Performance Evaluation of Call Admission Control Schemes in 3GPP Long Term Evolution Networks

Abdulhakeem Abdulazeez, Maniru Malami Umar, Solomon Yese Orduen, and Aminu Mohammed

***Abstract* — Radio resource management (RRM) techniques are employed for resource utilization in wireless broadband networks. One of the major RRM techniques that are aimed at controlling the admission and rejection of new or handoff calls/connections in a network is known as Call Admission Control (CAC). CAC accepts or rejects a connection request based on a certain pre-determined criterion(s). Performance Evaluation of some existing CAC schemes was presented in this paper. The schemes evaluated are; Adaptive Call Admission Control Scheme with Bandwidth reservation termed as (ACAC), QoS-Aware Call Admission Control Scheme termed as (QA-CAC) and Enhanced Adaptive Call Admission Control Scheme with bandwidth reservation termed (EA-CAC). Vienna LTE system level simulator was used for the simulation experiments conducted. After several experiments, the results show that the QA-CAC and EA-CAC schemes perform better in terms of increasing the throughput of real-time (RT) traffic while all the three schemes almost have the same performance in terms of admitting the non-real-time (NRT) traffic.**

***Key words* — CAC, LTE, Throughput, QoS, and QoE.**

I. Introduction

The number of mobile users and devices is exponentially increasing day by day. These users have high expectations for efficient transmission of their multimedia data with better quality of experience (QoE). Therefore, achieving speedy delivery of data to satisfy user needs requires improvement of quality of Service (QoS). Long Term Evolution (LTE) was one of the technologies proposed by the Third Generation Partnership Project (3GPP) as a promising wireless technology that will cater for the high demands of mobile users by supporting a number of diverse applications [1]. The main objective of LTE is to deliver high data rates for bandwidth-demanding applications such as; live streaming, high speed download and upload, as well as improving the spectral efficiency of the network [2]. These features and many more make LTE desirable solution to both mobile operators and users.

Also, due to the increase in the number of mobile users, the often scars network resources need to be properly managed to guarantee QoS of the diverse user traffic [3]. To achieve this, LTE utilizes many radio resource management techniques which are used to improve the utilization/management of the available network resources [3]. Such techniques are scheduling, call admission control (CAC), congestion control, power saving etc.

Call admission control is among the radio resource management techniques that is saddled with the responsibility of accepting or rejecting a call/connection requests into the network. Call/connection requests are usually classified into either a new call or a handoff call. A new call is a type of call request that originate within the cell coverage of the serving base station, and requesting to be admitted into the network, while a handoff call is an established connected call that needs to be transferred into another cell for continuity maybe due to mobility or any other factor [4]. Call requests are either accepted or rejected based on certain criteria that are defined by the CAC scheme. Such criteria's can either be availability of resources, signal strength of connection, traffic class etc. [5].

Different CAC schemes have been presented by different authors and researchers with the aim of addressing different challenges. A survey in [6] presented several CAC schemes developed for LTE networks. The authors categorized CAC schemes into five different classes. Each class has a number of schemes that have been proposed by different researchers. Similarly, the authors in [5] presented a survey of some existing CAC schemes by highlighting how they operate and some of the key strengths and weakness of the schemes.

Performance evaluation of some existing call admission control (CAC) schemes was presented in this paper. All schemes evaluated were proposed for the Long Term Evolution (LTE) networks. Throughput of both real time (RT) and non-real-time (NRT) was considered as a performance metric for the evaluation.

The other sections of this paper are organized as follows: In section II, some of the existing call admission control schemes were carefully reviewed under the review of related works heading. Section III gave a brief description of the three CAC schemes that are evaluated in the paper. Section IV shows the performance evaluation i.e., simulation setup, results and discussions. Finally, the paper was concluded with section V.

II. Review of Related Works

As discussed in section I, CAC is one of the RRM techniques that is responsible for controlling the number of connections in a network. A lot of researchers had proposed different CAC schemes for the LTE network. This sections reviews some of these schemes by highlighting how each scheme works i.e., the operation, as well as some of the strength(s) and weakness of each scheme.

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A Flexible CAC scheme was presented on [7]. The scheme was aimed at increasing the utilization of available network resources and also supporting multimedia services for diverse traffic types. Call requests are classified into real time and non-real time requests, the scheme further estimates channel quality of the traffics based on the received signal strength (RSS) to differentiate between a new and handoff call request. Call dropping probability (CDP of the RT calls is reduced by the scheme because of the higher priority given to them while the NRT calls suffer from an increase in call blocking probability (CBP) due to the preemption strategy employed by the scheme.

