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Efficient Delivery of Video Services to Unicast and Multicast Users by Subgroup Formation based on Channel Quality and Distance

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Abstract: As we knew that the mobile multimedia is one of the main sources of revenue for telecommunication industries, subscribers are often interested to receive data with the same rate and so it is necessary to handle both unicast and multicast traffic together efficiently and to increase user satisfaction. This paper proposes a virtual unified group approach (VUG), they forms sub-groups base on channel quality and the distance between the users within the unicast virtual groups and multicast groups. This will enhance the system performance as shown in the simulation results, in terms of throughput and the distribution of resources to unicast and multicast traffic.

I. INTRODUCTION

As we know, unicast mode deals with the transmission of the packet from a source to a defined destination, is still the predominant form of transmission on LAN and within the internet. All LANs (e.g. Ethernet) and IP networks support the unicast transfer mode, and most users are familiar with the standard unicast applications (e.g. HTTP, SMTP, and telnet). Coming to the next mode of transmission, that is the multicast mode in which data or the packet is transmitted from a single or multi-source to one or more destinations. An example of the application of multicast mode is in video server in TV channel, as it is required to transmit high-quality video to a large number of the user, that could even collapse high bandwidth video servers, here multicast mode is applicable. That is, a multicast mode of transmission is highly applicable if there is a group of clients requiring the same data at the same time or when the clients are able to receive and store (cache) common data until needed, this will highly reduce the required bandwidth. The telecom operators require dealing with a number of requests to receive same services, ie; multicast and the traditional unicast requests. On dealing with both services, it is essential to make sure that the resources are allocated to the users efficiently and they achieve efficient spectrum utilization. Also in the future the wireless mobile multimedia services will occupy a large portion of mobile data traffic cisco [1] (by 2021, 78 percentage of the mobile data traffic will be covered by video, which was 60 percent-age in 2016) so it is necessary for the mobile networks to handle this increasing demand which can be multicast or broadcast in nature.

In dealing with both unicast and multicast traffic, it is essential to consider efficient resource allocation between them but this is one of the main challenges faced as both uses different transmission modes. In case of unicast traffic, as we have to deliver the data to a single user, the Modulation and Coding Scheme (MCS) is chosen according to the channel conditions of that single user, whereas in the case of multicast traffic data is delivered to a group of users and the user with unfavorable channel state enforce the selection of MCS of the given group.

There were different approaches for the joint management of both the traffic like equal sharing (ES), equal competition (EC), unicast maximization (UM), and VUG. In ES the total available resource is equally shared between unicast and multicast traffic, this does not support dynamic load variation. Whereas in EC both the traffic compete for the resource, but the system gives higher priority to one which increases the throughput that is the multicast traffic. Com-ing to UM approach, as the name suggests it gives higher priority to unicast traffic, and provide only a minimal amount of resource to multicast. The next method is VUG, which is the most effective one in which unicast users forms a virtual group and several sub-groups are formed within these virtual groups and this approach will help to deal efficiently with both unicast and multicast traffic [2]. In this paper we proposes an efficient method for enhancing the VUG approach by forming subgroups within the unicast and multicast user groups based on channel quality and distance between users.

The remaining sections of the paper is as follows: the section II deals with the literature survey on the multicast and unicast traffic, in the next section we have the improved VUG approach and the following sections deals with simulation results and conclusion respectively.

II. SIMILAR WORKS

A. Handling of Different Multicast Groups

Many works in the literature have addressed the issues in efficient delivery of multimedia services to various multicast subgroups simultaneously when they are dealed by a single BS. In these cases multi-layer video encoding is used in which a video stream is encoded in to different layers. In order to maximize the utility function, the number of receivers per video layer is modified in the basis of the channel conditions and the available bandwidth. The authors of [3] focuses on the discovery of a utility-based resource distribution method for layer encoded IPTV multicast services, they also shows that the main issue in discovering the best subset of users in each multicast group is NP-hard, and they introduces an access that can run in polynomial time. Similarly, the works in [4] and [5] follow an identical approach of that of [3], by introducing a near-optimal algorithm for subgroup management. In [4], presents a fast greedy algorithm for the fair resource allocation. Authors in [5] aims to increase the total system utility, in order to achieve this we assume that all receivers should not receive the base layer, few video layers will be dropped or a part users does not receive any layer. Finally, [6] defines a theorem to transmit multicast data in burst and thereby to save the energy of mobile receivers. The prime demerit of these works is the presence of real-time services, rather than the more realistic case wherein such applications co-exist with unicast users.

