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Energy Efficient and Reliable Routing Protocol in Wireless Ad Hoc Network

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Abstract: The main aim of the project is to increase the energy efficiency, reliability and network lifetime of wireless ad hoc network. For achieving this aim we have Studied the Routing protocols and energy model of wireless network, then Reliable minimum energy routing (RMER) and Reliable minimum energy cost routing (RMECR) are implemented by considering the energy consumption and the remaining battery energy of nodes as well as quality of links, and at last above protocols are compared against the existing TMER (Traditional minimum energy routing) and minETX (expected transmission count) and results are achieved. By representing an in-depth study of energy-aware routing in ad hoc networks, and proposing the new routing algorithms for wireless ad hoc networks, namely, Reliable Minimum Energy Cost Routing (RMECR) and Reliable Minimum Energy Routing (RMER). RMECR can increase the operational lifetime of the network using energy-efficient and reliable routes. The general approach that used in the design of RMECR was used to also devise a state-of-the-art energy-efficient routing algorithm for wireless ad hoc networks. RMER finds routes minimizing the energy consumed for packet traversal. RMER does not consider the remaining battery energy of nodes, and was used as a benchmark to study the energy-efficiency of the RMECR algorithm.
Keywords: Energy, routing, MANET, reliable, packets

I. INTRODUCTION

Mobile Ad hoc Networks(MANETS) are Self-configuring network of mobile routers connected by wireless links which Forms arbitrary topology and will have Rapid, unpredictable topological changes. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently.

Each must forward traffic unrelated to its own use, and therefore be a router.

MANETS does not require any centralized control & administration, it should be Self-organizing and self – restoring. Some of the typical applications of MANETS include Military battlefield, Collaborative work, Local level, Personal area network and Bluetooth and Commercial Sector etc.

Recent analyses of WSN (Wireless Sensor Network) revealed that energy efficiency have been widely based on a sensor node power consumption model[2] where the impact of the sensor node device hardware (which can be improved) and external radio environment (which is largely uncontrollable) are lumped together.

However, the challenge is to use a more realistic power consumption model of the communication subsystem which clearly separates the power consumption of each hardware component and the impact of the external radio environment.

The figure 1shows the wireless ad hoc networks.

Routing is the process of moving packets across a network from one host to another. It is usually performed by dedicated devices called routers.

Packets are the fundamental unit of information transport in all modern computer networks, and increasingly in other communications networks as well. They are transmitted over packet switched networks, which are networks on which each message is cut up into a set of small segments prior to transmission.

Each packet is then transmitted individually and can follow the same path or a different path to the common destination. Once all of the packets have arrived at the destination, they are automatically reassembled to recreate the original message.

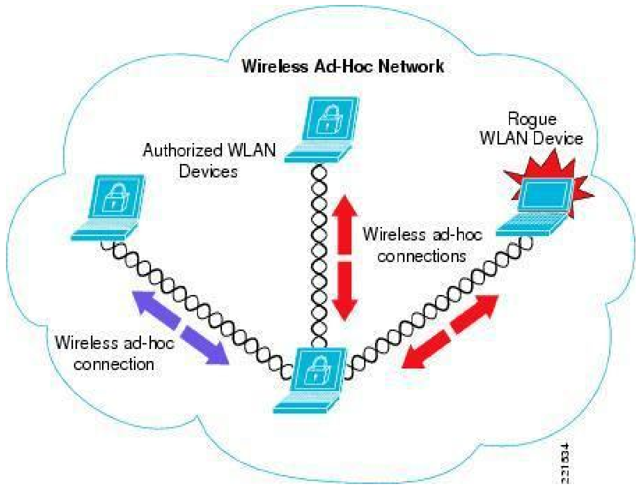

Fig 1: Wireless ad hoc Networks

Energy-efficient routing [3] is an effective mechanism for reducing energy cost of data communication in wireless ad hoc networks. Generally, routes are discovered considering the energy consumed for end-to-end (E2E) packet traversal. Nevertheless, this should not result in finding less reliable routes or overusing a specific set of nodes in the network. Energy-efficient routing in ad hoc networks is neither complete nor efficient without the consideration of reliability of links and residual energy of nodes. Finding reliable routes can enhance quality of the service. Whereas, considering the residual energy of nodes in routing can avoid nodes from being overused and can eventually lead to an increase in the operational lifetime of the network