To reduce the call blocking probability (CBP) and also satisfies quality of service (QoS) of call, authors in [8] proposed an efficient bandwidth CAC scheme. The scheme starts by estimating the quality of channels based on the received signal strength (RSS) of the traffic. It uses the channel quality to determine whether a channel is good or bad. Furthermore, the scheme employs a congestion threshold mechanism and a blocking probability limit for all call types. QoS of the admitted calls is guaranteed likewise the throughput of the overall system is increased by the scheme. However, NRT calls experienced high rate of CDP due to higher priority given to RT requests by the scheme

Authors in [9] presented a CAC scheme that is based on delay and user's categorization to guarantee the QoS of admitted calls. The scheme employs a virtual reservation technique used to reserve a certain amount of physical resource blocks for each traffic type. The reservation is done for future use by either new calls or handoff calls likewise for RT and NRT call requests. The scheme improves the QoS of admitted calls and also increases the utilization of network resources as a result of the virtual reservation technique it employed. NRT or lower priority calls experienced high rate of CDP due to higher priority given to RT traffics.

The work in [10] presented an Adaptive CAC scheme with Bandwidth Reservation to increase the utilization of available network resources and also prevent the best effort (BE) traffic from been starved in the network. The scheme starts by allocating the maximum bandwidth required by an RT call at the point of admission. It then allocates the minimum bandwidth required by an NRT call at the point of admission. This strategy makes it possible for the scheme to degrade admitted RT calls when the need arises. The scheme was able to increase the throughput of BE traffics due to higher priority given to them by allocating their maximum bandwidth requirement at the point of admission. However, the scheme wastes a lot of bandwidth in a scenario where degradation is not required.

A QoS-aware CAC scheme (QA-CAC) was presented in [2] with the aim of guaranteeing the QoS of admitted calls and also increasing the throughput of RT call requests. A call request is admitted by the scheme if and only if the requested bandwidth is lesser than or equal to the bandwidth available in the system, otherwise a degradation mechanism has been invoked by the system such that all admitted NRT calls will be degraded to their minimum bandwidth requirement. The QA-CAC scheme increases the throughput of admitted RT calls but reduces the QoS of NRT calls and also increases the wastage of bandwidth.

Enhanced Adaptive CAC scheme with bandwidth reservation was proposed in [1]. The EA-CAC scheme was aimed at improving the QoS of all admitted calls thereby increasing the throughput of the overall system without degrading the performance of NRT calls as it has been happening in the previous schemes. It starts by employing a prior-checking strategy which serves as a regulator to the scheme by ensuring that the amount of bandwidth to be degraded from admitted calls will be enough to admit the new call requests, otherwise the degradation will not take place. The scheme further employs an adaptive degradation mechanism which degrades admitted calls per class i.e., it degrades NRT calls first then test for sufficiency and then proceed to degrade RT calls. The EA-CAC improves the QoS of RT traffic and at the same time maintain the QoS of NRT traffic.

III. Description of CAC Schemes Evaluated

This paper presents a performance evaluation of three (3) call admission control schemes. The schemes were compared based on the throughput of both RT and NRT traffics. In this section of the paper, a brief description of all the schemes is given. But before describing these schemes, the reader needs to have an insight of the Basic Call Admission Control scheme also referred to as BCAC.

The BCAC is considered as the traditional CAC scheme or sometimes seen as the first CAC scheme that was developed. It also seen as a static CAC scheme because the admission criteria employed by the scheme is only one, which is the availability of network resources. Therefore, in BCAC once the bandwidth needed by the call request is lesser than or even equal to the available bandwidth in the system, the call request will be admitted otherwise it will be rejected [5]. Other admission criteria's such as channel quality, traffic type, latency and others are not considered in the BCAC for admission of a call request. Fig. 1 shows the description of BCAC.

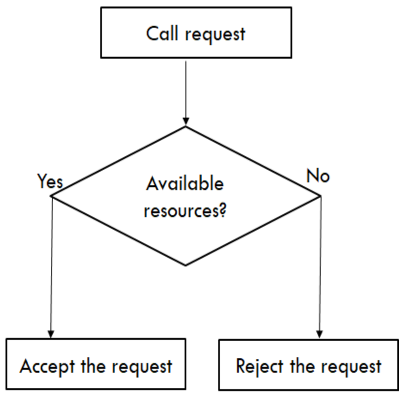

Fig. 1. Basic Call Admission Control (BCAC) Scheme.

