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RESEARCH ARTICLE

PRIORITY BASED FAIR RESOURCE ALLOCATION AND ADMISSION CONTROL TECHNIQUE FOR MULTICLASS TRAFFIC IN LTE-ADVANCED NETWORK.

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Abstract

In order to allocate resources for real-time traffic flows to meet their Quality of Service (QoS) requirements, Priority based fair Resource Allocation and Admission Control (PRAAC) technique forMulti-class downlink Traffic in LTE-A networks is proposed. In this technique, priority of the nodes is estimated based on the Tolerance of Latency, bandwidth and data arrival rate. This technique includes a two level resource allocation scheme, wherein the first level a radio admission control (RAC) scheme is introduced. In the second level, RAC combines the complete sharing (CS) and virtual partitioning (VP) resource allocation models. Simulation results show that the proposed technique achieves better throughput for Video and the Exponential traffic performs well when compared to CBR traffics in all aspects.

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Introduction:-

The past few years have brought new possibilities that changed the mobile users' expectations regarding connectivity. New social applications, high-definition multimedia, and other services have made mobile terminals the main connectivity tool for several users, i.e., users want to have the same experience as on a fixed computer. The upcoming standard from 3rd Generation Partnership Program (3GPP) named long-term evolution advanced (LTE-A) targets the support of such high requirements services. Relaying is an appealing technology that was introduced in LTE-A to provide seamless connection and high achievable data rates to the users located in the cell-edge or in coverage holes. Relay nodes (RN) are low power evolved NodeB (eNB) which, when deployed in the macro cell, improve the signal quality between the user equipment (UE) and eNB by dividing the radio link into two hops: the so-called backhaul link between the RN and the eNB, which in this context, is referred to as the Donor eNB (DeNB), and the so-called access link between the RN and the UE [1].

Resource allocation among multiple users sharing the whole spectrum bandwidth is one of the key design tasks in LTE systems. The aim here is to optimally assign resources to those users which need them, keeping in view not only their resource requirements, but also their instantaneous channel quality, instantaneous service quality, and the allocation history. Although, the presence of RN (multi-hop transmission) has proved to enhance the LTE system, it introduces some additional design challenges in the traditional resource allocation task [1]. In order to maintain minimal QoS, proper utilization of the bandwidth in the form of appropriate distribution is to be done. The resource allocation impacts on the applications utilizing the LTE network.

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Non-Real Time (NRT) services must posses minimum bit-rate and Real Time (RT) services require a high level of QoS [12]. The NRT services are bandwidth adaptive and do not require QoS guarantees. Several calls can be accommodated in a system by reducing the allocated bandwidth for the existing NRT traffic calls and by reducing the requested bandwidth for the incoming NRT traffic calls. Though decreasing the same amount of bandwidth from the NRT traffic calls to accept a handover call and a new call reduces the call blocking probability, it cannot reduce the handover call dropping probability significantly [11].

Too much users and limited Resource Blocks (RB) leads to infeasibility in guaranteeing all ongoing users' QoS as a result calls will be blocked and/or lost. Their types are New-call blocking, the failure of the initial call connection establishment and Handoff call dropping, the blocking of in-service calls when they move from one cell to another [9,10]. From user's point of view, it is better to block a new call rather than dropping a call in the middle [12].

The scheduling problem in downlink LTE should provide solution for resource allocation and fairness for all types of classes. The resource allocation should clearly describe the admission control and bandwidth allocation mechanisms.

A novel RAC scheme [13] was proposed for handling multiclass services in LTE systems to maximize the number of admitted users to enhance the system capacity. A combined complete sharing (CS) and virtual partitioning (VP) resource allocation model was presented for optimization and a service degradation scheme was found out for resource limitations. But it fails to present the standard techniques to determine the priority of each user of each class. Moreover fairness among the users of same group is not handled.