B. Managing of Both Unicast and Multicast Traffic

When dealing with the collective management of unicast and multicast traffics the prime trends are unicast maximization (UM), equal sharing (ES), equal competition (EC), virtual unified group (VUG).The unicast maximization method gives priority to unicast traffic, which guarantees a minimum data rate to the multicast traffic and provides the residual resources to the unicast traffic in order to increase the throughput. An example of this method in multicarrier orthogonal frequency division multiplexing (OFDM) as in [7] and [8].The second method is ES in which the resources available is shared equally by both unicast and multicast traffic. This method prevents any one of the traffic to utilize the resource provided to the other traffic. This seems to be fair, but the problem is that this method cannot adapt to the dynamic load variation. This is explained in [9], which where a power saving algorithm that manages mixed unicast and multicast traffic is presented. The next method is EC, in which both traffic compete equally for the resource. That is, its main goal is to provide a minimum data rate to unicast and multicast traffic and the remaining resource is allocated to the one which maximizes the throughput. An example of this method is explained in [10], in which the available resource is assigned either to unicast or to multicast so that it will increase the sum of available logarithmic data rates. So as our goal is to maximize the system throughput, this method provides greater priority to multicast users as it could a number of users in a single transmission. In all the above methods doesn’t really provide an efficient method for collective management of unicast and multicast. So another method is suggested in [11] that is the virtual unified group approach (VUG) in which the unicast users form a virtual group and so they can compete on equal footing with multicast users for the available resources. The simulated results show the fairness in the distribution of the resource. In [2] shows a small variation in the above method but with the high fair result. That is, by forming subgroups based on the channel condition within the virtual groups, VUG with subgroups will enhance the performance of the system. To further enhance the results we propose to form the subgroups based on the distance along with the subgroups based on channel quality within the virtual subgroups and within the multicast groups.

III. THE PROPOSED VUG APPROACH

We consider a cell with unicast and multicast traffic. Video streaming is one of the most dominant reason for network traffic. This will increases the workloads of video servers, and they get slowdown. In our case we employ a multi-layer video coding in which the video stream is divided into a base layer and a number of enhancement layers. On receiving the base layer the users can make use of the video stream and the quality of video depends on the number of enhanced layers received.

In the VUG algorithm the base layer is delivered to all the users while it try to deliver the possible additional enhancement layers. In order to achieve this, the unicast users are organized into a virtual group as similar to multicast groups. The groups are known as virtual as the users in the group are not interested in receiving the same type of date as multicast users. Further subgroups are formed inside the virtual groups by grouping the users with similar channel qualities. This will provide a homogeneous environment from the delivery point of view. As the unicast users are interested in receiving different videos with the different data rate, this will create a heterogeneous environment. To enhance the throughput and resource allocation of the system, groups are formed inside the virtual subgroups and within the multicast group(s) based on the distance between the users in them. That is we calculate the distance between the users and the users with least distance is grouped to one and the remaining forms the other subgroup. The behavior of the system is parallel to the data’s gathered by the BS from all the UEs regarding the measured quality on the downlink.

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These operations of the proposed enhanced VUG approach are summarized in fig 1. The symbols mentioned in this paper are outlined in table 1 and sum of them are taken from [2].

A. Steps of the Proposed Method

The details of VUG are described by the following steps:

1) *Monitoring of Channel Conditions:* The channel conditions are monitored by collecting the channel state information (CSI) from all users and accordingly computing the MCS.This step is repeated in regular time intervals so that the transmission parameters can adapt to the channel variations experienced due to the mobility of users.

