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Stable Clustering Approach for VANETs in Highways Communication with Fuzzy Decision Model

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Abstract: ***For providing a variety of communications in wireless communication through vehicles has been an attractive research area. The clustering is performed in the VANETs for the efficient transmission of data among vehicles. In various previous works, the clustering techniques were potentially well-organized to overcome the power consumption, bandwidth, and other resource problems while transmission communications between each vehicle to base stations. Despite the potential benefits, there are various major challenges for the clustering methods that degrade the network performance such as instable and complex networks. Therefore, in order to address the previous issues and to make the communication between vehicles more efficient and stable, the division of network is performed in the proposed work into various small cluster cells and the CH selection process is performed intelligently using Fuzzy Interface System (FIS). In order to demonstrate the efficiency of the proposed system, the simulation is performed in terms of various parameters. Also, the comparative analysis is performed among proposed and conventional approaches; and the results obtained demonstrate that proposed approach outperformed the previous approaches in terms of all considered parameters.***
Keywords: VANET, Clustering, Fuzzy Interface System.

I. INTRODUCTION

Communication ways and technology is increasingly becoming an integral part of individual's lives and also offers a range of opportunities to meet our everyday needs. In recent years, VENETs have been attracting considerable attention as a valuable communication tool, both in the research community as well as in the industry [1]. Since, the increasing numbers of private cars and other privately owned vehicles on roads, they cause road problems such as traffic congestion and accidents. Because of these factors, the number of deaths caused by road traffic is also rising. These incidents are putting our society at high risk and causes significant problems. Therefore, one of the key goals of VANETs is to make a safe and convenient travel for on-road vehicle riders and meet their communication needs while on the road. In order to facilitate the safety of passengers on the highway, VANETs recognize cars as the mobile nodes to create a mobile network that permits communication between road vehicles. The vehicles in VANETs behave as wireless routers and can possibly be connected to adjacent vehicles in the range of 100-300 meters [2]. If cars fall outside of a signal, they drop off from the network and other cars join further creates a mobile network of communication.

With the aid of a protocol i.e. Dedicated Short Range Communication, VANETs allow wireless communications among different vehicles [3]. Vehicle to vehicle (V2V) is a form of communication where vehicles directly communicates with each other wirelessly wherein the Vehicle-to-Infrastructure communication (V2I) and Vehicle-to-Road Side communication (V2R) connection allows automobile to communicate with infrastructure units mounted along the road[3].

VANETs provide different sorts of methods to improve wireless networking capabilities. VANETs also allow the educators to learn various applications, tools as well as protocols. This also gives researchers various challenges and different opportunities. Given that vehicles are complex in nature, stalled entries and congestion would most likely occur. Many solutions, in which the clustering is one of the solution strategies, were suggested to prevent these problems. Clustering is the term that has been used in long-standing wireless communications [4, 5]. Clustering is defined as the grouping of device, sensor or vehicle nodes situated in a geographical region based on certain laws. The clustering makes the infrastructure more stable and adaptive.

Clustering increases effective processing and delivery of messages. Clustering diminishes the overhead signals since communications between the vehicle nodes are more stable within the same cluster. Clusters improve flexibility and productivity in data delivery, such as utilization of limited resources [6]. The clustering method assists in network management by splitting the network into smaller, controllable segments within a larger, complex and distributed network.

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The benefit of clustering systems is that they decrease the amount of messages transmitted within the network, minimize congestion in V2R or V2V, increase network scalability, minimize contention and hidden station concerns and give service quality in routing. In addition, VANET scenario also has advantages including dealing with complex topological and density variations.