Researchers have been working tirelessly to improve the BCAC scheme. Different CAC schemes have been proposed over the years to improve the performance of BCAC. BCAC doesn't take into cognizance different traffic types and as such it cannot be applied in today's network which has diverse applications or traffic types.

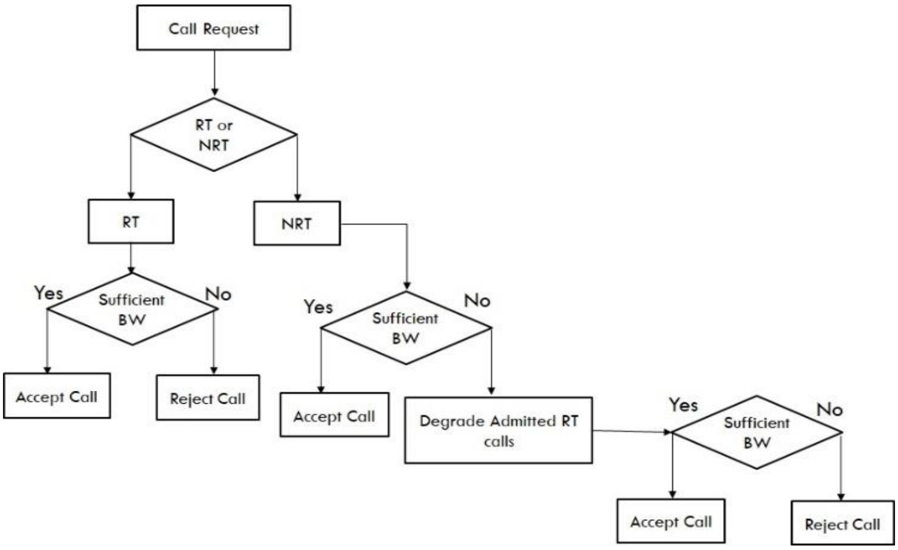

Fig. 2. Adaptive call admission control (ACAC) scheme.

In this paper, we are considering the schemes proposed in [1], [2] and [10]. Fig. 2 shows the diagrammatic description of the scheme proposed in [10] which is Adaptive Call Admission Control (ACAC) with Bandwidth reservation. The pseudo-code for algorithm proposed in [1] and [2] are also presented in this section.

As shown in Fig. 2, it can be seen that the ACAC scheme admits an RT call request if and only if the requested bandwidth is less than or equal to the available bandwidth in the system, otherwise the call is rejected. Therefore, it can be said that the only criteria employed by the scheme for accepting an RT call is the availability of bandwidth.

On the other hand, an NRT call request is accepted if the requested bandwidth is less than or equal to the available bandwidth, otherwise admitted RT calls are degraded by the system in order to gain bandwidth that will be used to admit the NRT call requests.

The scheme works perfectly for both RT and NRT calls but there is wastage of bandwidth when degradation is not needed because, the scheme allocates maximum bandwidth requirement for RT calls at the point of admission and minimum bandwidth requirement for all NRT calls at the point of admission.

Researchers in [2] tried to improve the performance of the ACAC by proposing the QA-CAC scheme. Pseudo-code of the QA-CAC scheme is presented below.

Algo. 1: QA-CAC scheme [2]

Input:
CallRT: *RT call request*
CallNRT: *NRT call request*
Initializations:

for CallRT check
if equation (3) *is satisfied then*;
Accept CallRT
else
degrade admitted Calls then
end if
if equation (6)*is satisfied then*
Accept callRT
else
reject callRT
end if
end for
for CallNRT
if equation (3)*is satisfied then*
Accept CallNRT
else
degrade admitted calls then;
end if
if equation (6)*is satisfied*
accept callNRT
end if;
end for;

The QA-CAC scheme works similar to the ACAC scheme but has a little improvement in terms of bandwidth allocation at the point of admission. The scheme allocates maximum bandwidth requirements for both RT and NRT calls at the point of admission instead of the way it was done in the ACAC scheme.

So, For the RT call requests, the bandwidth requirement allocation is shown below in equation (1):

$$CallRT = \mathrm{B}Wmax \quad (1)$$

where $CallRT$ represents an RT call and $BWmax$ denotes the maximum bandwidth the call requests.

In a similar vein, for the NRT call requests, the maximum bandwidth is shown below in equation (2):

$$CallNRT = \mathrm{B}Wmax \quad (2)$$

where $CallNRT$ represents an NRT call request while $BWmax$ denotes the maximum bandwidth requirements for an NRT call request.

