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Efficient Energy Consumption in MANET by AODV ERR

J. Ramya[1] , M. Sumathi[2]
[1]Mphil Scholar, [2]Head of the Department, Department of Computer Science and Application, Mahendra Arts and Science College, (Autonomous), Namakkal, India

Abstract: When dealing with MANET (mobile ad hoc network), one of the prime limitation is of the 'energy consumption' because of which entire network's performance gets drop down.Pertaining to a multi-hop MANET, energy efficiency can be gained by the scheme of transmission power control wherein the data packets gets transmitted by the nodes to the neighbor that is closest and has needs least power level. Though it's possible to lower just the transmission power within the node's neighborhood and energy efficiency can be achieved at the link level only. Based on the analysis and the output generated its ascertained that there can be control over the routing scheme rather than making use of low transmission power. In addition, there are only specific nodes for receiving and processing this routing request depending upon the signal strength obtained based upon which there can be reduction in the overall energy consumption of the network as well as the communication overhead. The recommended scheme encompasses an adaptive strategy which is highly energy efficient and obtains hightransmission range on the basis of AODV ERR (Ad hoc On-demand Distance Vector Routing Enhanced Range Routing) Protocol by employing the new routing strategy via ERR Algorithm and examined across multiple network sizes. There has been noteworthy change in the performance with the recommended AODV ERR protocol in contrast to the simple AODV in connection with the selected metrics.
Keywords: MANET, Adhoc Network, Multi hop adhoc network, Transmission Power, Energy Efficiency, Transmission Range, Enhanced Range Routing

I. INTRODUCTION

MANET comprises of various mobile nodes with no fixed infrastructure. Nodes that fall under the mutual wireless range of one another follow a direct communication whereas nodes residing outside the wireless range adhere to a multi hop path resulting in Multi-hop MANET (Mobile Ad Hoc Networks). Rajesh Kochher, Ritu Mehta, [1] defines the major features of MANET as following: dynamic topologies, restricted physical security, bandwidth-constrained and energy-constrained operation. One of the essential criteria in protocol design that is taken into account is the energy conservation since the nodes in such a network depends upon the battery power to fulfil their energy needs. The network's topology is determined by the location as well as the transmission power of the mobile nodes that can vary with time. According to the ATIS report published on energy efficiency of wireless networks [2], emphasis is on the parameter optimization that comprises of maximum coverage with least interference possible along with various aspects of wireless attributes including propagation. Through the process of intelligent routing, energy efficiency can be incorporated. Ioanis et al. [3] recommends that power awareness can be encouraged for carrying out the design and implementation of network routing protocols. The popular technique employed in power aware protocols is the mechanism that makes components sleep. Power aware MAC routing protocols ascertains that every link becomes highly energy efficient. These protocols are framed by making changes to the routing process in order to route the packets across energy efficient paths from source till the destination. Since there is no reduction in the overall energy consumption of the network using the above methods, a routing process must take the topological information into consideration. Among various factors of network topology, transmission range depicts the controllable factor. The study defines the [4] transmission range of node '*i*' in a network as the maximum range across which a packet can be received successfully without any interference from other nodes. Both the network topology and the total energy consumed are affected by the transmission ranges. The literature illustrates selection of best transmission range [5, 6]. Packets are delivered to the nearest neighbors in case of a smaller transmission range whereas in case of multi hop path, number of hops are increased. Moreover, because of the smaller transmission range there can be a huge number of interferences within the network. In [7] there is a discussion regarding the optimum one hop distance that minimizes the overall system energy. Therefore, for handling dynamic mobility and maintaining network connectivity, topological information is incorporated at the network layer. Hence for choosing the next hop, interaction among the MAC and the network layer must take place.