Worldwide, researchers have proposed several VANET clustering schemes. The clustering strategies focus on different subjects and even use the MANET clustering schemes. Those schemes are then defined by the respective parameters. The following figure summarized classifications of vehicle network clustering schemes [7]:

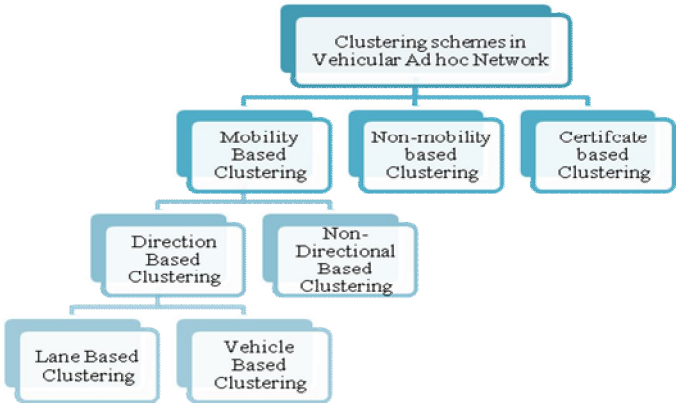

Figure 1: Classification of clustering schemes in VANETs

Combining the vehicles with the clusters and with the help of clusters establish the network, which is one of the most general and efficient ways. Because of its high mobility of vehicles, this property makes the VANETs distinct from the other MANETS. The earlier cluster-based technique for MANETs should face some trouble for VANETs. Thus, clustering in VANETs has attracted a lot of attention and various researches have been carried out in this field. Some of these proposed approaches in existing works are discussed in next section:

II. LITERATURE REVIEW

In current years, researchers believed that clustering can enhance the stability of the cluster in VANETs. Some of the existing works are reviewed as below:

In paper [8], the author had designed a novel approach that tackles the problem based on the Cluster-based File Transfer (CFT) scheme for highway VANETs. With Cluster-based File Transfer, when a vehicle required a file then the transmission capacity would be evaluated between the destination vehicle and the resource vehicle.

The author [9] had proposed a Chain Cluster with cooperative Drive-thru Internet scheme. Chain Cluster selected suitable vehicles to make a linear cluster on the highway.

The author [10] had proposed the latest DMMCA (distributed mobility-based multi-hop clustering algorithm) in the case of highways.

In paper [11], the author developed and improved the clustering algorithm to form constant clusters for delay-bounded applications such as dangerous zone activity and car crash alert, etc. on highway situations.

In paper [12], the prediction-based clustering algorithm for a VANET was proposed that they exactly considered the moving vehicles in the highways.

In paper [13], the author had proposed a smart native Bayesian probabilistic approximation practice for traffic flow to create a stable clustering in vehicular ad hoc network and it was named as NTSC.

The author [14] had proposed a transmission graph that formed between the vehicles for a special form of compound networks and the author also applied the current planned obligatory attachment the rule to synthesize such type of network structure.

The author had invented a center-based clustering algorithm in paper [15] to support self- managed vehicular ad hoc network that forms a stable cluster and minimizes the frequency of vehicle on the two metrics and highway.

The author [16] studied the issue of power-efficient cluster management in a heterogenous vehicular network.

In paper [17], the author had invented a center-based clustering mechanism that helps the self-designed VANETs forming stable clusters and that reduced the stage change frequency of vehicles on highways. This technique is efficacious in providing the information of the vehicle's status on the highways. It ensured stable cluster formation and provides better communication. Although, center based approach gives better results, but there are some shortcomings of this mechanisms that degrade the performance efficiency of the system. Thus, the previous drawbacks are needed to be resolved.

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III.PRESENT WORK

As reviewed in above section, a significant number of approaches have been introduced to attain effective communication between the vehicles. One such efficient approach [17] is reviewed in which center based clustering algorithm is proposed by the author. This approach gives better results, but there are some shortcomings of this mechanism which are needed to be resolved. Two concerns are highlighted in this section. In this existing approach, vehicles transmits beacons to show their present status and hence to form the cluster. If the traffic on the highway is increased i.e. more number of vehicles are present, it will affect the performance of the system in terms of making cluster. It would become difficult to handle the beacons and hence, the clustering will become complex. Secondly, Author has utilized three different parameters to form cluster. These parameters are velocity, acceleration and current location. Mobility metric is computed using these factors and weighted coefficients α,β,and γ. The value of coefficients is selected on the basis of real time scenario. The manual selection of these weighted functions may affect the entire performance if any one of the coefficient gets less value. Thus, considering these issues in the existing work, a novel approach is required to remove the concept of weight age coefficients and to reduce the complexity of the work.