The QA-CAC scheme further admits a call request if and only if the available bandwidth in the network is enough i.e., if the amount of bandwidth needed by the requested call is less than or equal to the total available bandwidth in the system as shown in equation (3):

$$BWreq \leq \mathrm{B}Wavail \quad (3)$$

Therefore, $BWreq$ is the bandwidth requested by a call and $BWavail$ is the bandwidth available in the system.

In a scenario where the bandwidth in the system is not enough to admit a new call request, then the QA-CAC scheme will employ a degradation mechanism on all admitted calls i.e. all admitted calls will be degraded to their minimum bandwidth requirement. Therefore, the degradable bandwidth for a new call request is computed as shown in equation (4) below:

$$BWCdeg = BWCmax - BWCmin \qquad (4)$$

The degradable bandwidth for a new call request is denoted by $BWCdeg$ while the maximum bandwidth required for a new call is represented by $BWCmax$ and then $BWCmin$ represents the minimum bandwidth required by a new call request.

It should be noted that, the QA-CAC scheme's degradation mechanism takes into consideration the minimum bandwidth requirements for a call, therefore while it degrades admitted calls, it ensures that no call is degraded below its minimum bandwidth requirement. This is computed using equation (5) below:

$$BWCdeg \geq BWCmin \qquad (5)$$

The degradable bandwidth for a call request is denoted by $BWCdeg$ while the minimum bandwidth require for a call request is represented by $BWCmin$.

At the end of the degradation process, the QA-CAC mops up all degraded bandwidth and adds it to the available bandwidth in the system. The new available bandwidth is then used to admit calls into the system. But before the admission is done, the scheme checks if the sum of degraded bandwidth is less than or equal to the bandwidth request of a new call request. That is computed using equation (6) below:

$$\sum BWdeg \geq BWCreq \qquad (6)$$

The total sum of bandwidth degraded from all admitted calls is denoted by $\sum BWdeg$ while $BWCreq$ represents the amount of bandwidth requested for a new call.

Note that, the QA-CAC scheme degrades all admitted calls to their minimum bandwidth requirements. Then the degraded bandwidth is used to admit new call request into the system. But, after the degradation mechanism has been invoked and utilized by the scheme, all call that will be admitted will be allocated their minimum bandwidth requirement not considering the class or type of the call i.e., either RT or NRT and NC or HC. This strategy will then prevent further degradation of newly admitted calls because they have been admitted with their minimum requirement already, therefore degrading those calls will cause more harm to the system by increasing delay and even causing more call drops.

Fig. 3 shows the representation of the QA-CAC scheme while algo. 1 shows the pseudo-code of the QA-CAC scheme.

Algo. 1 shows the programmatic representation i.e., the pseudo-code of the QA-CAC scheme that has been explained above. The pseudo-code can be used for implantation purpose using any high level programming language such as Java, Python etc. It shows the step-by-step procedure on how the QA-CAC operates and handle call requests.

The flow chat of QA-CAC scheme is shown in Fig 3 below [2]. The flow chart shows the step-by-step procedure or process on how the QA-CAC takes several decisions on either to admit or reject a particular call. The process is an iterative one, i.e., it continues until the last call in the queue has been admitted or network resources have been exhausted.

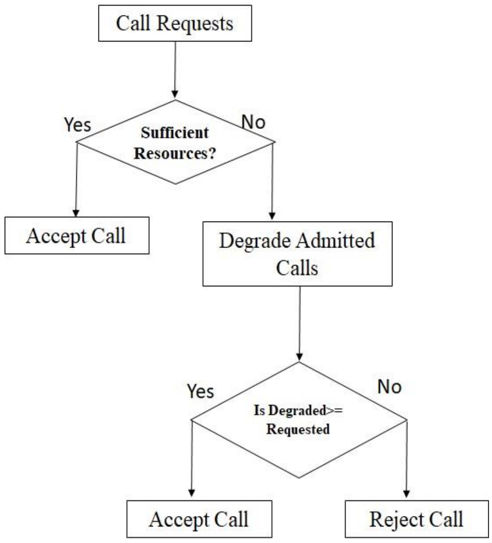

Fig. 3. Flow chart of the QA-CAC scheme.

As earlier stated, ACAC was one of the schemes that were proposed as an improvement for the BCAC scheme which was regarded as the traditional or static CAC scheme. The QA-CAC scheme was presented as an improvement of the ACAC hence it can be seen that it has improved the performance of the ACAC scheme in terms of QoS and throughput if the overall system. Nevertheless, the QA-CAC has a problem of bandwidth wastage as it degrades all admitted calls in order to obtain bandwidth that will be used to admit new call requests.