The routing of the data packets to the base station on the minimum-cost paths is efficient, so the rate of information generation is low or the channel bandwidth is sufficiently high. Still, if the nodes generate data constantly and the bandwidth is constrained, then routing data on the minimum-cost paths can overload wireless links close to the base station. Therefore, a routing protocol must take into consideration the wireless channel bandwidth limitations, otherwise, it might route the packets over highly-congested links and paths. This will lead to an increase of congestion, increased delay and packet losses, which in turn will cause retransmission of packets, thereby, increasing energy consumption.

II. LITERATURE REVIEW

The below paragraphs review about the various routing algorithms used in this paper for Energy Efficient reliable routing [8,9,10] and it also consists of the previous algorithms from the drawback of which the existing algorithms where used.

Reliable Minimum Energy Cost Routing (RMECR), is an algorithm whose studies show that RMECR is able to find energy-efficient and reliable routes similar to RMER, while also extending the operational lifetime of the network. This makes RMECR an elegant solution to increase energy-efficiency, reliability, and lifetime of wireless ad hoc networks. In the design of RMECR, minute details such as energy consumed by processing elements of transceivers, limited number of retransmissions allowed per packet, packet sizes, and the impact of acknowledgment packets are considered. This adds to the novelty of this work compared to the existing studies

Reliable Minimum Energy Routing (RMER), on the other hand, is an energy-efficient routing algorithm which finds routes minimizing the total energy required for end-to-end packet traversal. In RMER, energy cost of a path for E2E packet traversal is the expected amount of energy consumed by all nodes to transfer the packet to the destination.

In Traditional Minimum Energy Routing [4,5,6] (TMER), TMER neglects energy consumption of processing elements and the impact of HBH ACK. When compared with RMER, RMER not only is able to find more energy-efficient routes compared to TMER, but it is also able to find more reliable routes.

As mentioned before, TMER does not consider the energy cost of processing elements of transceivers. It only considers the transmission power, which decays with distance. This is why we can expect to have more reliable routes in RMER rather than TMER. In Expected Transmission Count (ETX), ETX is a routing algorithm which is usually refer to as Min-ETX which finds the path with the minimum accumulated ETX. We. By finding paths with the minimum accumulated ETX, Min-ETX can find links which have better quality. Min-ETX is an example of a routing algorithm which only considers the quality of links in route selection.

III. PROPOSED SYSTEM

In this project energy efficiency, reliability, and prolonging the network lifetime in wireless ad hoc networks is considered holistically. Two novel energy-aware routing algorithm, called reliable minimum energy cost routing (RMECR) and reliable minimum energy routing is proposed. RMECR finds energy efficient and reliable routes that increase the operational lifetime of the network. RMER,on the other hand, is an energy-efficient routing algorithm which finds routes minimizing the total energy required for end-to-end packet traversal

A. Energy-Aware Reliable Routing

The main objective is to find reliable routes which minimize the energy cost for E2E packet traversal. To this end, reliability and energy cost of routes must be considered in route selection. The key point is that energy cost of a route is related to its reliability. If routes are less reliable, the probability of packet retransmission increases[7]. Thus, a larger amount of energy will be consumed per packet due to retransmissions of the packet. By defining two different ways of computing the energy cost of routes, we design two sets of energy-aware reliable routing algorithms for HBH and E2E systems. They are called reliable minimum energy cost routing and reliable minimum energy routing (RMER). In RMER, energy cost of a path for E2E packet traversal is the expected amount of energy consumed by all nodes to transfer the packet to the destination. In RMECR, the energy cost of a path is the expected battery cost of nodes along the path to transfer a packet from the source to the destination. Before we proceed with the design of RMER and RMECR, we first define the minimum energy cost path as referred [11].