In order to deal with these concerns, the network is divided into the small cells in the proposed work. Each cell represents the clusters. The nodes in every cluster are then used for selection of the cluster head (CH). Here, nodes represent the vehicle on highway. Division of network into small cells reduces the chances of nodes overlapping and thus reduces the complexity. The CH election is carried out by using an intelligent system. In the proposed work, a fuzzy interface system FIS based mechanism is introduced for CH selection. This approach uses fuzzy rules and membership functions which help in taking the decisions more easily and effectively. FIS gives the output on the basis of three parameters namely, velocity, acceleration and current position of the vehicles. After selection of the cluster head, the data is transmitted from one vehicle to another. Thus, by making the system automatic and intelligent, the concerns of existing system can be resolved and more efficient system can be achieved.

The framework of the proposed work is shown in below figure

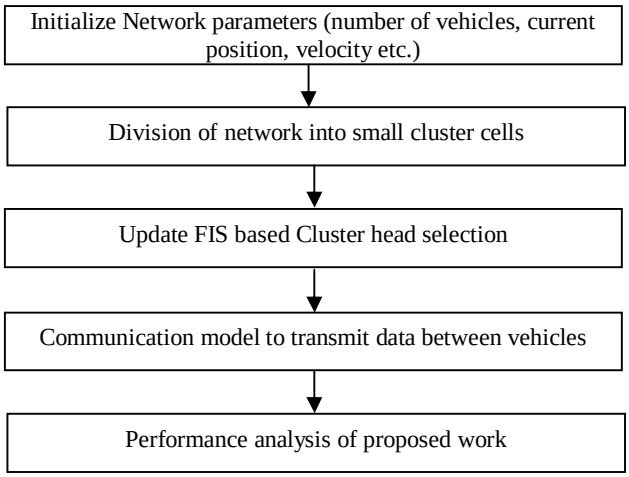

Figure 2: Framework of proposed work

The proposed work is analyzed in order to demonstrate its efficiency. And the results obtained by performing the performance analysis are discussed in the next section:

IV.RESULTS

In order to make the communication in VANETS more efficient and to overcome the previous issues, the novel approach is proposed in this work in which the division of the network is done into small cells and cluster head selection is performed using intelligent Fuzzy Interface System. The performance of the proposed system is analyzed and compared with previous approaches in terms of different parameters such as average CM (cluster member) lifetime, packet loss rate and average number of re-affiliation times. In this section, the results obtained are represented and discussed. As mentioned earlier that in this proposed work the network is divided into small cells in order to reduce the complexity of the system, and this division of network into small cells is illustrated in figure 3. As represented in figure, the whole network is divided into various small grids (cells) and each grid consists of various nodes in it. In this, the nodes represent the vehicle on highway. The each cell represents the cluster and the nodes in each cell are used for CH selection. The network division into small cells is performed in order that the overlapping chances of the nodes can be reduced and consequently the complexity of the system can be reduced.

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The process of CH selection between each cell and the then data transmission among the vehicles (represented as nodes) is exemplified in figure 4. In the proposed work, the selection of CH is performed intelligently using FIS which help in taking the decisions more easily and effectively. As figure shows, each cell represents a CH in it which is selected using FIS, and the random source and destination points are considered among which the transmission of data is then performed. This process can lead achieve an intelligent system for data transmission among vehicles.

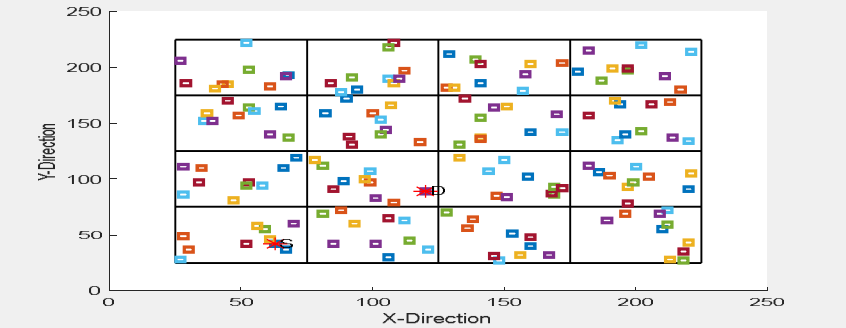

Figure 3: Division of network into small cells

And thus, by dividing the network, the uniformity of the system can be maintained.