II. RELATED WORKS

There are not much power aware MANET routing protocols in the literature. Also a route is chosen that will reduce the overall transmission power amidst the sender and the receiver. PAMAS or Power aware multi-access protocol [8] is an energy aware MAC routing protocol intended for energy efficiency in MANET wherein the transmission power resembles the link cost and the minimum cost route is determined. The minimum cost route depicts the minimum energy route path formed by the collective energy of the intermediate nodes. PARO (power-aware route optimization) [9] algorithm utilizes a method of distributed route calculation for variable range power thereby generating a route with numerous short distance hops. Apart from the minimum total transmission power metric, the network lifetime also acts as a metric. Singh et al. [10] for instance incorporates routing metrics like duration of network connectivity, energy consumed per packet, node capacity, node power variance and so on. The node capacity signifies the decreasing function of the residual battery capacity. Then by the means of the minimum-cost path selection algorithm, routes are navigated away from paths where various intermediate nodes confronts battery exhaustion. Similarly, both the routing algorithms MMBCR and the CMMBCR [11] exploits the battery capacity of individual nodes for the route selection metric. These algorithm employs the policy of MAX–MIN route selection that selects a path with the highest capacity value for its extremely critical node. For a given path, the critical node is the one having minimum amount of remaining battery power capacity.

In contrast to common-range transmission control [12] the variable-range transmission power control [13] in Mobile Ad Hoc Networks employs a variant of Bellman–Ford algorithm. It relies upon the link distance and thereby it determines a route with maximum hops. The literature also includes the research on topology control of a MANET via transmission power variation [14] based upon the minimum total transmission power for determining the route amidst the source and the destination. For multi-hop wireless networks, Prabavathi and Kavitha [15] presents energy efficient reliable communication by employing variable range power scenario.

Residual energy of a node is computed by the energy model [16] by minimizing the energy that the node utilizes for several routing decisions and for the packets that are sent, received, forwarded and dropped when being transmitted from source to destination node. This energy is then appended as a routing metric in the packet header and is further utilized for choosing an energy efficient path from the source to destination node. Though this chosen path might not be the minimum energy path but it comprises of maximum residual energy of the nodes as routing to increase the network's lifetime varies from minimum energy routing. There is high traffic flow for minimum energy routes and also the nodes in such routes die early because of battery exhaustion thereby resulting in overall network failure.

Nevertheless, routes that are chosen on the basis of maximum residual energy yields in high network lifetime as the load is balanced globally across all the routes and nodes within the network. AODV protocol in [17] is altered and transformed to perform on several paths for transmitting data. Initially, the route discovery process of AODV is customized. On receiving the RREQ pack by the destination, a reply is sent for all the received RREQ packets using back path (even if the sequence number is same). On the other hand the sender covers entire paths and reduce them based upon hop count and during data forwarding the best amidst the three paths is chosen by the sender. With this, the issue of route brakeage in AODV also gets resolved. On breakage of one route, source transmits the data via any other available path. The above recommended method is highly energy efficient as it splits the packet load transmitting to the entire nodes existing in various paths.

The author energy aware [18] mentions that AODV alters RREQ (route request) packet for the process of route discovery. Fields in the RREQ packet are being altered with addition of lowest residual energy and SRE (sum of residual energy) that maintains minimum remaining energy and sum of remaining energy down the path accordingly. There is an energy Difference field that withholds the difference amidst average minimum residual energy or the threshold/average sum of residual energy. Additionally, at the destination node, there is addition of threshold on the routing table. In context to BBU-AODV, entire set of nodes in probable routes amidst a source and destination pair comprises of huge remaining energy compared to the threshold. So the route with highest difference of average sum of residual energy and threshold between the routes is chosen. Else the selection is for the maximum difference of the average minimum residual energy and threshold between the routes.

In [19] there is a recommendation of an energy efficient routing protocol referred to as GBBU-AODV for mobile ad hoc networks. Herein the minimum remaining energy and node density or no: of neighbour nodes is combined in terms of a cost metric for reducing the energy consumption of mobile ad hoc networks. The demerits of BBU_AODV and traditional routing protocols of MANET is surmounted by the GBBUAODV routing protocol by managing a satisfactory reach-ability level simultaneously. The gossiping probability for every node in GBBU_AODV scheme is computed on the basis of minimum residual energy from the source to the node. Resultant small residual energy nodes are protected as a segment of data communication route by allocating tiny rebroadcasting probabilities for every intermediate node residing on the paths.

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III. PROPOSED WORK

There is a conduct of performance study [19] concerning the protocols DSR, AODV, AOMDV, DSD and MDART for examining the effect of transmission range. The protocols exhibit high performance in case the transmission range is less than half the size of the topological region. Reactive AODV routing protocol is selected based upon the examination for improvement purpose. Figure 1 depicts the energy model of AODV ERR Routing.