B. Energy Aware HBH Routing

This section presents design of RMER and RMECR algorithms for networks supporting HBH retransmissions. Considering the impact of limited retransmissions across each link, the size of data and ACK packets, and the reliability of E2E paths is the added value of our analysis, which distinguishes our work from. The energy cost of a path is analyzed in four steps: Analyzing the expected transmission count of data and ACK packets, analyzing the expected energy cost of a link taking into account the energy cost of retransmissions, analyzing the E2E reliability of a path, formulating the energy cost of a path taking into account the energy cost of links and E2E reliability of the path. This in-depth analysis of the energy cost lays the foundation for designing RMER and RMECR algorithms for the HBH System.

C. Energy Aware E2E Routing

This section presents design of RMER and RMECR algorithms for networks supporting E2E retransmissions. Similar to the HBH system, we first analyze the energy cost of a path for transferring a packet to its destination In the E2E system, the energy cost of a path depends on the number of times that the packet and its E2E ACK are transmitted. This, in turn, depends on the E2E reliability of the path. To determine the energy cost, we start with formulating the E2E reliability of the path for data packets and E2E ACKs. Then, the expected energy cost is calculated. In the E2E system, the expected energy cost of path for transferring a data packet from the source node to the destination is the expected energy cost during a single transmission from the source to the destination multiplied by the expected number of times that the source transmits the packet (including the first transmission). Let us neglect the effect of the E2E ACK on the expected energy cost. H1 neglects the effect of the E2E ACK on the energy cost of a path. If the size of the E2E ACK is not small compared to the size of the data packet, this assumption may not be a valid assumption. H2, on the other hand, considers the impact of the E2E ACK on the energy cost. In H2, the energy cost of packet transfer from a source node s to any destination node v is calculated in a recursive way.

D. Algorithm: Energy Aware Routing Algorithm

1) *Step 1:* Analyzing expected transmission count of data and ACK packets

$$E[n_{u,v}(L_d)]=\frac{1-(1-p_{u,v}(L_d)\ p_{u,v}(l_h))^{Q_u}}{p_{u,v}(L_d)\ p_{u,v}(l_h)}$$

2) *Step 2*: Analyzing total energy consumption across a link taking into account the impact of HBH retransmission.

$$a_{u,v}(L_d)=E[n_{u,v}(L_d)]\varepsilon_{u,v}(L_d)+E[m_{u,v}(L_h)]w_{u,v}(L_h)$$

$$b_{u,v}(L_d)=E[n_{u,v}(L_d)]w_{u,v}(L_d)+E[m_{u,v}(L_h)]\varepsilon_{u,v}(L_h)$$

3) *Step 3:* Analyzing link and path reliability.

$$R_{u,v}(L_d)=1-P_r\{\text{packet lost after } Q_u \text{ transmission}\}$$

$=1-[1-p_{u,v}(L_d)]^{Q_u}$

4) *Step 4:* Analyzing the expected energy cost of a path
5) *Step 5:* Finding MECP (minimum energy cost path) considering costs as the weights using Bellmanford algorithm.
6) *Step 6*: By defining appropriate link weights RMER & RMECR are derived. For RMECR, we define the battery cost of a link as "the fraction of the residual battery energy of the two nodes of the link which is consumed to forward the packet".

IV. PERFORMANCE ANALYSIS

To evaluate the performance the implemented protocols are compared with the existing protocols. The trace files generated is used and using AWK scripts various parametric values are collected and graphs are plotted using GNU plot.

Table 1 shows the simulation parameters set for the proposed protocols.