Hence, EA-CAC was proposed in [1] to overcome the challenges of the QA-CAC. The scheme works in a similar way with the QA-CAC but has some improvements by introducing a prior-checking mechanism and also an adaptive degradation procedure all with the aim of improving the performance of the QA-CAC. EA-CAC scheme is an extension/improvement of both ACAC and QA-CAC schemes.

At the point of admission, the EA-CAC allocates maximum bandwidth requested for a new call be it a real time (RT) or non-real time (NRT) call and/or new call (NC) or handoff call (HC) as the case maybe. Maximum bandwidth requested for a new RT call request is shown in equation (7) below:

$$Call_{RT} = BW_{max} \qquad (7)$$

From equation (7) above, it can be seen that $Call_{RT}$ represents a new RT call request while BW_{max} denotes the maximum bandwidth requirement for the new RT call.

On the other hand, the maximum bandwidth needed for an NRT call request is described in equation (8) below:

$$Call_{NRT} = BW_{max} \quad (8)$$

where $Call_{NRT}$ represent the new NRT call request while the maximum bandwidth needed by a new NRT call request is denoted by BW_{max}

The EA-CAC scheme admits new call requests if there is enough bandwidth available in the system i.e., it checks if the bandwidth requested by the new call is less than or equal to the bandwidth available in the system as of the time of request. This process is described in equation (9) below:

$$NC_{accept} = BW_{req} \leq BW_{avail} \quad (9)$$

In equation (9) above, the new call (NC) request to be accepted in the network is represented by NC_{accept}. BW_{req} denotes the amount of bandwidth requested by the new call i.e., the bandwidth that is needed by the new call request. The available bandwidth in the system is represented by BW_{avail} i.e., it is the amount of bandwidth that can be used to admit new call requests.

On the other hand, the scheme accepts a handoff call (HC) request using the same condition or criteria for the NC requests i.e., it checks if the requested bandwidth is less than or equals to the available bandwidth in the system. Therefore, at this stage, the only concern is availability of bandwidth in the system. This procedure is shown in equation (10) below:

$$HC_{accept} = BW_{req} \leq BW_{avail} \quad (10)$$

The HC_{accept} in the above equation represents the HC call request that need to be admitted into the network while the amount of bandwidth that is needed by the HC call request is denoted by BW_{req}. BW_{avail} signifies the total usable bandwidth in the system.

If the usable bandwidth i.e., available bandwidth in the system is not enough to admit the call request i.e., either an NC or HC call request, then the EA-CAC scheme invokes a degradation mechanism which operates in two phases; at the first phase, admitted NRT calls are being degraded to their minimum requirements. Equation (11) describes how the degradable bandwidth i.e., amount of bandwidth that can be degraded is computed by the scheme:

$$BWC_{deg} = BW_{max} - BW_{min} \quad (11)$$

The amount of bandwidth that can be degraded is represented by BW_{deg} while BW_{max} denotes the maximum bandwidth that is needed for a call request i.e., amount of bandwidth it needs to execute to the end. BWC_{min} represents the minimum requirement in terms of bandwidth for a particular call request.

At the end of the first phase of the degradation procedure, the total bandwidth degraded is then added up to the pool of usable bandwidth in the system (as shown in equation 12) thereby increasing the amount of available bandwidth. The available bandwidth is then used to admit the requested call that prompted the degradation procedure if the available bandwidth will be enough i.e., if it is less than or equal to the requested bandwidth.

Note that, calls admitted after the degradation of admitted calls are allocated their minimum bandwidth requirement thereby preventing the system from further degrading them in the future. This strategy reduces the number of dropped calls in the system thereby increasing the number of admitted calls.

$$\sum NRT\_BW_{deg} + BW_{avail} \quad (12)$$

From equation (12), the total sum of degraded bandwidth from admitted NRT calls in order to admit newly requested calls is denoted by $\sum NRT\_BW_{deg}$ *while* BW_{avail} represents the bandwidth available in the system.

The second phase of the degradation procedure is employed by the EACAC scheme when the degraded bandwidth from admitted NRT calls is not enough to admit the requested call. The second phase of the degraded starts by employing a prior-checking mechanism which ensures that the degradable bandwidth from the admitted RT calls will be sufficient to admit the new call request. This is done for the purpose of reducing the wastage of bandwidth and dropping of RT calls. The prior-checking procedure is described in equation (13):

$$\sum RT_{BW_{deg}} + BW_{avail} \geq BW_{req} \quad (13)$$

The amount of bandwidth that can be degraded from admitted RT calls is denoted by $\sum RT\_BW_{deg}$ while the total available bandwidth in the system is represented by BW_{avail}. The bandwidth that is needed by the requested call is denoted byBW_{req}.