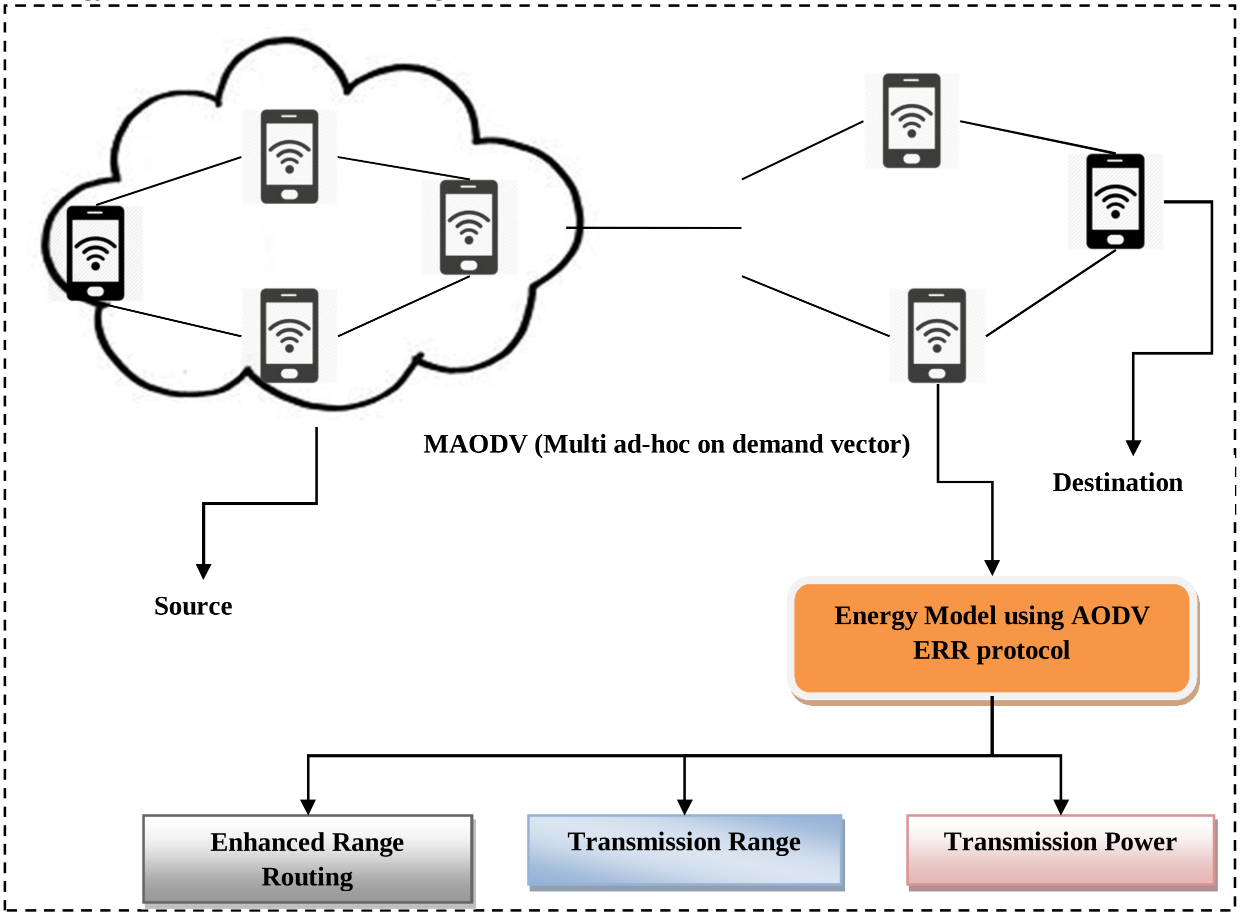

Figure 1: Energy model of AODV ERR Routing

A. Ad Hoc on-Demand Distance Vector Enhanced Range Routing (AODV ERR) Protocol

AODV which being a reactive/on demand hop by hop protocol is efficient for uni-cast and multicast routing. This protocol is self-starting dynamic and projects loop-free multi-hop routing. As and when the source requires, the routes are determined or discovered and are maintained till the source needs them. Mainly routing relies upon two mechanism namely route discovery and route.