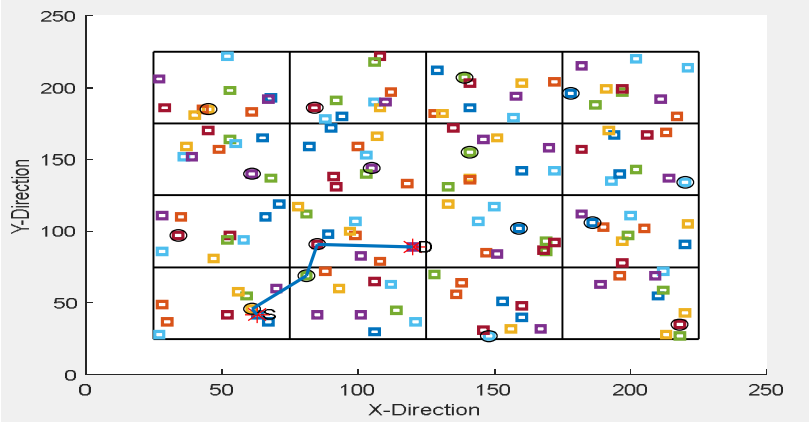

Figure 4: CH selection using FIS

Now, the comparative analysis between proposed approach and conventional approaches i.e. KMB (K-Means Based) method, SCalE algorithm and CBSC (Center-Based Stable Clustering) algorithm, is performed in terms of considered parameters i.e. packet loss rate, average CM lifetime and average number of re-affiliation times per vehicle, and the results obtained from the analysis are represented graphically as below:

The performance of the proposed and conventional approaches is analyzed and compared in terms of packet loss rate by considering different values of N and R, and the obtained results are depicted in bar graph of figure 5.

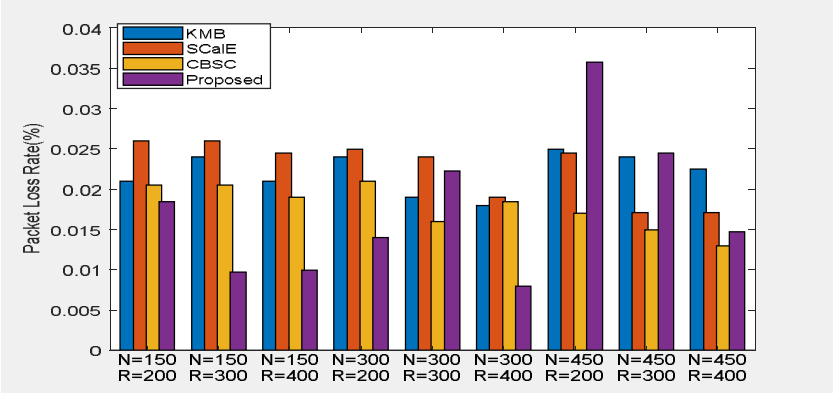

Figure 5: Comparative analysis in terms of packet loss rate vs. N and R

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As it is clearly comprehensible from the graph that, for the first six cases i.e. when the number of vehicles is 150 and 300, the proposed approach has the lowest value of packet loss rate as compared to all other previous approaches for all different transmission ranges i.e. 200, 300 and 400, expect at N=300 and R=300 (here CBSC has lowest packet loss rate). And when the number of vehicle became highest i.e. 450, then the packet loss rate of CBSC approach is lowest than all other approaches for different transmission ranges, and not of the proposed approach. Thus, for case N=450, R=200; N=450, R=300; N=450, R=400 and N=300 and R=300, proposed approach is not the most optimal one in terms of packet loss rate. However, on determining the overall performance, proposed approach is still the efficient one.

Also, as represented in figure 6, the comparative analysis is performed between proposed approach and traditional approaches i.e. KMB, SCalE and CBSC, in terms of average number of re-affiliation times per vehicle by considering different values of v and R. The analysis of the graph reveals that in all the cases i.e. for all different values of v and R, the proposed approach is superior as it has lowest value of average number of re-affiliation times per vehicle in each case as compared to all other approaches. And also, the worst technique among all these is the SCalE algorithm as it represents highest value for all the cases.