The EA-CAC scheme checks if equation (13) is satisfied before invoking the phase 2 of the degradation procedure. Therefore, the new call request is admitted if the phase 2 is executed or the call is rejected otherwise. By this, we can conclude that the EA-CAC reduces the wastage of degraded bandwidth which is one of the problems encountered by the ACAC. The scheme also increases the number of calls admitted in the system thereby reducing the number of rejected and dropped calls.

Algo 2, shows the pseudo-code of the EA-CAC. These codes show the step-by-step programmatic view of the scheme which can be implemented using any high-level language such as Java, Python etc. Fig. 4 shows the flow chart of the EA-CAC scheme. The chart shows the step-by-step procedure used by the scheme to accept or reject any call request.

Algo. 2: EA-CAC Scheme [1]

Inputs:
NC: *New Call*
HC: *Handoff Call*
RT: *Real time calls*
NRT: *Non − real time calls*
SMT: *Simulation time*
TTI: Transmission Time Interval

Initializations:
while TTI is within SMT do;
for NC;
computer NC according to equation (9)
if equation (9)*holds then*;

$accept\ NC$
$else$
$degrade\ admitted\ NRT\ according\ to\ equation\ (12)$
$end\ if$
$end\ for;$
$if\ equation\ (12)\ holds;$
$accpet\ NC$
$else$
$reject\ NC$
$end\ if;$
$for\ HC;$

$compute\ HC\ according\ to\ equation\ (10);$
$if\ equation\ (13) holds\ then;$
$accept\ HC$
$else$
$execute\ step\ 17\ to\ 24$
$end\ if$
$end\ for$
$end\ while;$

The flow chart of the EA-CAC scheme is shown in Fig 4. The chart shows the step-by-step procedure on how the scheme operates.

Following the discussions made so far in this section, it can be concluded that, the BCAC is the traditional CAC scheme that was proposed during the 2G wireless technology era. The ACAC, QA-CAC and EA-CAC schemes are all schemes that were proposed by researchers as an improvement of the former scheme.

With the advent of new wireless broadband technologies, we may agree that the BCAC can no longer be sufficient or cannot meet the demand of mobile users. The three (3) schemes considered in this paper were all proposed for the Long Term Evolution (LTE) networks.

IV. Performance Evaluation

In this section of the paper, we present the simulation setup that was used in the implementation of the schemes under study. The performance evaluation results obtained after running a series of simulation experiments was also presented in this section. Fig. 5 shows the simulation setup used in the simulation experiments where an eNodeB is deployed to provide service to the application server and a number of user equipment (UEs) within the service range of the eNodeB. The application server generates two types of traffic: RT and NRT traffic. Live video and streaming are considered types of RT traffic while email and instant messaging are considered examples of NRT traffics. For the purpose of the experiments, call requests can either be RT or NRT while call type can either be NC or HC.

Vienna LTE system level simulator was used for the purpose of conducting the simulation experiments. It was chosen because academic and non-commercial license of the software are given free by the developers. The simulator was implemented using Matlab software environment, thereby making it easy for any programmer to use the software with a little knowledge of programming. Table I shows the simulation parameters used for the experiments. These parameters were used for across the implementation of all the three schemes.

TABLE I: Parameters for Simulation Setup

Parameter	Value
Total Bandwidth	5MHz
No. of PRBs used	25
TTI used	1000s
Traffic Arrival	Poisson Process
SST	1000s
Transmission modes	2×2 MIMO, OLSM
Devices distribution	Uniform

For the purpose of this study, table I shows the parameters that were set for a successful simulation experiment. A total of 5MHz bandwidth was used for the simulation experiments. On the other hand, a total of 25 physical resource blocks were used, each block comprising of 12 subcarriers spacing. The time used for the simulation experiment was 1000s and the result was taken by averaging the figures obtained over the total number of simulation experiments conducted. In simple terms, several simulation experiments were conducted, and an average was taken as the final result.