Route discovery request is carried by AODV. Routes that have been used are then stored in the routing table for the purpose of route maintenance. There are four kinds of control messages HELLO, RREQ, RREP, and RERR utilized by AODV. For determining a route to a destination node AODV broadcasts a RREQ- route request () message along with its ID and the destination sequence number to all its neighboring nodes. The RREQ message traverses across the network and all the neighboring nodes till destination node arrives. Figure 2 depicts AODV ERR routing Scenario. An AODV RREQ comprises of following:

1) RREQ ID
2) Source IP
3) Source sequence #
4) Destination IP
5) Destination sequence #
6) Hop count
7) Flags

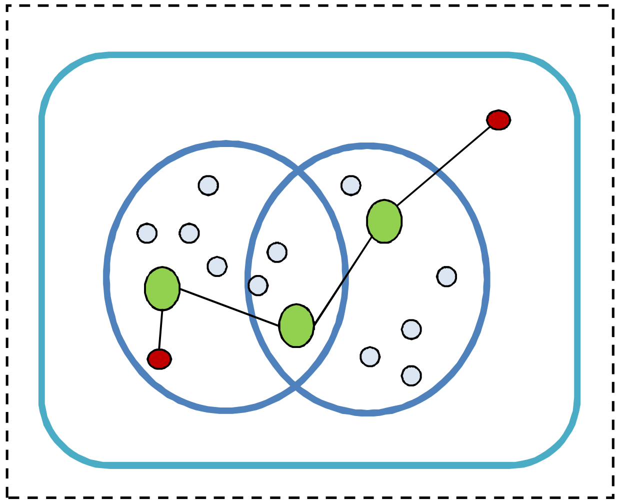

Figure 2: AODV ERR Routing Scenario

The sequence numbers helps to avoid cycles in a route. When the intermediate node receives a RREQ message and if its routing table comprises of routing information to the destination then it responds with a RREP message. Else the message is transmitted by the intermediate node to its neighboring nodes which have received no message yet. In case of any link failure or unavailability of routing information, an RERR message is transmitted to the source node. For generating a reverse path, the source information is saved within the table by the node that transmits RREQ message. A reverse path is selected by AODV having least hop count. RREP (route reply) message is generated by the destination node which traverses across the intermediate nodes following a reverse path till the source node which has generated the route request. Generally the AODV routing protocol identifies and selects the nearest neighbor and obeys a multihop path within the transmission range of nodes.

B. Received Signal Strength Estimation

There is modification in the routing strategy depending upon the power estimation of intermediate nodes that has been received. For computing the signal strength that is received at the nodes, the transmission power model is employed that also helps in selection of routing region. The bi-directional links amidst the nodes and the node's transmission power are assumed to be set equal by the AODV protocol. By the means of radio wave propagation models and device parameters, the received signal power can be computed theoretically. The radio wave propagation is characterized by the radio wave propagation models in terms of frequency function, distance and rest of the conditions and helps in predicting the transmitter's effective coverage area. The literature introduces three radio wave propagation models viz—free space model, two-ray ground reflection model and the shadowing model. Both the free space model and the two ray ground model depicts the range of radio communication as an ideal circle. The cross-over distance d_1 is given by

$$d_1 = \frac{4\pi \times h_t \times h_r}{\lambda}$$

The received signal power in free space at distance d from the transmitter is given by

$$P_r(d_1) = \frac{P_t \times gn_t \times gn_r \times \lambda^2}{(4 \times \pi \times d)^2 \times L}$$

The model of free space propagation model considers the ideal propagation condition which is the clear line of sight path amidst the sender and the receiver. The signal power received relies upon the following: antenna gain, transmission power and the distance between the transmitter and the receiver. With the square of the distance there is a decrease in the power received. Any one of the models is chosen by taking into account the cross-over distance (d1) and the distance amidst the transmitter and the receiver (d). The free space model is employed in case d is smaller compared to dc else the two-ray ground model is incorporated.