Simulation parameter	Value
Simulator	NS2(2.34)
Topology area	350*350
Packet size	512bytes
Nodes	200
Pause time	0sec
Simulation	200sec
Packet rate	1packet/sec
Traffic type	CBR(constant bit rate)
Initial energy	100joules
Transmission range	70mts
Tx energy	0.1
Rx energy	0.1

Table 1 Simulation Parameters

A. *The Metrics Used For Protocol Comparison Are*

1) *Packet delivery fraction:* The ratio of number of data packets successfully received by CBR destination to the number of packets generated by the CBR sources.
2) *Energy Consumption:* The energy consumed by the nodes while transmitting and receiving data and control packets.
3) *Reliability of routes:* The maximum the number of data packets successfully received by the destination, the high is the reliability of routes.
4) *Network lifetime:* The duration of time the network is alive.

B. *Performance of RMER*

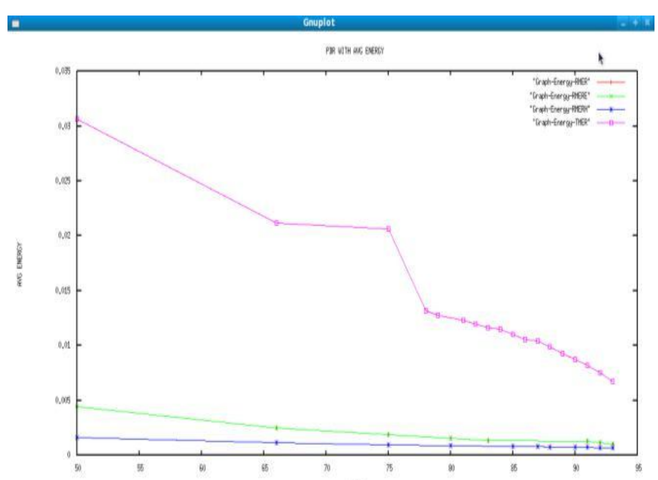

Fig 2 Packet delivery fraction with Average energy consumption

Fig 2 shows the performance of RMER (Reliable Minimum Energy Routing) against existing TMER (Traditional Minimum Energy Routing) by taking PDF (packet delivery fraction) on x-axis and energy consumption on y-axis. As the packet delivery fraction is decreasing the energy consumption of nodes also decreases but it is less in proposed RMER for hop by hop and end to end network.

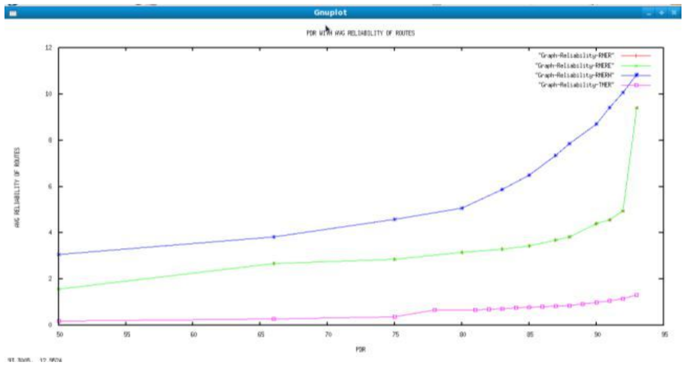

Fig 3 Packet delivery fraction with average reliability of routes

Packet delivery fraction on x-axis and RELIABILITY on y-axis. As the PDF increases the reliability also increases and it is high in proposed RMER for Hop-by-HOP and End-to-End network. Fig 3 shows the performance of RMER (Reliable Minimum Energy Routing) against existing TMER (Traditional Minimum Energy Routing) by taking PDF