Literature Review:-

Mohammad J. Abdel-Rahman et al [3] have proposed novel stochastic joint channel and BS allocation schemes that account for uncertainty in channel availability. First, they developed two static (proactive) joint allocation models. They referred to these models as Het-SMKP1 and Hom-SMKP. In these models, the allocation is done once such that user demands are probabilistically met. In Het-SMKP1, a user can request different probabilistic rates for different small cells, whereas in Hom-SMKP each user requests the same probabilistic rate for the entire network. Second, they proposed an adaptive (proactive and reactive), two-stage allocation model for heterogeneous rate demands, which they referred to as Het-SMKP2. The adaptive model allows for correcting the initial resource allocation once the channel availability uncertainties are partially resolved.

DardouriSamia et al [4] have proposed a scheduling algorithm in two levels based on cooperative game theory, aiming at improving performance and justice in the distribution of radio resources. Simulations demonstrate that the proposed algorithm improve the level of the system's QoS more effectively than other algorithms under the circumstance that guarantees users minimum QoS requirement.

NasimFerdosian et al [5] have presented a greedy algorithm to evaluate user candidates which are waiting for scheduling and select an optimal set of the users to maximize system performance, without exceeding available bandwidth capacity. The greedyknapsack algorithm is defined as an optimal solution to the resource allocation problem, formulated based on the fractional knapsack problem. A compromise between throughput and QoS provisioning is obtained by proposing a class-based ranking function, which is a combination of throughput and QoS related parameters defined for each application.

MundeleTshienda Serge et al [6] have proposed optimal resource allocation strategy.In this method two variants of technique called Queue Based Control (QBC) are presented. These two variants are QBC version 1 and QBC version 2. Performance of QBC version 1 and QBC version 2 showing that QBC version 1 is having better Delay and Los performance as compared to QBC version 2, and QBC version 2 is having better power consumption performance as compared to QBC version 1. It means both this techniques are based on concepts of carrier aggregation of LTE networks. Both approaches showing that, they failed to address the tradeoff between power efficient and QoS efficiency.

M. J. Rezaei et al [7] have proposed a new fairness index to measure resource allocation performance for real-time/delay-tolerant applications. This index can suggest a new approach for resource allocation. There are several methods in resource allocation of cellular networks which employ fairness index for performance evaluation. Here, they focused on utility-function-based resources allocation and related algorithms. According to the suggested method, the base station (BS) allocates resources based on different services requirements. Appropriate utility function for each application is defined, and the requested quality-of-services (QoS) are satisfied through solving the corresponding optimization problem.

Proposed Solution:-

Overview:-

Based on the problems identified, we propose to develop a multi level resource allocation technique for prioritized multi-class downlink traffic flows in LTE-A networks. Here the priority of the user class will be determined based on the parameters such as class type, Data Arrival Rate, Requested bandwidth, Bandwidth Utilization and Tolerance Level. Once the priority is determined, using the CS and VP schemes, resource will be allocated to the various classes of the traffic as per [13].

In this approach initially, when the data packets arrives, the node enters into the first level. In this level, the priority of the node is checked based on the fault tolerance, data arrival rate and bandwidth. In the second level the resource required for the nodes is allocated based on the complete sharing (CS) and virtual partitioning (VP) schemes. This schemes describes whether a service data flow can drop the resources allotted to it in order to acknowledge a service data flow with a higher priority level.

Priority Assignment:-

Data Arrival Rate:-

Through the data arrival rate, it is possible to estimate the number of data packets received by a node in the network.

$$r_a = \frac{s_i}{R} \quad (1)$$

Where,
r_a is the data arrival rate
$s_i$is the data packet size
R is the data rate.

Utilized Bandwidth;-

The utilized bandwidth by the nodes in the network is estimated by the following equation
$B_u = B - r_k$ (2)
Where,
B_u is the utilized bandwidth
B is the total bandwidth

Tolerance of Latency (TOL):-

Along with the user's requirement of resources, the tolerance of latency (TOL) is also specified which indicates the minimum level of delay the user can expect. It ranges from 0 to 2, where 0 stands for no tolerance, 1 for medium level and 2 for highest tolerance.