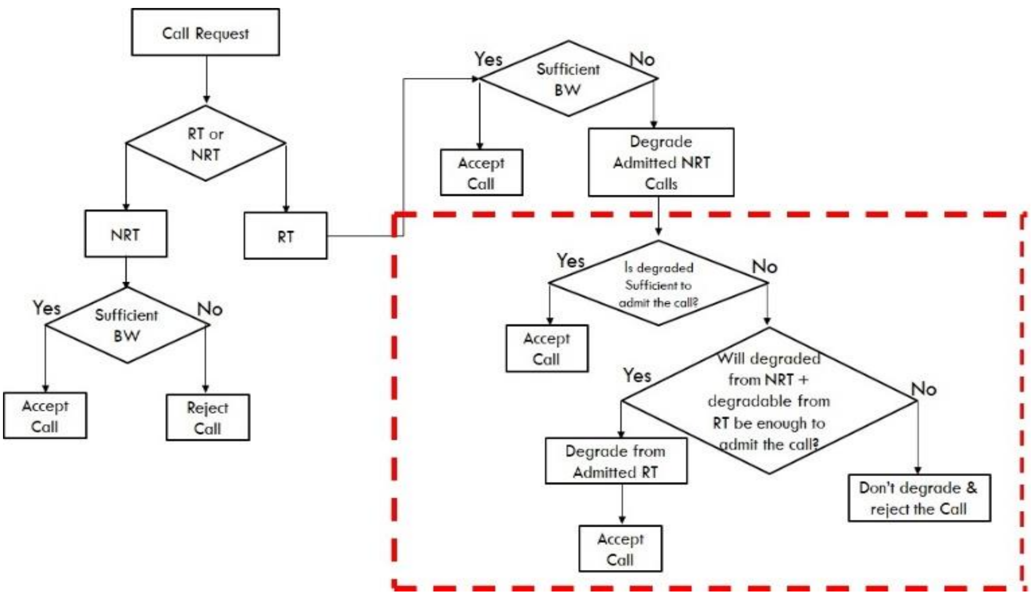

Fig. 4. Flow chart of the EA-CAC scheme.

Several experiments were conducted using 20, 40, 60, 80, 100 and 120 devices. Traffic was generated using Poisson distribution and the percentage of RT and NRT traffic was maintained at 50-50, 70-30 and 30-70 for all the schemes. Therefore, it can be clearly said that different traffic scenarios have been considered while performing the simulation experiments.

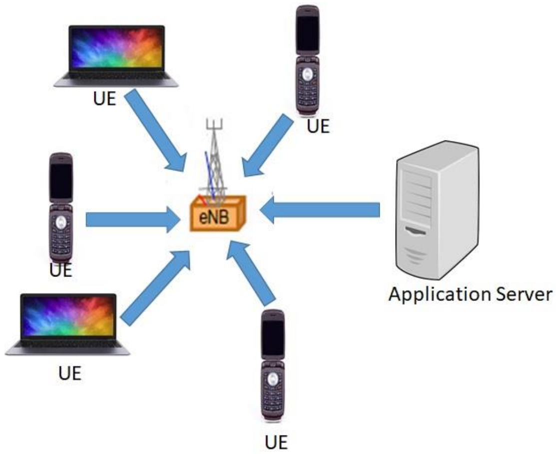

Fig. 5. Simulation Setup.

After performing several simulation experiments, the average of the results was taken as the final results of the experiment. As earlier stated, this paper concentrates on the throughput of the system. In this scenario, we consider throughput as the number of calls admitted into the network over a particular period of time (simulation time in this case).

A. Throughput for RT Calls

Fig. 6 shows the graphical representation of the results obtained by the three schemes for the throughput of RT calls. It can be clearly seen that there is a significant improvement in throughput of RT calls by both QA-CAC and EA-CAC schemes. At the beginning of the simulation experiment i.e., when there is low traffic in the system, all the three schemes maintain almost the same performance by admitting a reasonable/same number of RT calls.

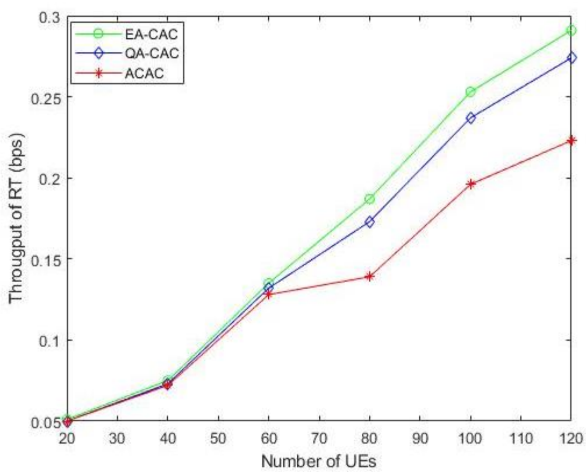

Fig. 6. Throughput for RT call requests.