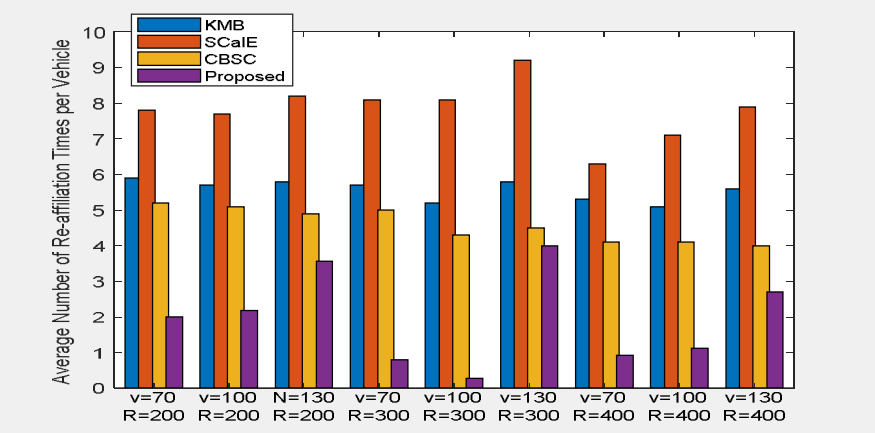

Figure 6: Comparison in terms of average no. of re-affiliation times per vehicle vs. v and R

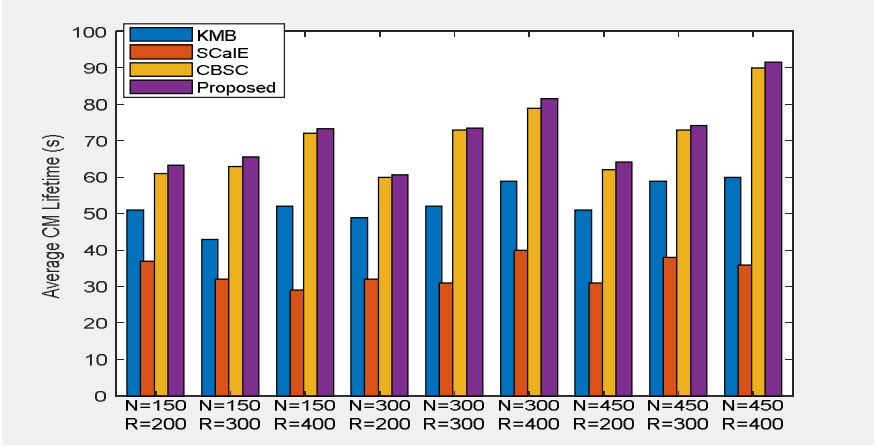

Figure 7: Comparative analysis in terms of average CM lifetime vs. N and R

The proposed and traditional approaches are also compared with respect to average lifetime of cluster member by considering different number of vehicle and transmission ranges, the result of which is represented graphically in figure 7. The close examination of the graph demonstrates that proposed approach is the most efficient technique than all other conventional approaches in terms of CM lifetime, as it has highest value of average CM lifetime for all different number of vehicles and transmission ranges, which ensures the high stability of the clustering. Thus, in every case, the proposed approach in the most efficient technique than all previous techniques for reliable and stable communication among the vehicles.

Therefore, all the obtained results demonstrate that the proposed approach is the most efficient technique than the previous techniques in terms of all considered parameters.

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V. CONCLUSION

In conventional works, various clustering techniques were introduced to make the communication among vehicles more efficient, however, they lacks in various aspects. Therefore, the proposed work is introduced that emphasizes majorly on the stable and efficient communication in VANETs. In the proposed work, the network is divided into small cluster cells in order that the complexity of the system can be reduced. Also, the CH selection process is made intelligent by using FIS that will help to take decisions more efficiently and easily. Also, the performance analysis of the proposed approach is performed and is compared with traditional approaches in terms various parameters such as packet loss rate, average CM (cluster member) lifetime, and average number of re-affiliation times per vehicle. And the results obtained from the analysis demonstrate the superiority of the proposed approach over all other previous approaches in terms of considered parameters as it has low packet loss rate, low average number of re-affiliation times per vehicle and high average CM lifetime. Therefore, these results imply that with the help of proposed approach an efficient, stable and reliable system can be attained for the communication among vehicles.

