Bacterial foraging optimization supported utility based call admission control framework for 3GPP LTE networks

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Abstract: In this paper, we present a new design of optimal utility based call admission control framework using Bacterial Foraging Optimization. With the aim of ensure the Quality of Service (QoS) and to reduce the performance degradation in call admission process the utility based scheduling call admission process is optimized. In the proposed algorithm, The foraging behavior of bacteria is considered as user call requests in the call admission process and the available resources is considered as gradients of the chemicals in the environment. Locomotion mechanisms of the bacteria in the environment are considered as the mobility of the nodes in the environment. The information processing strategy and the quality policies are defined as the perception of food and the motivation of move in the environment. The optimization can be achieved through the series of processes on the stimulated cells. The call admission decision and the rescheduling process are based the channel state of network. The utility function of each call request is evaluated based on the Received Signal Strength (RSS), throughput of the network and set of subscribers participated in the call admission process. Our simulation results shows the performance enhancement and optimization using the bacterial foraging optimization with parameters like throughput, fairness, and delay for real time and non real call request. The QoS parameters are evaluated and the proposed method shows reduction in call dropping probability and call acceptance rate is also increased.
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Keywords: Bacterial foraging optimization, Quality of Service, Long Term Evolution, Utility Factor, Received Signal Strength.

1. Introduction

LTE is a base for the 4G networks (Super 3G), designed to facilitate high speed data transmission for mobile devices and data terminals. The standard for LTE is developed by 3GPP organization in Release 8 (Rel.8) and the enhancements are specified in Release 9 (Rel.9).the main objective of LTE is to provide better Quality of Service (QoS) with highest user demand for highest data rates. It is developed based on UMTS/HSPA network technologies, optimized to provide higher data rate. As per LTE's specifications the downlink data rate is 300 Mbps and uplink data rate is 75Mbps with the latency of 5ms [1].

Call admission control in LTE networks

Call admission control is a process of ensure and maintain certain level of the Quality of Service(QoS) for real time and non real time call requests in the network. The main objective of CAC is to maintain the efficient resource allocation and to monitor the resource utilization in the high volume of traffic. CAC manages the total bandwidth with respect to number of call request available in the base station. The call requests are classified into new call or handoff call and real time or non real time call request. CAC allocates signal strength for eNB with a minimum threshold value, when an eNB's signal strength reaches below this threshold value the call request will be blocked. [2] The available resources in the base station are distributed to the available UE's in the network with maximum and minimum threshold value. When a call request received by the base station the initial status of the available resources is checked.

Quality of Service is focuses on the guarantee for service provision based on the quality policy specified for the service request. [3] The design of call admission process concern with the following parameters,

- **Availability of Resources:** In eNB's new call and handoff call request are admitted based on the available resources. If the resources are limited, call admission decision is made with the acceptance of the available resources. While design the call admission control mechanism, call admission criteria considers the load of the network. Prediction based decisions are employed to admit the new calls with respect to resource reservation.

- **Quality of the network parameters:** the connection quality plays the major role in the establishment of interference free transmission. Received signal strength (RSS) is used to evaluate the quality of the link between the network components of the system. Quality parameters for each network element is designed and taken into account for the design of the call admission process.
- **Quality policies:** Qos requirements are categorized with regard to the parameters like throughput, delay, fairness and bandwidth utilization. The traffic characteristics are analyzed to find the parameters for the performance degradation on the network. QoS provision is to guarantee the user request with quality policies based on the Qos demands of the user. The traffic conditions of the network are predicted to ensure the need based service with the fulfillment of required network resources.
- **Call prioritization:** The incoming call request are classified into real time(rt) and non real time(nrt) calls, the real time call request are provided with highest priority when compared to the non real time calls. Eg. Live video streaming calls are more prioritized than the internet browsing. Highest priorities are provided for handoff calls and emergency related calls. Reservation schemes and queuing mechanisms are introduced to deploy the priority for call request.
- **Mobility Management:** In order to reduce the call blocking and call dropping probability, the mobility factors are considered to predict the movement UEs across the base station. Mobility prediction helps the call admission process to classify the call request either new call or handoff call, as the result it produces the efficient resource allocation. Optimization methodologies.

To enhance the performance of call admission process, wide range of optimization techniques are introduced. [4] The main objective of the call admission framework is to provide end to end QoS with the ability to manage the transmission interference problems in the radio channel. In order to ensure the better QoS the transmission architecture involves operations like, network planning, parameter configuration and optimization. [5]Network architecture is modified based on the status of the network to generate the flow of data and control over error. Optimization process reduces the complexity of the call admission process and the parameters for each call request specified with the threshold value. [6] The incoming calls or new calls are evaluated based of the threshold value, minimum and the maximum value for each parameter will be specified in the parameter list. An objective function is constructed by means of the objective function of the network transmission parameter.