Setting Priority of Users:-

Initially the node's data arrival rate, utilized bandwidth and TOL are estimated.
If DA >DA_{th} and BW >BW_{th} and TOL = 0
    Then set Pr = 4
Else If DA >DA_{th} and BW >BW_{th} and TOL = 1
    Then set Pr = 3
Else If DA >DA_{th} and BW <BW_{th} and TOL = 1
    Then set Pr = 2
Else If DA >DA_{th} and BW <BW_{th} and TOL = 2
    Then set Pr = 1
Else If DA <DA_{th} and BW <BW_{th} and TOL = 2
    Then set Pr = 0

Resource Allocation:-

According to the resource allocation, the pre-emption vulnerability information describes whether a service data flow can lose the resources allotted to it in order to admit a service data flow with a higher priority level. Therefore, the network categorizes the multiclass services into three groups.

- Group 1 represents the services where the resources can be pre-empted.
- Group 2 and 3 are for services where the resources cannot be pre-empted while group 2 can pre-empt the resources that are allotted to services in group 1.
- Group 3 can be described based on the traffic flows that need to provide a guaranteed bit rate while service groups 1 and 2 have to provide a variable bit rate.

These groups are respectively discussed to as “guaranteed bit rate” and “maximum bit rate”.

Complete Sharing (CS) and Virtual Partitioning (VP) Schemes:-

Here the resource allocation method adopts the basic concept of the Complete Sharing (CS) and Virtual Partitioning (VP) schemes and keeps the system ready for resource allocation in using radio admission control scheme. Here in radio admission control scheme according to the feature of every service group, within service group 1, network have CS, where each service class shares the nominal bandwidth B1. Groups 2 and 3 also have CS and the nominal bandwidth B2 is completely mutual. In group 1 and 2 have VP, where the nominal bandwidth B2 is fully utilized and also acknowledge some traffic of service group 2 subject to pre-emption by degradation of the services in group 1 by which the system capacity can be enlarged.

i.

$$r_k = \begin{cases} r_k^g, & \sum_{i=1}^{1}\sum_{j=1}^{n_i} \mathrm{r_j} + r_k^g \le B1 \\ r_k^{\max}, & \sum_{i=1}^{1}\sum_{j=1}^{n_i} \mathrm{r_j} + r_k^{\max} \le B1 \\ 0, & \text{otherwise} \end{cases} \qquad (3)$$

Where,

r_k is the instantaneous bandwidth allocated to service class k user;

r_k^g is the guaranteed bit rate of service class k;

r_k^{max} is the maximum bit rate of service class k;

B1 is the nominal bandwidth for Group 1,

where $B1 = \alpha * B$;

B is the total amount of bandwidth available in the system;

α is the ratio of nominal bandwidth to system capacity for Group 1;

ii.

$$r_k = \begin{cases} r_k^g, & \sum_{i=l+1}^{K}\sum_{j=1}^{n_i} \mathrm{r_j} + r_k^g \le B2 \\ r_k^{\max}, & \sum_{i=l+1}^{K}\sum_{j=1}^{n_i} \mathrm{r_j} + r_k^{\max} \le B2 \end{cases} \qquad (4)$$

Where,

K is the total number of service classes where Group 1 includes traffic classes from 1 to l, Group 2 includes traffic classes from l+1 to m and Group 3 includes traffic classes from m + 1 to K;

B2 is the nominal bandwidth for Group 2 and 3,

where B1 + B2 = B

iii.

$$r_k = \begin{cases} r_k^g, & \sum_{i=l+1}^{K}\sum_{j=1}^{n_i} \mathrm{r_j} + r_k^g > B2 \; and \; \mathrm{R_a} \geq r_k^g \\ 0, & otherwise \end{cases} \quad (5)$$

Where,
R_a is the service degradation.
iv.

$$r_k = \begin{cases} r_k^g, & \sum_{i=l+1}^{K}\sum_{j=1}^{n_i} \mathrm{r_j} + r_k^g \leq C2 \\ 0, & otherwise \end{cases} \quad (6)$$

During the resource allocation in the network the Radio Admission Control (**RCA**) rules combines the CS resource allocation and VP resource allocation models.

When a new call is organised in service class k which belongs to service group 1 and the remaining bandwidth in Group 1 is greater than or equal to r_g^k, the call is acknowledged into the system; otherwise the call is excluded. The allotted bandwidth r_k is given by (3).