On the other hand, when the traffic flow increases, the results clearly shows that QA-CAC and EA-CAC schemes admit a higher number of RT calls compared to the ACAC scheme. Taking the average of the simulation results obtained, the improvement in the performance of the two schemes is related to the allocation of maximum required bandwidth that is been done at the point of admission by both QA-CAC and EA-CAC schemes contrary to the allocation of minimum and maximum bandwidth requirements for NRT and RT calls respectively by the ACAC.

Another reason for the improvement i.e., why the two schemes admit more RT calls than NRT is as a result of admitted NRT calls been degraded when there are not enough resources without degrading admitting RT traffics to admit a new call request, this is done in the QA-CAC scheme.

The increase in the performance of the EA-CAC scheme can be attributed to the adaptive degradation strategy that is been employed by the scheme which tends to degrade admitted NRT calls first before degrading RT calls (if the need arises).

The QA-CAC scheme increased the throughput of RT calls by 25% while that of the EA-CAC was increased by 30.1%. This clearly shows that, both QA-CAC and EA-CAC performs better in terms of throughput compared to the ACAC scheme

B. Throughput of NRT Calls

The results obtained for the throughput of NRT calls is shown graphically in Fig. 7. Performance of the three schemes tends to be the same when there is low number of call requests in the system. This can be concluded that, the three schemes admit almost the same number of NRT calls when the traffic arrival rate is low in the system.

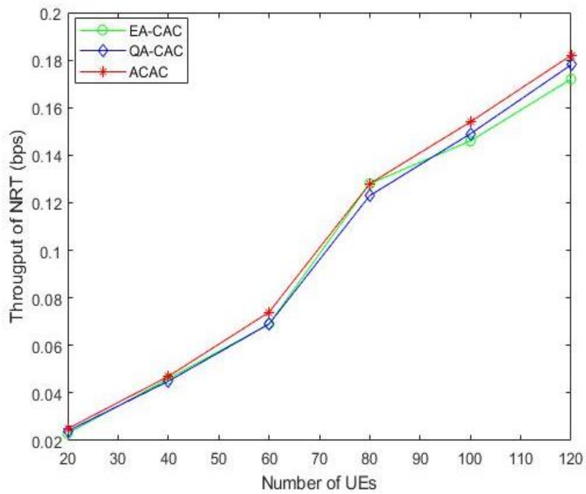

Fig. 7. Throughput for NRT call request.

As the traffic arrival rate increases, ACAC tends to admit more NRT calls than the QA-CAC and EA-CAC. This means that, ACAC admit a greater number of NRT calls as the traffic arrival rate increases in the system. The figure also shows that all the three scheme almost have the same performance both when the traffic arrival rate is low and when it's on the high side. One of the reasons why the ACAC scheme admits a slightly higher number of NRT calls than the other schemes is that the ACAC scheme gives NRT call request i.e., the BE traffic a higher priority than the RT call requests in a scenario where the available bandwidth is not enough to admit a new call request. At that junction, the ACAC scheme degrades admitted RT calls in order to obtain more bandwidth that it can use to admit the new call request.

QA-CAC scheme admits a smaller number of NRT calls compared to ACAC scheme because of the degradation that is been invoked on admitted NRT calls, thereby making the same to admit fewer number of NRT calls. Similarly, the EA-CAC scheme also degrades admitted NRT calls but in a different manner i.e., using an adaptive degradation procedure where a certain class of traffic is degraded first before degrading another class.

Finally, the ACAC scheme increased the throughput of NRT calls by 2.3% while EA-CAC does that by 2.8%. Meaning the increase was not that significant.

V. Conclusion

This paper presented a performance evaluation of some existing call admission control schemes that were proposed for the long-term evolution networks. Three schemes were considered for the performance evaluation which are ACAC, QA-CAC and EA-CAC schemes. The performance evaluation was done using simulation experiments with the aid of Vienna LTE system level simulator. Several Simulation experiments were conducted, and the results obtained were averaged and graphically presented to show the performance. Certain simulation parameters were set for the purpose of having a smooth and consistent simulation experiment. From the results obtained, it shows clearly that the QA-CAC and EA-CAC admits a greater number of RT calls compared to the ACAC. On the other hand, the ACAC tends to perform slightly better than QA-CAC and EA-CAC in terms of admitting NRT call request. Finally, it can be concluded that the QA-CAC and EA-CAC schemes outperforms the ACAC in terms of admitting RT call requests while all the three schemes almost have the same performance in terms of admitting NRT call requests.

Conflict of Interest

Authors declare that they do not have any conflict of interest.

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