In this paper we present an efficient utility based call admission process that uses bacterial foraging optimization technique. The foraging behavior of the bacteria (E.coli) is taken into account for optimization in the utility based call admission process. In this optimization technique E.coli drives them and it rotates clockwise and counter clock wise for the reception of food. Bacteria find the new direction for accessing the food and swims in the direction of the food.

2. Material and Methods

H Pal Thethi et.al [7] presents the key factors to develop adaptive inverse models for network components like channels, signal, and digital data. In this the bacteria foraging optimization is used for construct the learning rules that leads the operations like channel equalization, digital data recovery and other applications.

Hongbing Lian et.al [8] introduces new optimization procedure based on heuristic method. In this Qos requirements like call blocking probability, call dropping probability, bandwidth utilization and quality policies are evaluated. The optimization techniques allows the call admission decision to exchange the transactions among call dropping and call blocking based on QoS requirements. The objective function is embedded with Landscape Smoothing Search (LSS) to make combination of QoS requirements and resource utilization.LSS is further modified to handle hard optimization. When compared to Genetic Algorithms (GA) and Stimulated Annealing (SA), LSS produces better QoS and good optimization speed.

Qiaoling Wang et.al [9] proposes a call admission control optimization technique based on QoS constraints. In this paper examines the complexities to handle the Qos constraints, Neuro Evolution algorithm is introduced to make the coordination among the QOs constraints. The speciation and complexification features of Neuro Evolution algorithm used to optimize the call admission decision by comparing superiority of feasible points and static penalty function.

Mehdi Kashefikia et.al[10] states Ant bee colony based call admission control method, based on constraint optimization the objective function is designed to minimize the call dropping probability in dynamic conditions, minimize the traffic load of the network and maximization of channel allocation to the incoming call request.

Michał Wągrowski et.al [11] presents elastic threshold based algorithm, which focuses on quality of service satisfaction and reward based optimization. This algorithm considers wide range of priority classes that generates a value based on the service provided by CAC. This value is called reward; QoS requirements are analyzed and compared with other CAC algorithms to generate the optimal threshold value. Heuristic-based search methods are used to find the best threshold value.

Antonopoulos et.al [12] introduces traffic aware call admission control for LTE networks this technique concentrates on the packet differentiation and the quality level for each call request for the users in the network architecture. Based on the traffic condition the quality level is improved in terms of adopting the new approach for dynamic call blocking.

Enrique Stevens-Navarro et.al [13] introduces optimization based call admission control, in this the QoS requirements for real time and non real time call requests are differentiated. Based on the differentiation admission control policies are limited for each connection request. An amble model is developed to perform optimal evaluation for control policies of the system.

A.N.K. Nasir et.al [14] proposes Hybrid spiral dynamics bacterial foraging (HSDBF), which is simplified from bacterial foraging algorithm (BFA). In this the spiral adaptive characteristics of BFA and the exploitation procedure of spiral dynamics algorithms (SDA) are combined to strengthen the control design applications. Based on SDA and BFA wide range of uni-models and multimodal are developed to test the control design parameters.

Okan Yilmaz et.al [15] proposes pricing based optimization technique for multiple service classes. In this pricing and revenue is adjusted periodically with respect to the global optimal pricing for each call request. The pricing scheme is analyzed and associates with service demand based on pricing. Cost of the process is increased in order to guarantee the QoS requirement satisfaction.

Feng Ming et.al[21] presents a fairness based Qos guarantee method for WiMax. In this the limited resources is allocated the multiple users based on cross-layer subcarrier permutation (CLSP) mechanism by means of cross layer designs. Throughput of the system improved with the quality policies of low latency and long term fairness for multiple users.

Rony Ohayon et.al [22] proposes virtual reservation scheme for ensuring the Qos for CBR based wireless networks. In this the real time applications like voice and video are provided with the distributed time slot without any control information. Due to reduction in the interruption of reserved slots, propagation delay is reduced and the channel utilization is increased.

LiFeng Zhou et. al [23] states the procedures for QoS violations in the end to end communication systems. A statistical method is proposed to regulate the type of violation, performance of the traffic pattern, and based on the universal approximations orthogonal algorithm is implementation to train the real time violations.