C. Performance of RMEC AND RMER

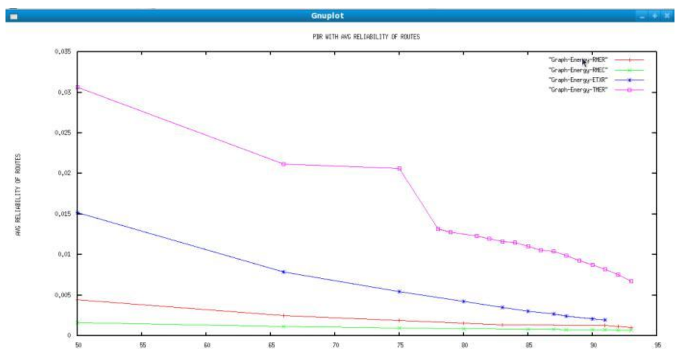

Fig 4 Packet delivery fraction with Average Energy consumption

Fig 4 shows the performance of RMER (Reliable Minimum Energy Routing) and RMECR (Reliable Minimum Energy Cost Routing) against existing TMER (Traditional Minimum Energy Routing) and MIN-ETX(Expected Transmission Count) by taking PDR(packet delivery fraction) on x-axis and ENERGY CONSUMPTION y-axis. As the PDR decreases the energy consumption of nodes also decreases and it is high in proposed RMECR then in RMER.

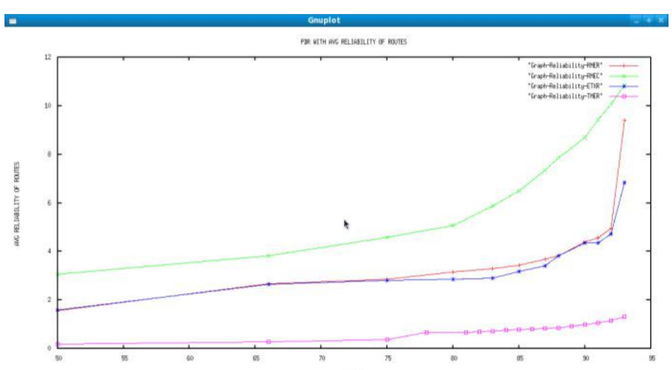

Fig 5 Packet delivery fraction with Reliability of routes

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Fig 5 shows the performance of RMER (Reliable Minimum Energy Routing) and RMECR (Reliable Minimum Energy Cost Routing) against existing TMER (Traditional Minimum Energy Routing) and MIN ETX(Expected Transmission Count) by taking PDR(packet delivery fraction) on x-axis and RELIABILITY OF ROUTES on y-axis. As the PDR decreases the energy consumption of nodes also decreases and it is high in proposed RMECR then in RMER.

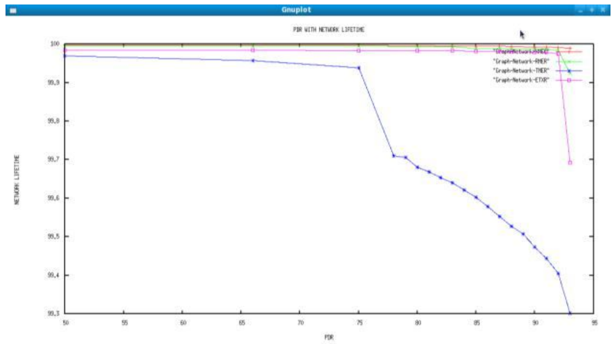

Fig 6 Packet delivery fraction with Network lifetime

Fig 6 shows the performance of RMER (Reliable Minimum Energy Routing) and RMECR (Reliable Minimum Energy Cost Routing) against existing TMER (Traditional Minimum Energy Routing) and MIN ETX(Expected Transmission Count) by taking PDR(packet delivery fraction) on x-axis and NETWORK LIFETIME on y-axis.

V. CONCLUSION

The proposed system presents here an in-depth study of energy-aware routing in ad hoc networks, and proposed a new routing algorithm for wireless ad hoc networks, namely, reliable minimum energy cost routing (RMECR). RMECR can increase the operational lifetime of the network using energy-efficient and reliable routes. In the design of RMECR, a detailed energy consumption model for packet transfer in wireless ad hoc networks is used. RMECR was designed for two types of networks: those in which hop-by-hop retransmissions ensure reliability and those in which end-to-end retransmissions ensure reliability. The general approach that used in the design of RMECR was used to also devise a state-of-the-art energy-efficient routing algorithm for wireless ad hoc networks, i.e., reliable minimum energy routing (RMER). RMER finds routes minimizing the energy consumed for packet traversal. RMER does not consider the remaining battery energy of nodes, and was used as a benchmark to study the energy-efficiency of the RMECR algorithm.

