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Investigation and Analysis on Energy Efficient Stable Election Protocol (SEP) for WSN

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Abstract: We study the impact of heterogeneity of nodes, in terms of their energy, in wireless sensor networks that are hierarchically clustered. In these networks some of the nodes become cluster heads, aggregate the data of their cluster members and transmit it to the sink. We assume that a percentage of the population of sensor nodes is equipped with additional energy resources—this is a source of heterogeneity which may result from the initial setting or as the operation of the network evolves. We propose SEP, a heterogeneous-aware protocol to prolong the time interval before the death of the first node (we refer to as stability period), which is crucial for many applications where the feedback from the sensor network must be reliable. SEP is based on weighted election probabilities of each node to become cluster head according to the remaining energy in each node. We show by simulation that SEP always prolongs the stability period compared to (and that the average throughput is greater than) the one obtained using current clustering protocols. We conclude by studying the sensitivity of our SEP protocol to heterogeneity parameters capturing energy imbalance in the network. We found that SEP yields longer stability region for higher values of extra energy brought by more powerful nodes. Sensor nodes usually have limited energy supply and they are impractical to recharge. How to balance traffic load in sensors in order to increase network lifetime is a very challenging research issue. Many clustering algorithms have been proposed recently for wireless sensor networks (WSNs). The use of mobile sinks has been shown to be an effective technique to enhance network performance features such as latency, energy efficiency, network lifetime, etc. In this paper, a modified Stable Election Protocol (SEP), which employs a mobile sink, has been proposed for WSNs with non-uniform node distribution. The decision of selecting cluster heads by the sink is based on the minimization of the associated additional energy and residual energy at each node. Besides, the cluster head selects the shortest path to reach the sink between the direct approach and the indirect approach with the use of the nearest cluster head. Simulation results demonstrate that our algorithm has better performance than traditional routing algorithms, such as LEACH and SEP.
Keywords: wireless sensor networks; mobile sink; clustering; multi-hop; lifetime

I. INTRODUCTION

A sensor node in a Wireless Sensor Networks (WSNs) is typically equipped with a transducer, a radio transceiver, small micro-controller and a power source (usually batteries) deployed in phenomenon intended to monitor situations and parameters at diverse locations. Sensor nodes are capable of sensing many types of information from the environment including temperature, light, humidity, pressure, wind direction and etc. They usually transmit the acquired data through RF (Radio Frequency) channel to the base station or Gateway. Recently, WSNs has been used and implemented for a wide range of application areas such as – industrial process monitoring &control and remote control, environmental monitoring,

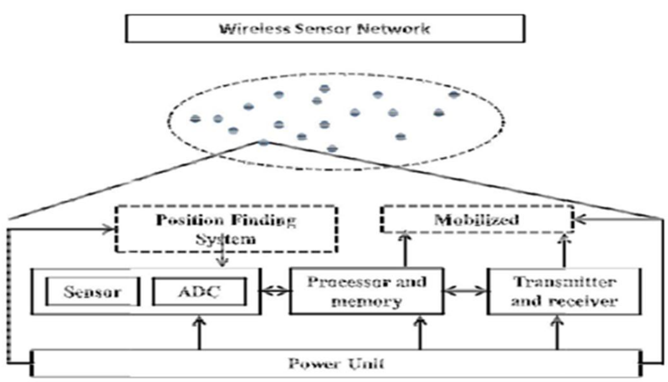


Fig.1: WSN and Components of Sensor Node

Habitat monitoring, health care applications, home automation, object tracking, traffic control and many other civilian and defense applications. However, WSN has its own set of issues and constraints pertaining to design limitations and resource requirements in practices. Resource constraints include a limited availability of valuable resource primarily –Energy, Range of Communication, Bandwidth, Processing Power, Storage Capacity. The recent research in WSNs intend to overcome these constraints by introducing new design concepts, creating newer improving existing protocols, building new applications, and developing new algorithms. Earlier researchers reported that Corchado et.al (2010) the role of cluster heads is randomly and periodically rotated over all the nodes to ensure the same rate of dissipation of battery power for all the sensor nodes. In heterogeneous sensor networks, two or more different types of sensor nodes with different hardware capabilities and battery power are used. The sensor nodes with higher hardware capabilities and more battery power compared to other sensor nodes act as cluster heads.