Chen et. al [24] presents a set of procedures to incorporate the diverse user requirements with help of adaptive Qos guaranteed algorithm. Adaptive algorithm is used to provide extractions of cross layer congestion concepts like, spectral efficiency, received signal strength to facilitate real time application with minimum delay.

3. Metrials and Methods

According to the biological phenomena, the capabilities of Bacterial Foraging Algorithm (BFA) are highly suitable for real world optimization applications. When compared to the other natural inspired optimization algorithms, like Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO) and Bee Colony optimization BFA produces efficient optimization over real world applications. [16]The BFA consist of four major modes of operations namely, Chemo taxis, Swarming, Reproduction and Elimination and Dispersal.

Chemo taxis:

Foraging behavior of E-coli bacteria consist of two different movements of operations those are swim and tumble. Swim is the bacterial movement towards the direction of good concentration of nutrients. Tumble is bacterial movements' starts when the E-coli identify and reaches the good concentrated food. Tumbling is performed after the completion of the swimming movement, E-coli performs the random walk towards the high concentration for food. It changes the direction and performs swimming and tumbling to achieve the high concentrations of nutrition. [17]The methodologies involved in the foraging decision making are considered to perform the resource management of call request in LTE environment. Figure 1 shows the operation of E.Coli Bacterium

Swarming:

The E-Coli identifies the high nutrient food, it generates attractant to attract the group towards high nutrition patterns. Each bacterium represents the response for the benefit of the whole group. Reception of food concentrates are considered as the resource allocation for each call request in call admission process. The attractant of the swarming process is taken as call admission decision based on the resource density of the network.

Reproduction:

Fitness value of each bacterium is evaluated based on the fitness value the foraging process will be performed in the nutrition centric environment. The entire population is segmented based on the fitness function; if the fitness value is good enough the chemo tactic procedure will be performed the least fitness value bacterium are allowed to the conditional foraging process. The reproduction phase of the E-coli is considered as utility based call admission process; in this the utility function of the call request is taken as the fitness value of the Bactria. Based on the received signal strength (RSS) the channels are classified into good and bad channels the good channels are allowed to allocate the resources like healthy bacteria.

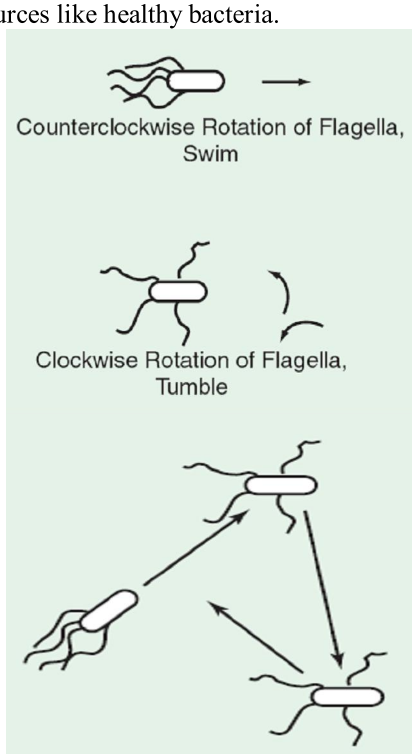

Figure 1. Chemo tactic behavior of E. Coli Bacterium

Elimination and Dispersal:

This phase includes the elimination and termination of group of bacteria. When bacterium completes its chemo tactic process that must be replaced with other group of Bactria to access the high nutrient food. The elimination and dispersal process is used to kill the current foraging process and performs the replacement operations. In the call admission process the call drooping and call blocking probability are considered as the Elimination and dispersal phase of the bacterial foraging algorithm.

Utility Based Call Admission Control (UBCAC):

Due to heavy traffic in the eNB, the entire network architecture faces the traffic oriented performance degradation. In this context there is number of call admission mechanisms are developed. Utility based call admission control framework intended to increase the abilities of call admission framework with less performance degradation. UBCAC facilitates to provide efficient load balancing, maximized resource utilization, reliable QoS. The utility factor for each call request is evaluated based on the nature of the call requests like new call, handoff call, real time or non real time call request and based on the [18]RSS value the channels are classified as good and bad channels.