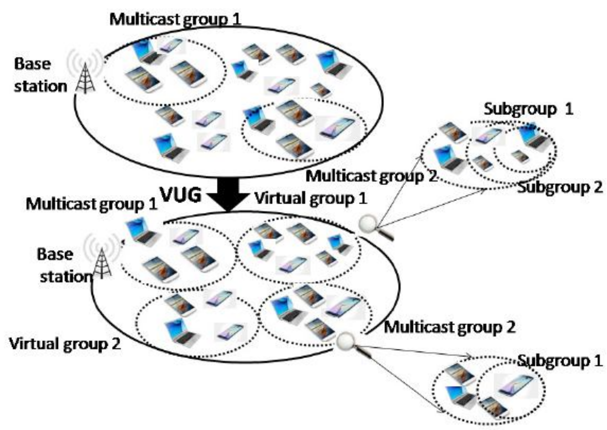

Fig. 1: The Proposed VUG technique

Table 1 Summary of symbols [2]

T	period of a frame
N	Number of usable resource
C	Maximum number of MCS levels
U	User set
${}_{G}mul$	Multicast group set
${}_{G}uni$	Virtual group set
${}_{Ug}mul$	Set of users in multicast group g
${}_{Ug}uni$	Set of users in virtual group g
Ls;u	Amount of layers for the transmission of video s to user u
${}^{d}s;u;l$	Amount of bits required for the transmission of layer l of video s to us
$S_{g;m}^{uni}$	Set of users for subgroup relevant to the mth virtual group g
$S_{g;d}^{uni}$	user set for the subgroup based on the distance between users in virtual
$S_{g;d}^{mul}$	user set for the subgroup based on the distance between users in multi
$r_{g;m}^{uni}$	Amount of resources allocated to the subgroups with in the virtual group
$b_{g;m}^{uni}$	Amount of bits required by subgroup related to the mth MCS of virtual
${}_{au}uni$	Amount of resources already allocated to user u

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2) *Formation of Groups:* Here the total users in the cell are organized into different groups of multicast and unicast. That is the users interested in same data forms multicast group g G^{mul}, and form the userset U_g^{mul} and the remaining forms virtual unicast group(s), g G^{uni}, and form the user set U_g^{uni}, it is known as the virtual group as the users are requesting to different types of data. A multicast group can be formed even if there are only two users interested in the same type of data, and if the multicast users reduces to one, then they joins to the virtual group. It is best suited to have the size of virtual group not greater than the multicast group in the cell. Also, if the size of the virtual group is higher, more advantage is taken by the unicast group(s).
3) *Subgroups Formation:* The virtual group is again organized to form subgroups of users having same channel qualities. So that the users in the subgroup can receive data based on the best channel quality available in the group. Let $S_{g;m}^{uni}$ U_g^{uni} indicates the subset of users of the virtual group g G^{uni} that support the m-th MCS level.This is to include users which can support individual m_u greater or equal with the m-th MCS level associated with that sub-group as in [2], which can be written as:

$$S_{g,m}^{uni} = u\epsilon U_g^{uni} \mid m_u \geqslant m \quad \forall g\epsilon G^{uni} \qquad (1)$$

Further to increase the efficiency of the system we again form groups inside the virtual subgroups and in the multicast groups based on the distance between the users within them. Let $S_{g;d}^{uni}$ =u U_g^{uni}; 8_g G ^{uni} and $S_{g;d}^{mul}$ = u U_g^{mul}; 8_g G^{mul}, be the sub-groups within virtual subgroup and multicast groups respectively. As these groups are formed based on the distance between users, initially, we find the positions of each users (x_i; y_i),then we calculate the distance between the users by euclidean formula by considering location of one of the user as reference point (x,y).

$$D_i = \sqrt{(x - x_i)^2) + (y - y_i)^2} \qquad (2)$$

Now find the minimum of D_i, that two users achieving this will form a group and the remaining once forms the other group.

4) Base layer allocation: We assume that in order to provide a minimum video service to each user in the cell, all of them should provide at least a single base layer of the requested video services. The amount of resources essential for the transmission of the base layer to the multicast group ($r_{g;m}^{mul}$) and the virtual group ($r_{g;m}^{uni}$) is given in [2] as:

$$r_{g,m}^{mul} = \lceil d_{s,u,1/c(m)} \rceil, \quad if g\epsilon G^{mul}$$
$$r_{g,m}^{uni} = \Sigma_{u\epsilon S_{g,m}^{uni}} \lceil d_{s,u,1/c(m_u)} \rceil, \quad if g\epsilon G^{uni} \qquad (3)$$

$$\text{Where } m = min_{u\epsilon S_{g,m}^{uni}} \{m_u\} \quad m_u\epsilon 1, 2, ...C$$

we calculate the amount of resources required by the multicast group is based on number of bits of the base layer of the requested video service and the transport block size related to the MCS of the user in the worst channel condition. Whereas the in the case of virtual group the amount of resource is calculated as the sum of resources assigned to each user in the group.