In the second rule a new call in service class k which belongs to service group 2 and the residual bandwidth in Group 2 and 3 is greater than or equal to r_g^k, the call is admitted into the system and the allotted bandwidth r_k is given by (4).

If a new call in service class k which belongs to service group 2 and the remaining bandwidth in Group 2 and 3 is less than r_g^k, according to pre-emption over Group 1, network assume that the bandwidth consumed by using the service degradation R_a. If R_a is larger than or equal to the necessary bandwidth, the call is admitted into the system; else the call is rejected. The allotted bandwidth is given by (5).

When a new call which belongs to service group 3 in service class k and the left out bandwidth in Group 2 and 3 is larger than or equal to r_g^k, the call is sent the system else the call is rejected. The allotted bandwidth r_k is given by (6).

Simulation Results;-

Simulation Model and Parameters:-

In this section, we simulate the proposed PRAAC scheme using Network simulator (NS2) [14] which is a general-purpose simulation tool that provides discrete event simulation of user defined networks. We have used the LTE/SAE implementation model for NS2. We compare the proposed PRAAC scheme with the radio admission control (RAC) scheme.
The simulation parameters are given in Table 1.

Table 1:- Simulation Parameters

Number of cells	5
Number of eNB	5
Number of UE	31
Area Size	1200x1200
Simulation time	50 seconds
Traffic Type	CBR, Exponential and Video
Packet Size	500,750,1000 and 1250 bytes
Total Bandwidth	100Mb
Traffic Rate	10Mb
MT Speed	30m/s

Transmission power	40 dBm
Scheduling duration	2 ms
Cell radius	500m
Number of Flows	6,12,18 and 24.

The scenario is defined for the urban macrocell environment of 1000m with heterogeneous distribution of users and services. The simulation consists of 5 cells and the users are occupied in 1200 m x1200 m NS2 simulation grid. The simulation time take 50 seconds, depending on the growing number of users and BSs in the network as well as its load, thus consuming a substantial amount of time. The simulation topology is given in the Fig 1.

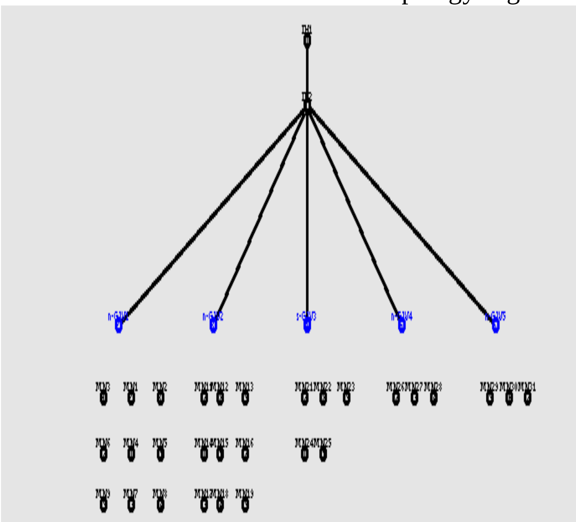

Fig 1:- Simulation Topology

Traffic generators in NS2

In order to make the simulation results more reliable different traffic generators that have a diverse range of statistical properties are used. This helps to analyze the network performance more effectively. In this research work, three applications are considered namely CBR VoIP, Exponential VoIPand Video traffic.

CBR Traffic

CBR traffic generate packets at fixed bit rate and it come under guaranteed bit rate. The applications include services such as video conferencing, telephony (voice services) or any type of on-demand service, such as interactive voice and audio. Configuration parameters for CBR traffic are presented in Table 2

Table 2 Parameters for CBR traffic

Parameters	Values	Discription
Packet Size	210	Application payload size in bytes
Rate	488 x 103	Sending Rate in bps
Max.packets	167	Max. number of application payload packets that CBR can send
Interburst transmission interval	3.44 ms	-

Exponential Traffic

Exponential traffic generates On/Off periods. During "on" periods, packets are generated at a constant bit rate. During "off" periods, no traffic is generated. Burst times and idle times are taken from exponential distributions. The application includes real time VoIP, compressed audio and video. The configuration parameters are described in Table 3