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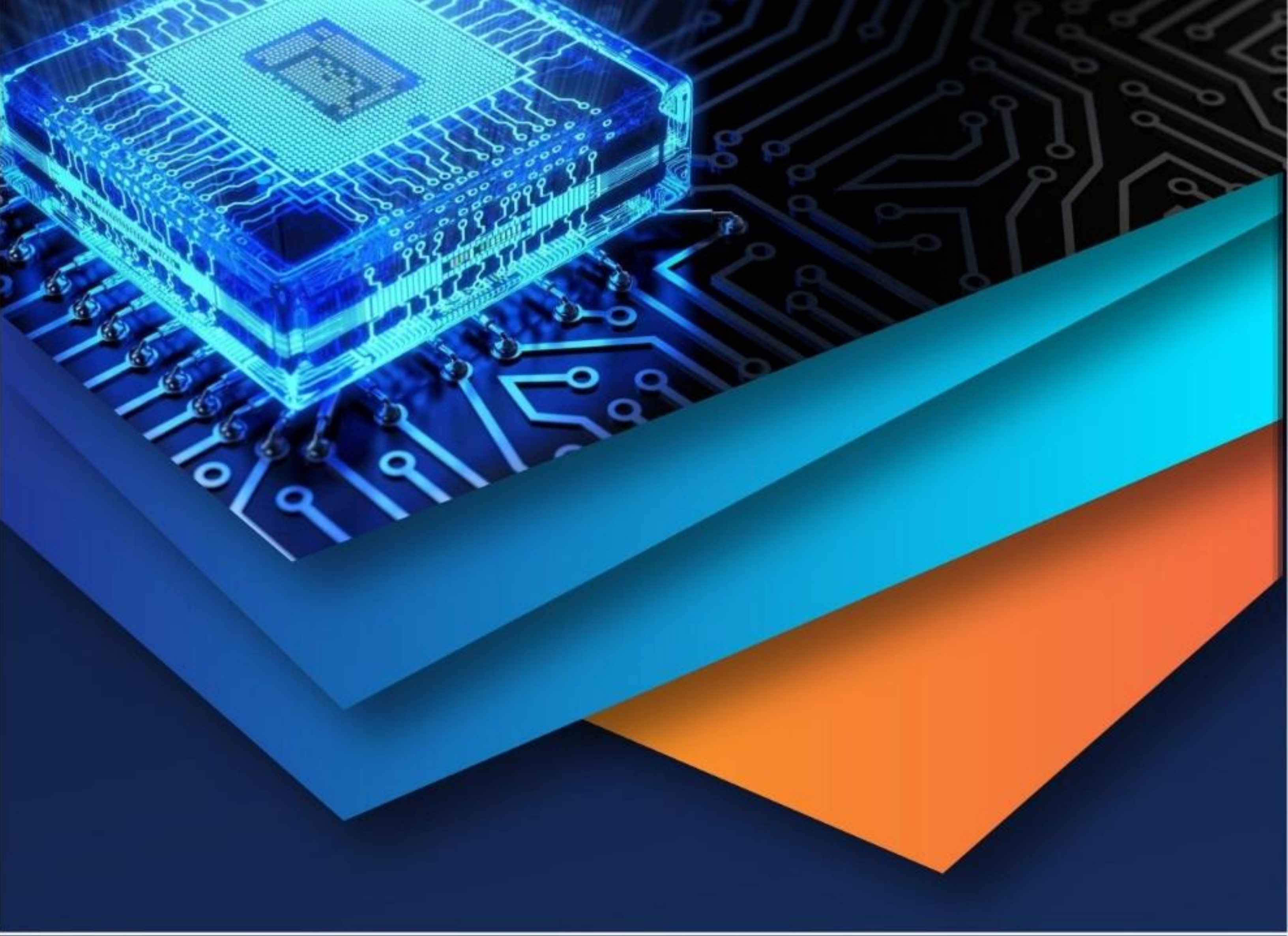

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