5) Enhancement layer allocation: Once we allot the base layer to all users in the cell, even then if the resources are still available the base station randomly assign this to any group (virtual group or multi-cast group) such a way that the efficiency of the system is increased. For every set of subgroups in the virtual group, the base station cal-culates the required number of bits, then it selects the subgroups to serve and then it assigns the resource to it as given in [2];

$$\text{Let } Y = \Sigma_{l=1}^{L_{s,u}} d_{s,u,l}$$

$$b_{g,m}^{uni} = \frac{1}{\mid S_{g,m}^{uni} \mid} \quad \Sigma_{u\epsilon S_{g,m}^{uni}} (Y - a_u^{uni} c(m_u)), \quad if g\epsilon G^{uni} \quad (4)$$

After the determination of required resource of each subgroup, the algorithm selects a group that increases the throughput of the system as in [2]:

$$\hat{g}, \hat{m} = argmax_{g\epsilon G^{uni}, m\epsilon 1,2,...C} \quad \{b_{g,m}^{uni} \cdot \mid S_{g,m}^{uni} \mid\} \qquad (5)$$

Then we calculate the amount of resources to be assigned to the selected subgroup as [2] as:

$$\text{Let } c = \lceil b_{\hat{g},\hat{m}}^{uni} / c(\hat{m}) \rceil$$

$$r_{\hat{g},\hat{m}}^{uni} = c \quad if \{b_{g^*,m^*}^{uni} \cdot \mid S_{g^*,m^*}^{uni} \mid\} < \{b_{\hat{g},\hat{m}}^{uni} \cdot \mid S_{\hat{g},\hat{m}}^{uni} \mid\} \qquad (6)$$

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If a virtual group is selected, for increasing the throughput of the system, the user with best channel quality is iteratevly selected by the base station as described in [2]:

$$\hat{u} = argmin_{u\epsilon S_{\hat{g},\hat{m}}}\left\{(Y - a_u^{uni}c(m_u))/c(m_u)\right\}$$

$$s.t. \quad u = argmax_{u\epsilon S_{\hat{g},\hat{m}}}\{m_u\} \qquad (7)$$

As we select a unicast user u^ ,the base station assign the required resource for it, if the available resources are higher than requested by the user,then we iterate the resources until the resources are made available for the selected virtual subgroup.

IV. TESTING SETUP AND SIMULATION RESULTS

A. *Experimental Plan and Assessment Metrics*

We test the performance of our system using Matlab simulation under a LTE network managed by ENodeB. The reason why we use LTE is that it provide low latency, high system capacity and spectral efficiency compared to other networks. Also, by implementing MBMS,LTE can by used to support multicast transmission efficiently in both core and radio access networks [12].The performance of the system is analyzed in terms of the following parameters:

1) Average throughput: it is the packets delivered successfully during the simulation time, which is represented in bits per second.
2) Inter-Class Throughput Distribution (ICTD): It is used to calculate the equity in throughput of both unicast and multicast traffic and can be calculated as mentioned in [2] as :

$$ICTD = 1 - \frac{t_{avg}^{uni}}{(t_{avg}^{uin} + t_{avg}^{mul})} \qquad (8)$$

Where t^{uni}_{avg} and t^{mul}_{avg} shows the moderate value of ratio between experienced data rate and maximum sustained data rate all unicast and multicast respectively. The optimal value of ICTD is 0.5, that is, both unicast and multicast traffic has fair throughput, and if its value is greater than 0.5 ,it shows that multicast transmission has higher throughput, if it is less than 0.5, higher throughput is fo unicast traffic. This kind of information can be obtained from GDI [13] or Jain's fairness index [14] parameters.

3) User Equipment per video layer: This parameter measures how much users in the cell receive same video layer.
4) Assigned resources: It evaluate how resources are partitioned between the traffic in the cell.