Table 1. List of parameters for UBCAC

Parameter	Parameter description
d_i	The average data rate at the time of call admission decision.
D_i	Data rate for call request
t_i	delay threshold of the incoming call request
$b_{rb(i)}$	Number of resource blocks allocated for real time call request.
$b_{nrb(i)}$	Number of resource blocks allocated to a non real-time user
η_i	The effective data rate of the i^{th} user computed from the utility function of all the subcarriers
Y_N	Utility function of user N
E_N	Rate
ρ_N	Transmit power on the subcarrier
$\delta_{sc,N}$	Set of subcarriers
RSS_N	received signal strength achieved by user N
$M_{N,C}$	gain in the utility function Y_N

The above Table 1 provides the list parameters used for establish the objective function for the UBCAC. The resource allocation is determined as follows [19]:

$$B\,rb(i) = \left(\frac{\mu}{\mu+\lambda}\right)\left(\frac{\frac{1}{Ti}}{\sum_{n-1}^{W}\frac{1}{Tn}}\cdot\frac{\left(\frac{di}{Di}\right)}{\sum_{n-1}^{W}\left(\frac{di}{Di}\right)}\right)B \qquad (1)$$

The above equation (1) shows the allocation of resources blocks to the real time and non real time users. Based on the network parameter μ and λ, the available resources are evaluated to perform the efficient allocation for call admission process.

$$B(n)rb(i) = \left(\frac{\mu}{\mu+\lambda}\right)\left(\frac{\varphi}{\sum_{n-1}^{W}\varphi n}\cdot\frac{\left(\frac{di}{Di}\right)}{\sum_{n-1}^{W}\left(\frac{di}{Di}\right)}\right)B \qquad (2)$$

The bandwidth reservation performed based on the utility of the each call request, the utility factor is determined subcarriers of the network for bandwidth reservation. Based on the RSS value the channel quality is categorized into good and bad channels. Each call request is allocated with good channels with respect to the marginal utility function, transmitted power.

$$Yn\left(En\left(\rho n, \delta sc, n\right)\right) = \frac{En\left(\rho n, \delta sc, n\right)}{RSSn} \quad (3)$$

Marginal utility calculation:

$$Mn, c = Yn(En(\rho n, \delta rb, n \cup \{c\}) - Yn(En(\rho n, \delta rb, n)) \quad (4)$$

The above eq(3) and eq(4) are used to calculate the marginal utility function for each call request.

4. BFA Algorithm for Utility Based Call Admission Framework

The following Figure 2 shows the bacterial foraging supported utility based call admission control framework. In this the incoming call request are analyzed with the parameters like request bandwidth (Rb), account and authorization parameters. Call requests are classified as new call and handoff call request. The available bandwidth is compared with the requested bandwidth. If the resources are available the call will be accepted to perform optimization process using BFA. If the resources are not available the call requests are further classified into real time and non real time calls, real time calls are provided with highest priority when compared to the non real time call request. In LTE based system the quality based call admission schemes are always expected the guarantee of quality policies. The proposed BFA supported UBCAC algorithm for efficient call admission control as follows:

Intialization:

i)Intialization of optimization parameters.
ii)Intialization of search space for bacteria.
iii) Initialization of number of parameters in UBCAC (U_a),length of Bacteria(B_l), Swimming Length N_s, number of iteration for Chemotaxis loop $N_{c.,}$ number of reproduction N_{re}, number of elimination and dispersal N_{ed} are intialized.
iv)position of the bacteria is identified for each chemo tactic loop by

$$Pos(j,k,l) = \left\{ \theta i(j,k,l) / i = 1,2,1 \ldots \ldots, S \right\}$$

v)The parameters of behavioural aspects of the bacteria like $d_{attract}$,$w_{attract}$,$h_{repellant}$ and $w_{repellant}$ used for swarming.

Implementation of BFA algorithm.

i) Calculate the Fitness function based on U_a
ii) Check fitness and define as best fitness based on the marginal utility function.

Compute $f(xi(j))$, then set *Jbest* $f(xi(j))$, If $Rb_{req} < Rb_{max}$
Jerror (i,j,k,l).

Jerror (i, j, k, l) = Jerror (i, j, k, l) + Jcc (Δi(j, k, l), P(j, k, l))

Jlast = Jerror(i,j,k,l)

(ii) Bacteria tumble

$$\theta i(j+1,k,l) = \frac{c(i)\Delta(i)}{\sqrt{\Delta^T(i)\Delta(i)}}$$

iii) Reproduction:
For the given k and l, and for each
I=1,2,3,4,…………,S

$$J_{health} = \sum_{j=1}^{n+1} Jerror(j,k,l)$$

iv) Elimination and Dispersal:
For i=1,2,3,…………,S.
If $Rb_{req} > Rb_{max}$
Elimination loop $l = l + 1$.