Figure 3 demonstrates, a distinctive on-demand routing protocol with choice of shortest path among the three possible routes namely PQRU, PSTU or PQSTU. Though among all the three, only PSTU path is selected by the proposed algorithm as it comprises of the node with minimum Left over battery power that is more compared to the nodes on rest other paths. This protocol supports the path with highest lifetime since it finally leads to high network lifetime of the Mobile Ad Hoc Networks.

For instance consider fig.3, where there are three paths for making selection. There are three hops in the first path with node Left over battery power values represented as 70, 80, 20, and 60, and say there are three hops in the second path with energy values depicted as 70, 50, 30, and 60 and consider four hops in the third path having energy values as 70, 80, 50, 30 and 60. The min LBP (Left over battery power) for the second and third path is 30, whereas for the first path the min LBP is 20. Because 30 is more, second and third path stands out as the options. The second path (P-S-T-U) is finally chosen as it has the least hop count. With this selection there is increase in the lifetime of the network and message passing carries out smoothly.

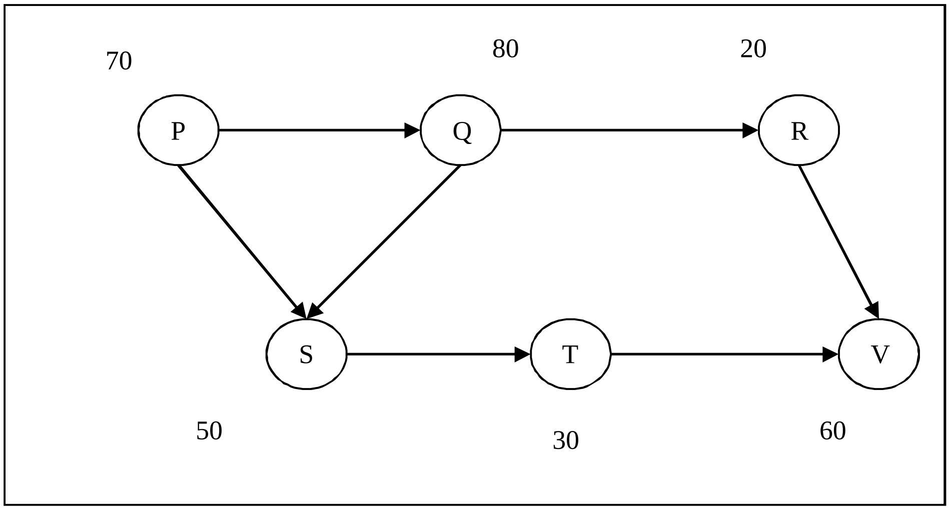

Figure 3: Network lifetime of the MANET

C. ERR Algorithm

1) *Step 1: Packet Receiving*
2) *Step 2: Start*
3) *Step 3: If ERR packet*
4) *Step 4: If ERR Route Request*
5) *Step 5: Calculate distance r_0*

$$r_0 = \frac{4\pi \times h_t \times h_r}{\lambda}$$

6) *Step 6: Similarly find distance r_{00}*
7) *Step 7: Find Received Signal Strength at distance r_0 as RSS_1*

$$P_r(d_1) = \frac{P_t \times gn_t \times gn_r \times \lambda^2}{(4 \times \pi \times r_0)^2 \times L}$$

8) *Step 8: Similarly find Received Signal Strength at distance r_{00} as RSS_2*
9) *Step 9: If RSS $>RSS_1$ and RSS $<RSS_2$*
10) *Step 10: Processing the Route Request*
11) *Step 11: Else*
12) *Step 12: Dropping Route Request*
13) *Step 13: end*
14) *Step 14: Else*
15) *Step 15 Normal packets processing*
16) *Step 16: end*
17) *Step 17:End*

D. Route Selection by the Destination Node

In AODV, when the destination node receives the first route request it sends a reply and rejects any other requests because of its shortest path formation conduct. Herein, when the destination node receives first RREQ (route request) it waits for a small time interval say Δt and thereafter sends a reply for a path with maxETR_{final} value as depicted in.ETR_{final} is computed for carrying out the hop count for selecting the route. The following relation helps in evaluating:

$$ETR_{final} = K_1 * ETR_{Path} + K_2 * HF,$$

Where K_1 and K_2 are weights with condition (K_1 +K_2 =1) and HF is the hop factor calculated as

$$HF=\frac{H_{Max}-H_{Count}}{H_{Max}}$$

Where H_{Count}resembles hop count and H_{Max} represents the max hop count allowed by the protocol. Hop factor ranges from (0, 1) with direct links denoting HF as 1 which goes on minimizing with a rise in the no: of intermediate nodes. With the variation in these weights, the importance of ETR_{Path} can be also changed along with the hop count at the time of route selection. Here, each one is initialized with a value of 0.5. Additionally, there can be use of any other substitute function with effecting generality of the recommended solution.