B. *By Varying the Number of Unicast Users*

Here we consider the unicast users are varying from 10 to 50 and multicast traffic is fixed, and then we checkout the performance of above mentioned policy. We first analyze the performance in terms of ICTD and the result is as shown in fig 2, and this result is compared to the existing VUG approach and to the ES. It is very clear from the graph that the modified VUG approach has a fair distribution of throughput com-pared to the other two methods as its performance is close to 0.5. Also, the ES give more preference to multicast users and the existing VUG approach achieves only a near fair throughput distribution. The performance of modified VUG approach that is VUG with more subgroups is also highlighted in terms of its throughput.

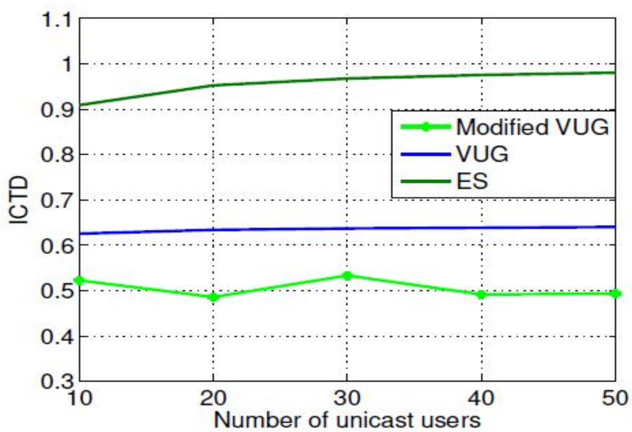

Fig. 2: ICTD of the system

It is very clear from fig 3 that the modified VUG approach has higher average cell throughput than the existing VUG method and that of ES. It can be seen from the figure that the throughput decreases slightly as the unicast users decreases in both cases, that is in existing and modified VUG approach, the reason for this is that these approaches are aimed to achieve fairness in throughput distribution between unicast and multicast users. Also, the throughput is decreased in ES method also, as it gives more preference to multicast users even though the cell is more with unicast users.

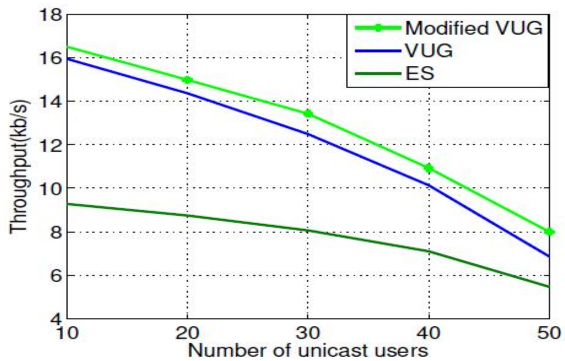

Fig. 3: Average cell throughput

From fig 4 it is very clear that by varying the number of unicast users the throughput of multicast users are very high compared to the existing VUG approach and the ES method. The subgrouping inside the VUG brought this change but we can see that as the unicast traffic rises the throughput decreases this is because the system has to keep the fairness in resource allocation.

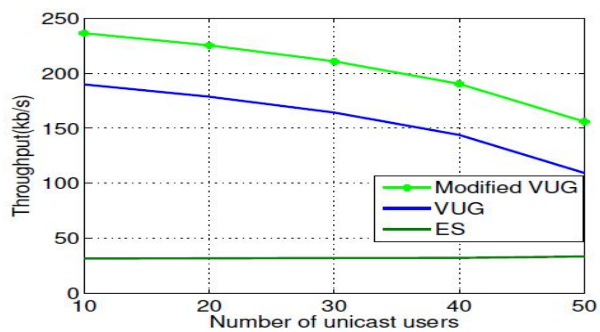

Fig. 4: Throughput of multicast users

The fig 5 shows the percentage of UEs per video layer for an increasing number of unicast users and a fixed number of multicast users. This is used to evaluate the performence in terms of average video quality delivered to both unicast and multicast users. The fig 6 depicts the percentage of resources assigned between unicast and multicast services.