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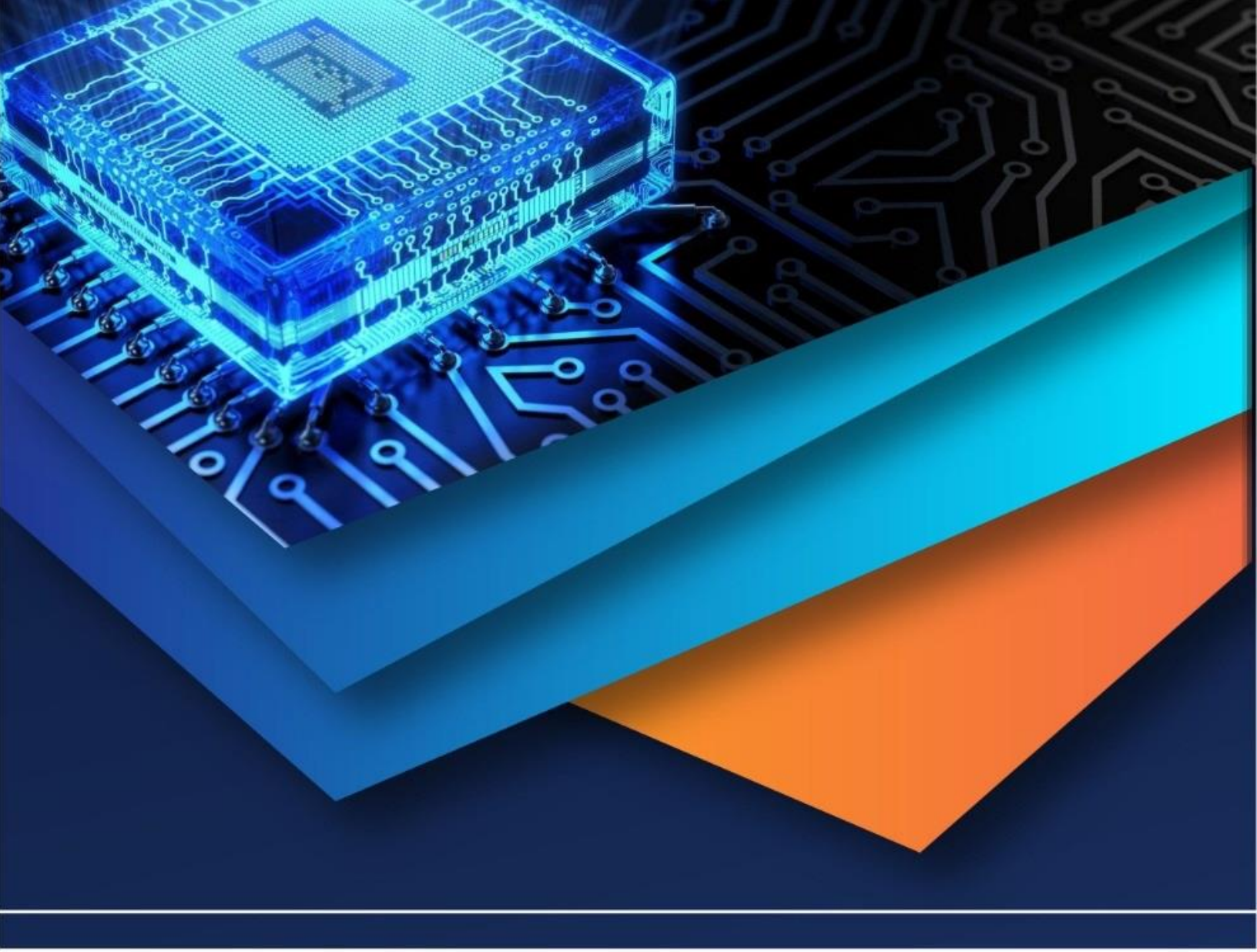

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