IV. RESULT AND DISCUSSIONS

A. Simulation Using NS2

The simulations are performed using ns2 network simulator under Ubuntu Linux. The ns2 version ns2.35 are being employed. There is enhancement of Ns2 implementation of AODV code which can conduct like AODV ERR. In addition, the random way point mobility mode l existing in ns2 has been incorporated for generating random topology files for assessing the routing algorithms.

B. Results and Analysis

A study is performed concerning the protocol's performance with regard to different network sizes. Based upon the network sizes, simulations are carried over various node orientation and movements or say varied scenario files thereby taking only the average value into account. Tables 1 and 2 shows the analysis results of the AODV and AODV ERR routing protocol**.**

Table 1. Results of AODV Routing Protocol

Number of Nodes	Overhead	Throughput	Consumed Energy
20	4686.6	21.90	10.14
30	8877.3	19.81	10.68
40	15276.3	27.17	11.25
Avg	12226.05	23.875	10.9

Table 2. Results of AODV ERR Routing Protocol

Number of Nodes	Overhead	Throughput	Consumed Energy
20	2874	22.36	10.02
30	5488	21.37	10.43
40	9768	26.99	10.95
Avg	7783.7	24.72	10.695

Figures 4 and 5 shows the performance of the routing protocols in terms of energy consumption. Energy consumption in the case of AODV is high and increasing with respect to the increase in node deinsity. The proposed AODV ERR performance is good and consumed less energy than normal AODV. The below figure shows the significant reduction in energy consumption.

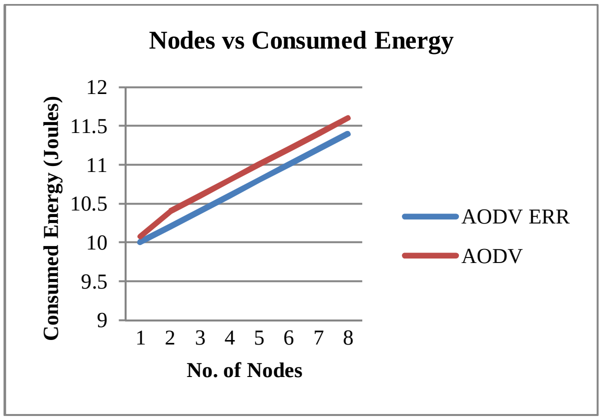

Figure 4: Nodes vs Consumed Energy

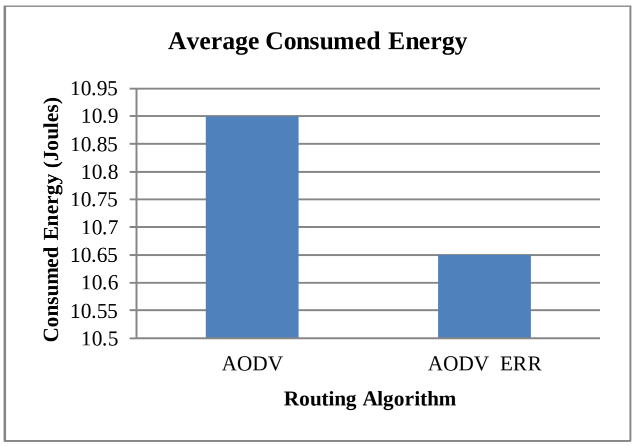

Figure 5: Comparison of AODV and AODV ERR: The average energy consumption

V. CONCLUSION AND FUTURE WORKS

There has been affirmative simulation of AODV ERR algorithm by the means of NS2. There is evaluation of the algorithms performance based on various network scenarios. The results ascertains and reports noteworthy improvisation in performance and overhead reduction. There can be implementation of "Enhanced Range Routing" in multipath MANET routing protocols too. The influence or effect of "Enhanced Range Routing" in multipath AODV routing algorithm can be addressed in future work. Apart from this, the future works can also cater to the ways and means for dynamically estimating and setting the transmission range/power of the nodes in regard to the various dynamic network parameters thus achieving surpassed improvement

