stat of the network into account. If the network is congested the peak hour charge is levied which is normally higher than the regular hour price.

III. CAC IN NEXT GENERATION WIRELESS NETWORKS

The varied QoS requirements of multimedia applications and the coexistence of different RATs, facade major challenges in designing CAC algorithms for next generation heterogeneous wireless networks. The challenges are heterogeneous networking, multiple service classes, flexible in bandwidth allocation and cross layer issues based design.

A. Heterogeneous networking

4G networks will have different types of RATs different from each other by air interface technology, cell size, services, price, access method, coverage, so CAC schemes must be able to handle new type of handoff called vertical handoff.

B. multiple service classes

The B3G networks should be able to accommodate the applications and user with different QoS requirements, so the CAC algorithms should be designed handle different classes of service meet the QoS needs of all types of applications.

C. flexible in bandwidth allocation

The diversity in multimedia applications and mobile users QoS requirements in NGWN, The resource utilization and QoS performance can be improved by adaptive bandwidth allocation. This clearly indicates that the CAC should be designed taking into consideration the flexible bandwidth allocation, where, more resources can be allocated when the there is less traffic and the allocated bandwidth can be revoked when there is congestion.

D. Cross layer issues based design.

The traditional CAC schemes were based on the call level QoS only and few of them have considered the physical layer QoS like SIR as QoS criteria. Unlike the tradition voice oriented circuit switched network t , the next generation network predicted to be pure packet based network , the QoS needs to be addressed both at call level as well as at packet level. This mandates that the new call has to be admitted only if both call level QoS metrics like call blocking and dropping probabilities and the packet level QoS measures like packet transmission delay and packet dropping probability are maintained at some desired levels.

IV.CALL ADMISSION CONTROL ALGORITHMS USING MCDM

The multi criteria decision making system is an optimization technique used to analyze the contradicting decision making parameters. The MCDM based decision making systems are generally used in the fields o reliability, financial analysis, social and political related analysis and environmental impact analysis etc.

The NGWN has different RATs coexisting which are with different capabilities and they should cater the varied QoS requirements of multimedia applications admission control with single criteria mat be too trivial, in this prevailing scenario the admission control decision should be based on Multi criteria such that the optimization user satisfaction and selection of optimal RAT is achieved.

There are several algorithms proposed on handling the admission control decision making using MCDM in heterogeneous wireless networks. This section discuss the Different admission control algorithms based on multiple criteria. We can categorize the CAC schemes as *Utility – function based CAC* and *computation Intelligence CAC.*

In the Utility function based CAC the incoming calls are admitted based on some utility or cost function based on multiple criteria. These algorithms are very optimal algorithms and in most of the case are complex in nature and pose high computational overhead.

Chen et al. [15] propose a network selection and radio resource allocation algorithm for heterogeneous wireless networks. The algorithm is based on a concept called arbitration probability, which indicates the willingness of a data user to use a network's resources. Arbitration probability is calculated for each available network using relative link quality, user's satisfaction on quality of service, and monetary cost. It is assumed that each network broadcasts it access bandwidth value to users. After calculating the arbitration probability for each network, a user can decide which network is most suitable for his/her service. The proposed algorithm is user-centric but not optimal algorithm. The algorithms uses predictive based Design consideration. It belongs to the Initial RAT selection CAC algorithm which is designed to make decision of RAT selection for new calls.

Ormond et al. [14] propose a utility-based algorithm that accounts for user time constraints, estimates complete file delivery time (for each available access network), and then selects the most promising access network based on consumer surplus (CS) difference. The algorithm is designed for non-real-time services. It is assumed that every user has a patience limit with a threshold value for the duration the user is willing to wait for the complete transfer of his/her data. Beyond this threshold, the user becomes dissatisfied and unwilling to pay any money for the file delivery. In the proposed scheme, a multi-mode mobile terminal initiating a call will survey the radio interfaces and determine a list of available access networks. This indicates that the proposed algorithm is user- centric which enhances the user satisfaction and is very suitable for next generation wireless networks.It works on Initial RAT selection principle, and uses predictive design consideration.