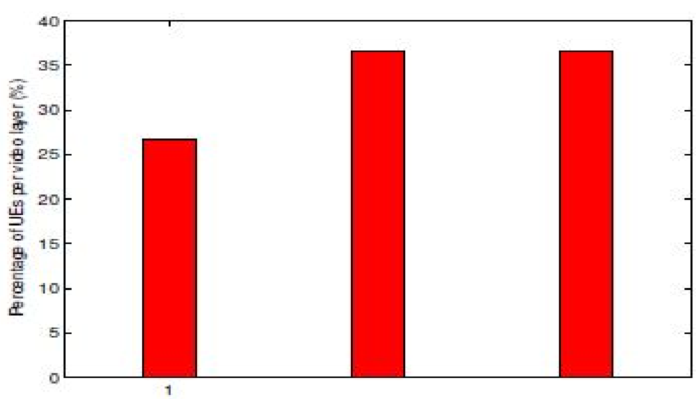

Fig. 5: User per video layer in 10 unicast UES scenario

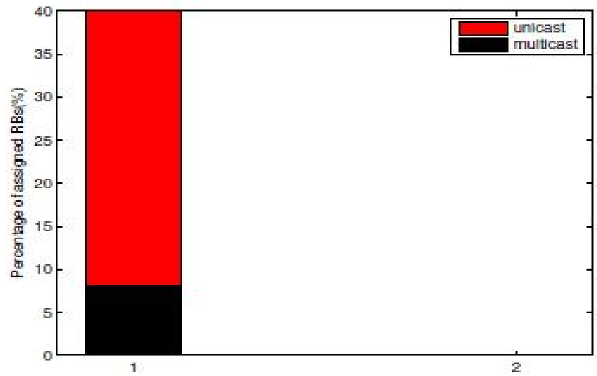

Fig.6: Assigning of resources with 20 unicast UEs

C. The Impact Of Multicast Users

This section deals with evaluating the performance of the system by varying the number of multicast users and keeping the unicast users fixed.

First we evaluate the performance of the system in terms of ICTD and throughput and is represented in fig 7 and fig 8 respectively. From fig 7 it is clear that the existing and modified VUG shows a fair distribution of throughput between unicast and multicast traffic even when the multicast users are varied and unicast users are fixed. Whereas the ES method still gives preference to multicast users.

The throughput of unicast users by varying the number of multi-cast users is shown in fig 8, and it is very clear from the figure that the throughput of the unicast user is higher in modified VUG than the existing VUG This is because of the subgrouping is done inside the virtual subgroup and multicast groups. since a constant amount of bandwidth is reserved for unicast traffic the ES policy is not affected by the number of active multicast users.

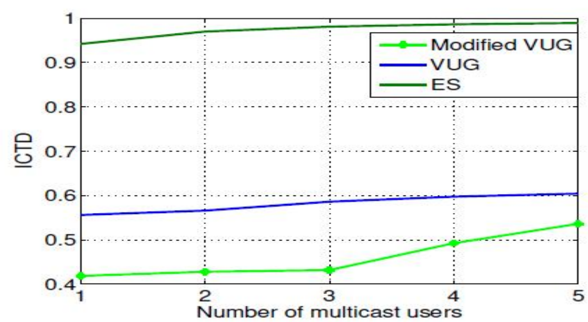

Fig. 7: ICTD

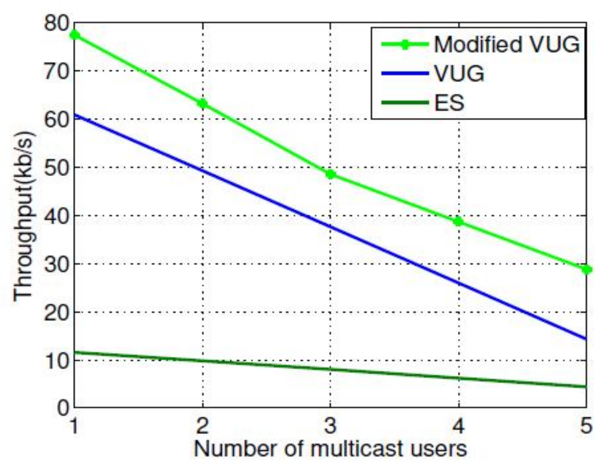

Fig. 8: Throughput of unicast users

V. CONCLUSION

Here we addresses the issues of fair distribution resources among the unicast and multicast traffic specially in multimedia services for the next-generation mobile networks. We propose a modified virtual unified group approach, which is a radio resource management system that organizes the users within virtual subgroups and the users within the multicast users to different subgroups based on the distance between them. The performance of the proposed VUG method is compared to the existing VUG method and the equal sharing (ES) methods, and the results show the benefit of subgrouping and demonstrate the fairness in throughput and resource distribution between unicast and multicast users for varying loads.