Similarly, DeFreitas et.al(2009) proposed a three-layer architecture for heterogeneous WSNs. In this architecture, the top layer contains only one sink that receives sensed data and analyze them. The second layer includes sensors with no energy constraint. These sensors, called line-powered sensors, have unlimited energy resources by connecting them to a wall outlet. The third layer contains battery-powered sensors that are one-hop away from line-powered sensors. The rationale behind this architecture is that the sensors closer to the sink in a multi-hop sensor network with many-to-one delivery consume more energy than all other sensors in the network, and thus should be line powered.

However, Elbhiri et.al, 2009), a unique identity is assigned to each node and chooses the node with lowest identity as cluster head. Various simulation results have shown that the LID clustering algorithm is more stable in an environment in which the network topology changes frequently.

Kumar et.al (2009) the throughput is low in HCN approach. However, the drawback of LID is that there may be quick power drainage of the cluster head node and Gateway nodes. List clustering change (LCC) algorithm is proposed to minimize the frequency of cluster head change where cluster stability is the major consideration under certain circumstances.

In the present study reported that, it is observed that the motivation by allowing rotation of cluster head role among the sensor nodes trying to distribute the energy consumption optimally over all nodes in the network. Selection of cluster head for such rotation greatly enhances the energy efficiency of the network. As part of this thesis and research work, many different routing protocols and algorithms are investigated to find ways to reduce power consumption. In this thesis protocols are proposed for both homogeneous and heterogeneous WSNs, which suggests different clusterhead selection strategies and various cluster formation techniques. Comparison of their costs (in terms of energy) of clusterhead selection in different rounds and other significant effects like cluster formation techniques, selection and distribution of clusterheads as well as creation of clusters shows a need of a combined strategy for bringing up optimum and better results (Ramesh&Somasundaram,2011). Finally, the thesis p rovides the qualitative and quantitative analysis of the research work done systematically and has been put across as the outcome of th is research study work.

II. METHODOLOGY

A. SEP Deployment

The heterogeneity in the energy of nodes could result from normal network operation. For example, nodes could, over time, expend different amounts of energy due to the radio communication characteristics, random events such as short-term link failures or morphological characteristics of the field (*e.g.* uneven terrain). To deal with such heterogeneity, our SEP protocol could be triggered whenever a certain energy threshold is exceeded at one or more nodes. Non-cluster heads could periodically attach their remaining energy to the messages they sent during the handshaking process with their cluster heads, and the cluster heads could send this information to the sink. The sink can check the heterogeneity in the field by examining whether one or a certain number of nodes reach this energy threshold. If so, then the sink could broadcast to cluster heads in that round the values for *pnrm* and *padv*, in turn cluster heads unicast these values to nodes in their clusters according to the energy each one has attached earlier during the handshaking process. If some of the nodes already in use have not been programmed with this capability, a reliable transport protocol, such as the one proposed in [10], could be used to program such sensors. Evaluating the overhead of such SEP deployment is a subject of our on-going work.

B. SEP Protocol

Existing SEP is a heterogeneity-aware protocol and election probabilities of nodes are weighted by initial energy of each node relative to that of other nodes in a network. A Stable Election Protocol for clustered heterogeneous wireless sensor networks (SEP) is developed for the two-level heterogeneous networks, which include two types of nodes, the advance nodes and normal nodes according to the initial energy.

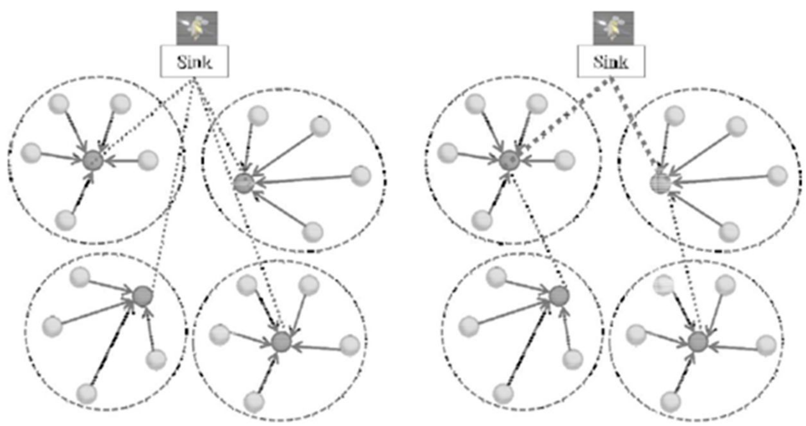
$$T(s) = \begin{cases} \dfrac{p}{1 - p * \mathrm{mod}(r, round(\frac{1}{p}))} & \text{if} s \in G \end{cases} \quad (1)$$

III. RESULT AND DISCUSSION

This chapter contains the outcomes of our research work. In this chapter, results of all the experiments are mentioned with their explanations and reasons behind the outcomes. This chapter gives the details of variation in results, graphical and tabulated representation of results.