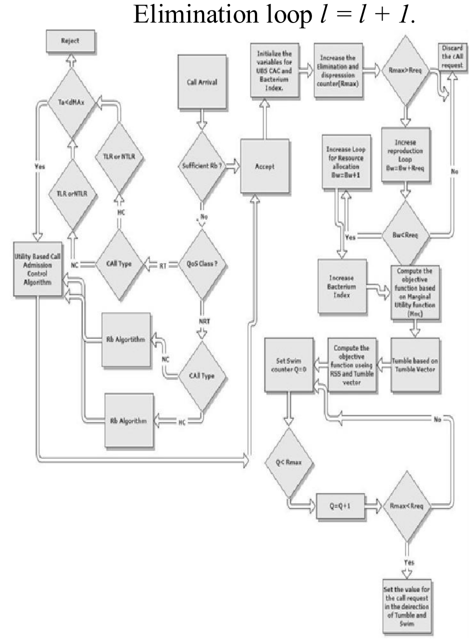

Figure 2. BFA supported UBCAC Framework

5. Results and Discussion

We have stimulated the proposed model by using LTE/SAE model of NS2 [20].the following table shows the simulation parameter for BFA supported utility based call admission scheme. The following table 2 shows the Simulation parameters.

Table 3. Simulation parameters

Number of Servers	02
Number of aGW	02
Number of eNB	20
Number of UE	100
Traffic Types	CBR,VoIP,Video
Traffic rate	50 ≈100 Kbps
Number of packets per frame	02
Voip Codec	GSM.AMR, H.263

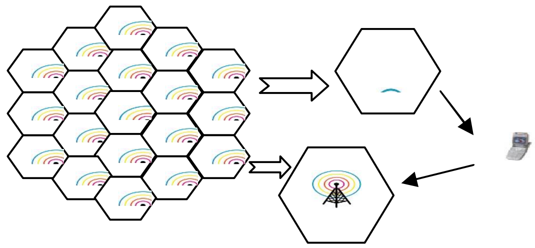

Figure 3. Network Topology

In this section the performance of the proposed algorithms are investigated. The Figure 3 shows the architecture for the call admission process. The performance of the system is compared with the previous call admission control schemes like, Adaptive call admission control (ADCAC), Dynamic bandwidth adaptation supported call admission control(DBACAC), Channel state based call admission control and(CBCAC) utility based call admission control framework(UBCAC). In this AdCAC and DBACAC is based on the concept of load balancing.CBCAC is focuses on the quality of the channel based on the RSS value. The UBCAC is intended to focuses on the utility of the call request. BFA supported UBCAC is evaluated in terms of CBR, VoIP and Video for real time and non real time call request.

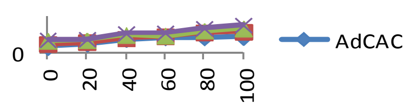

Figure 4. Rate Vs Bandwidth

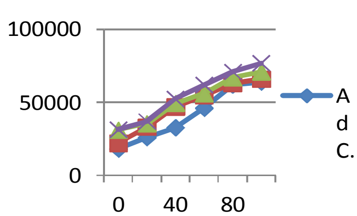

Figure 5. Throughput Vs Rate

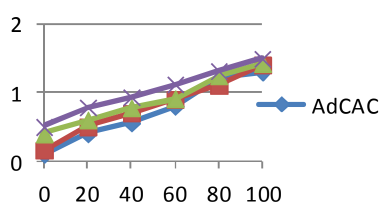

Figure 6. Rate Vs Fairness

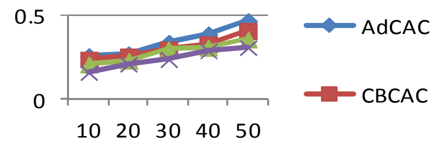

Figure 7. Rate Vs Delay

The above figure shows the performance evaluation of BFA supported utility based call admission control mechanism. In the Figure 4 represents the differentiated performance of BFA supported UBCAC over the bandwidth utilization, this framework provides average peak data rate as 6Mbps and the bandwidth of 100kb traffic. Figure 5 represents the comparison of call admission control schemes based on the throughput ratio for new call and the handoff call request. The BFA supported call admission schemes presents high call acceptance ratio with least call blocking probability. Figure 6 presents the fairness of call admission framework with respect to bandwidth allocation and the acceptance rate. BFAUBCAC produces reduced call dropping probability and increased efficiency of the network. Figure 7 illustrates the time consumption on the call admission process; the statistics shows the efficiency of the call admission process with respect to delay.

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