Table 3 Parameters for Exponential traffic

Parameters	Values	Description
Packet Size	210	Application Payload size in bytes
Rate	64×10^{3}	Sending rate in bps during ON period
Burst time	0.5	Average On period in secs
Idle Time	0.5	Average Off Period in secs

Video as Trace file

The video flow is a trace-based application that sends packets based on realistic video trace files. Traffic trace generates payload burst according to given trace file. Trace objects are used to generate traffic from a trace file. Unlike other traffic generators, traffic trace file is to be specified in the OTcl domain using the OTcl command. A trace file consists of any number of fixed length records. Each record consists of two 32 bit fields. The first indicates the interval until the next packet is generated in microseconds. The second indicates the length of the next packet in bytes. The application includes VBR H.264 compression video. Context Adaptive Binary Arithmetic Coding (CABAC) which is used as entropy coding. The video size considered here is 1920 *1080 with frame rate of 30.

Results:-

Performance results for the proposed (PRAAC) method

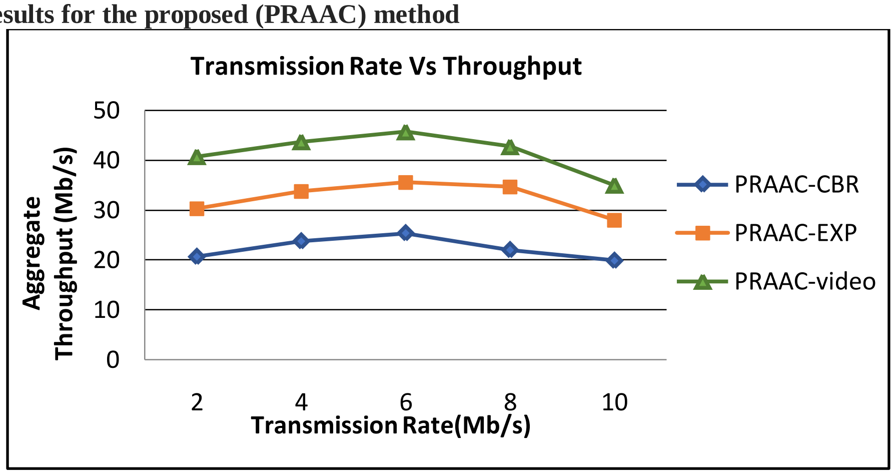

Fig 2 Aggregate Throughput performance of PRAAC method for various types of traffic

Figure 2 shows aggregate throughputversus transmission rate for CBR, Exponential and Video traffic based on the proposed PRAAC method for 40 number of users. Aggregate throughput is the sum of throughput that is delivered to all terminals in a network.

From Figure 2 it can be observed that the video traffic by adopting H.264 compression standard achieves better throughput such that the video bit stream are improved and consequently experiences an enhanced fluent video quality. Further the throughput of Exponential traffic outperforms CBR traffic. It is because the exponential traffic allows a higher bitrate to be distributed to the more complex segments of audio/video files while less space is allocated to less complex segments. i.e., it adjusts the bit rate down and to the upper limit based on the data required by the system. While CBR traffic will not realize the differentiation between the more complex segments and less complex segments and maintains constant bit rate over the entire audio/video clip. This leads to congestion in the network and thus decreases the throughput when compared to the exponential traffic.