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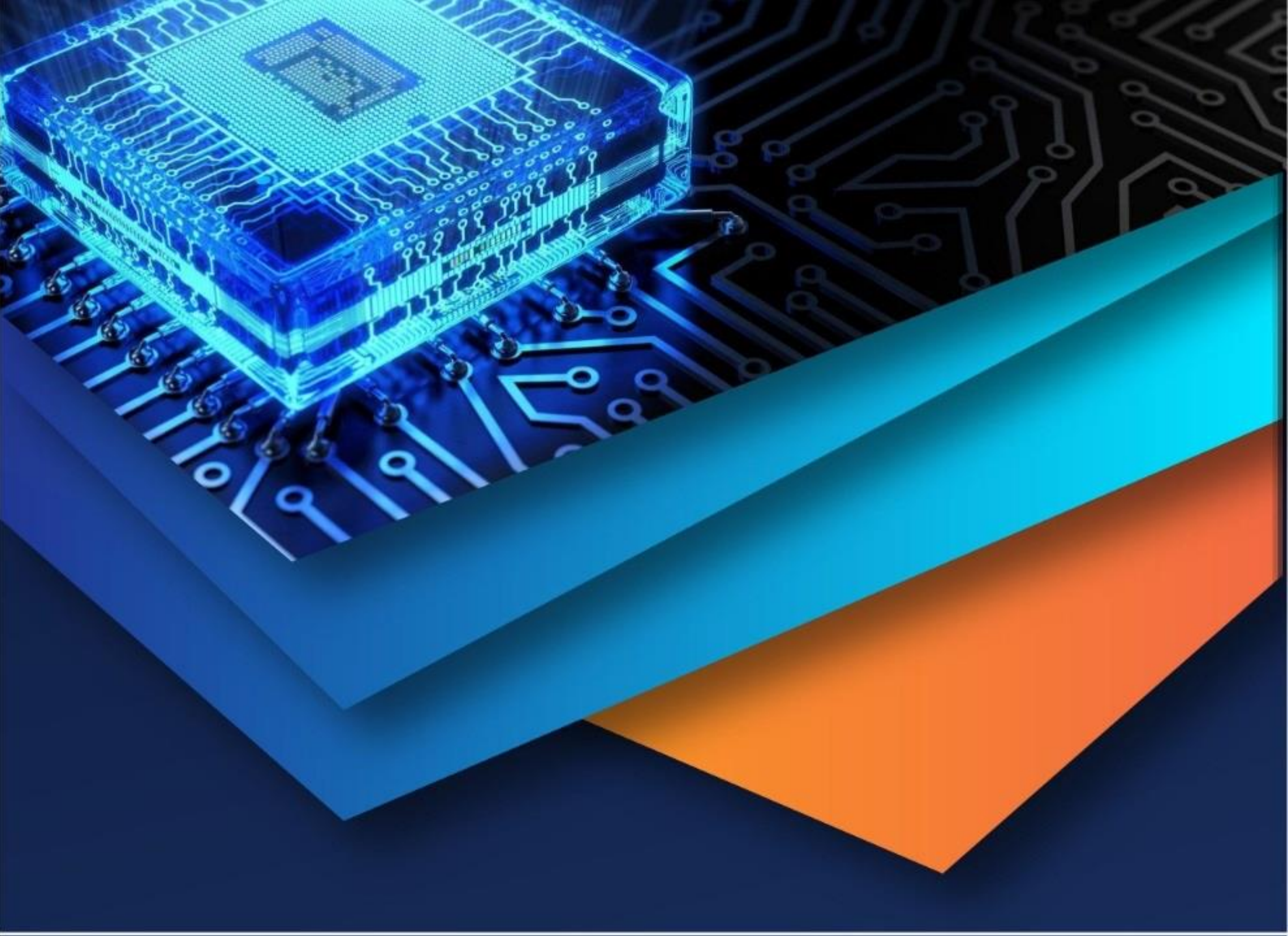

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