Karabudak et al. [16] propose a cost function based JCAC algorithm incorporating genetic algorithms. The objective of the algorithm is to maximize wireless network utilization, meet mobile user QoS requirements, and reduce handoff delay. In the proposed algorithm, all the parameters that affect handoff process in each network such as signaling (Sig), switching (Sw), power consumption (Pw), and bandwidth (Bw) are fed into a cost function. The cost function is as follows:

$$(Real\ Cost)_N = F\,(Sig_N, Sw_N, Pw_N, Bw_N) \qquad (3)$$

Where $(Real\ Cost)_N$ is the cost of handoff in RAT N, and Sig_N, Sw_N, Pw_N, Bw_N represent *Sig, Sw, Pw, Bw* in RAT N, respectively.

The proposed algorithm is not user-centric, and not optimal but easy to implement. The algorithms uses prediction based design consideration for the CAC. The predictive based algorithms integrate prediction techniques in selecting the most suitable RAT for a new or handoff calls. The predictive CAC algorithms are more efficient but are more prone to error. The performance of such algorithms depends on accuracy of the predicted information.

The computation intelligence based CAC algorithms makes the decision of Call admission for a new call or and handoff call by applying computational intelligence technique based on multiple criteria. the commonly used intelligent techniques are fuzzy logic, fuzzy neural,

genetic algorithms fuzzy MADM(multi attribute decision making. Computational–intelligence methods are highly efficient but complex to implement. Some of the proposed works on computational intelligence are as follows.

Guo et al. [17] propose a fuzzy multiple-objective decision based JCAC algorithm for heterogeneous cellular network, where the algorithm is design to select RATs for handoff calls. It uses cell type, data rate (Mbps), coverage (m), transmission delay (s), and call arrival rate, as RAT evaluation criteria. It also uses weight vectors allocated according to the traffic class of the incoming call. A fuzzy multiple-objective decision is then applied to select the optimal cell from all candidate networks. Zhang et al. [18] proposes an approach, which uses fuzzy logic to represent the imprecise information of some attributes. The fuzzy MADM method operates in two steps. The first step is to convert the imprecise fuzzy variables to crisp numbers. The second step is to use classical MADM technique to determine the ranking order of the candidate networks.

The highest-ranking RAT is then selected for the call. The proposed algorithms are User-centric sub optimal and non predictive design based. The non predictive algorithms do not incorporate prediction technique. They perform the admission control based on the available information. These are less prone to error but not efficient as predictive based algorithms

In [17], Chan et al. present a RAT selection algorithm based on the concept of fuzzy multiple objective decision making (MODM). Seven example criteria are used in the algorithm namely, signal strength, bandwidth, charging model, reliability, latency, battery status and the user's preferred segment. The purpose of the RAT selection algorithm is to select the most suitable RAT for requirements in cellular networks, particular service class based of the criteria mentioned above. This is one of the example in which it uses both initial RAT selection and handoff RAT selection.

Wilson et al. [19] propose a decision strategy for making the optimal choice of wireless access networks. They use fuzzy logic as the inference mechanism and develop a prototype, which uses two metrics from a candidate network, a metric from application requirements, and user defined criteria as input. The algorithm uses both types of RAT selection.

V.CONCLUSION AND FUTURE WORK

This paper reviews Call admission control algorithms for next generation heterogeneous networks. We have discussed the motivation for using JCAC algorithms in NGWN. We have discussed the different conventional CAC algorithms. The challenge posed by the Next generation heterogeneous wireless networks makes it very difficult to meet the user's requirements therefore multi criteria decision making for CAC will be more appropriate than using single criteria CAC. The advantages and disadvantages of different MCDM based CAC algorithms were discussed. Currently we are working on the artificial neural network (ANN) based MCDM for joint call admission control in beyond 3g wireless networks. In the proposed work we are using artificial neural networks as a decision making tool in making decision of joint call admission control.

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