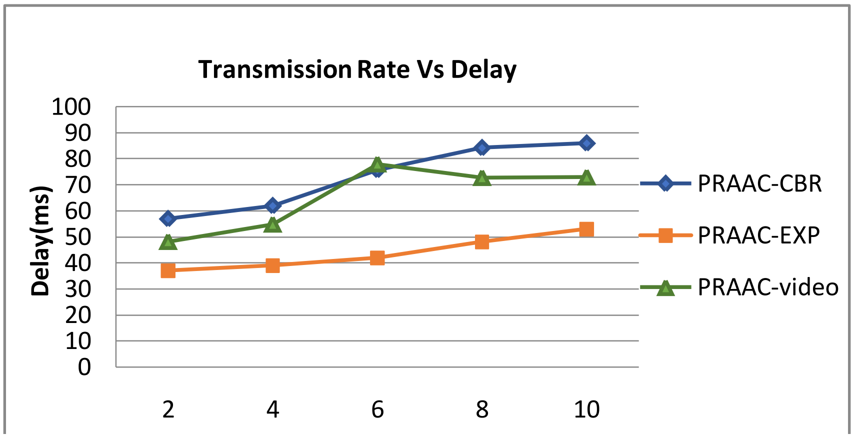

Figure 3 Delay performance of PRAAC method for various types of traffic

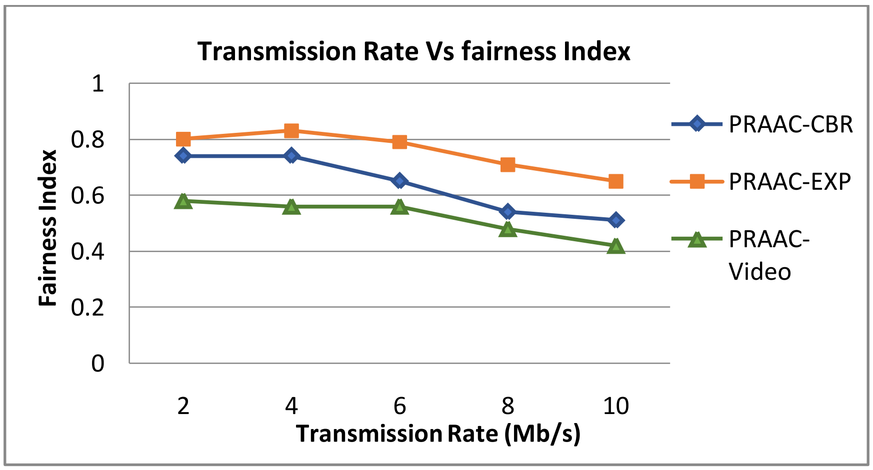

Figure 4 Fairness Index performance of PRAAC method for various types of traffic

From Fig 2 it can be observed that the video traffic by adopting H.264 compression standard achieves better throughput such that the bit stream are improved and experience a enhanced fluent video quality. Further the throughput of Exponential traffic outperforms CBR traffic. It is because the exponential traffic allows a higher bitrate to be distributed to the more complex segments of audio/video files while less space is allocated to less complex segments. i.e., it adjusts the bit rate down and to the upper limit based on the data required by the system. While CBR traffic will not realize the differentiation between the more complex segments and less complex segments and maintains constant bit rate over the entire audio/video clip. This leads to congestion in the network and thus decreases the throughput when compared to the exponential traffic.

Fig 3 shows Delay versus transmission rate for CBR, exponential and video traffic based on the proposed PRAAC method with the number of 40 users. The figure shows that there is dramatic increase in the delay of CBR traffic when compared to Exponential traffic. This is due to the characteristics of CBR sources whose constant stream of packets cause traffic congestion. Further it can be observed that the video traffic also realizes unpredictable delay when compared to Exponential traffic. It is because of the bursty nature of video traffic and high storage space. As known H.264 has complex process which is more susceptible to errors when compared to CBR VoIP and Exponential VoIP.

Fig 4 illustrates Fairness Index versus transmission rate for CBR, exponential and video traffic achieved by the proposed PRAAC method with the same fixed number of 40 users. From the figure it can be seen that when the transmission rate increases the network experiences better fairness for the Exponential traffic when compared to CBR and Video traffic and also it depicts that the average throughput only reflects the long term fairness.

Conclusion:-

In this paper, Priority based Fair Resource Allocation and admission control Technique (PRAAC) for Multi-class downlink Traffic in LTE-A networks is proposed. It includes a two level resource allocation scheme, wherein the first level a radio admission control (RAC) scheme is introduced. This RCA combines the complete sharing (CS) and virtual partitioning (VP) resource allocation models. Through this approach it is possible to achieve an enhanced Quality of Service (QoS) for multimedia services mainly in LTE downlink system. Simulation results show that the proposed technique PRAAC achieves better throughput for Video and the Exponential traffic performs well when compared to CBR traffics in all aspects.

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