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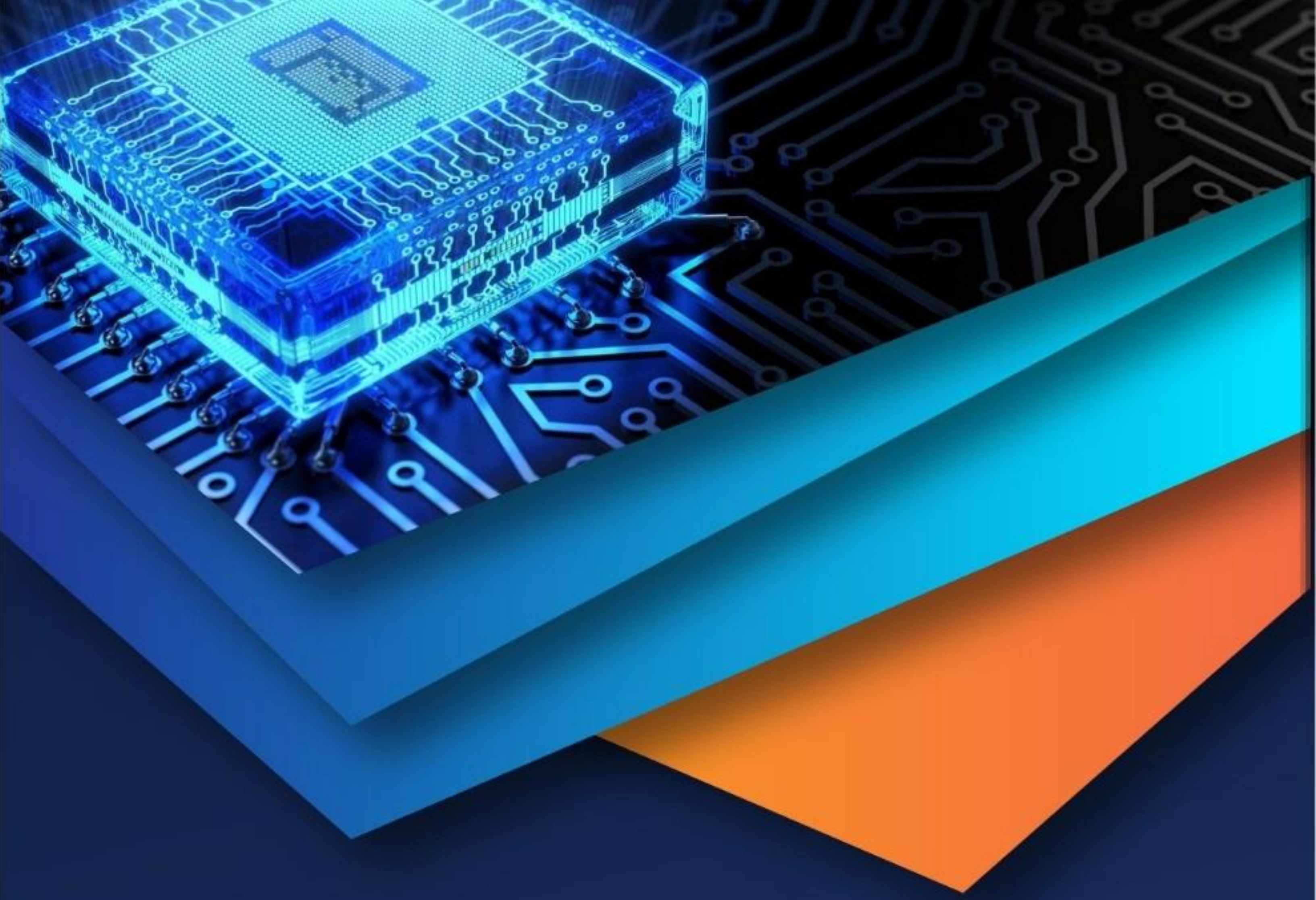

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