A. Clustered Wireless Sensor Network in a field with Dimensions 100m× 100m.

The population of the sensors is equal to *n* = 100 and the nodes, both normal and advanced, are randomly (uniformly) distributed over the field. This means that the horizontal and vertical coordinates of each sensor are randomly selected between 0 and the maximum value of the dimension. The sink is in the center and the maximum distance of any node from the sink is approximately 70*m* (the setting of Figure 3). This setting is realistic for most of outdoor applications. The initial energy of a normal node has been set to *E*0 = 0.5*J* (equal to one AA battery)—Although this value is arbitrary for the purpose of this study, this does not affect the behavior of our method. The radio characteristics used in our simulations are summarized in Table 1. The size of the message that nodes send to their cluster heads as well as the size of the (aggregate) message that a cluster head sends to the sink is set to 4000 bits.



(a) Single Hop Cluster ing Model (b) Multi Hop Clustering Model

In the next subsections we simulate the heterogeneous-oblivious LEACH and our SEP protocol, in the presence of heterogeneity in the initial energy of nodes. We evaluate the behavior of both protocols in terms of the performance measures defined in Section 3. We also examine the sensitivity of SEP to the degree of heterogeneity in the network. We first summarize our general observations:

1) In a wireless sensor network of heterogeneous nodes, LEACH goes to unstable operation sooner as it is very sensitive to such heterogeneity.
2) Our SEP protocol successfully extends the stable region by being aware of heterogeneity through assigning probabilities of cluster-head election weighted by the relative initial energy of nodes.
3) Due to extended stability, the throughput of SEP is also higher than that of current (heterogeneous-oblivious) clustering protocols.
4) The performance of SEP is observed to be close to that of an ideal upper bound obtained by distributing the additional energy of advanced nodes uniformly over all nodes in the sensor field. • SEP is more resilient than LEACH in judiciously consuming the extra energy of advanced nodes—SEP yields longer stability region for higher values of extra energy. \

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B. Working Model of the Proposed Protocol

Initially nodes are deployed in the field. During the node deployment, each node is assigned with different energy levels ranging from 0-10 J. After the node deployment, it is divided into several clusters. The entire operating is divided into three phases.(a)Creation of Clusters and Cluster Head.(b)Selection of Cluster Head(c)Data transmission.

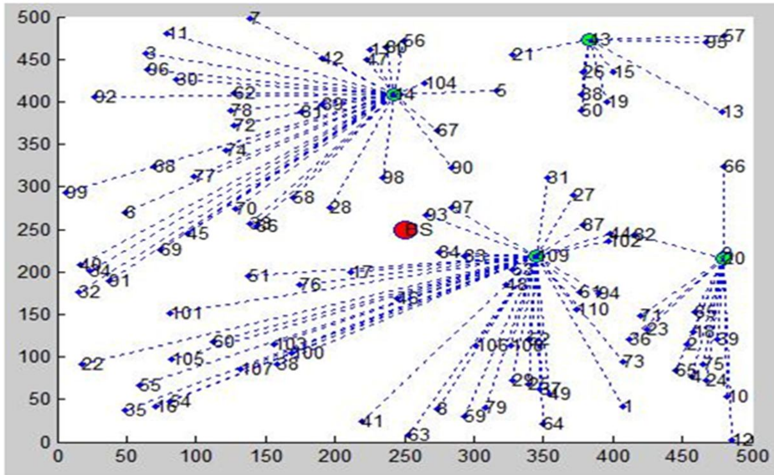

Fig.3: Node Deployment and Clustering

The creation of cluster head phase takes place after the node deployment. The nodes are divided into several clusters as shown in the Figure 3. And Each cluster has a leader called cluster-head, other nodes called cluster-members. Proposed protocol has a cyclical nature, and it proposes a concept named ‘round’, each round can be divided into two phases: cluster building phase and stable data transfer phase.In the cluster building phase, the sensor nodes generate a number between 0 and 1 randomly. Compared with T(n), the node will be selected as cluster-head if its generated number is less than the threshold. In the stable data transfer phase, the gathered data packages are delivered from members back to cluster-heads, and finally sent to sink node by cluster-heads.

C. Implementation and Analysis

The proposed protocol is simulated using Mat Lab version 7.0 tool. The simulation is performed i n the area of 500m × 500m. It shows the re sults for varying number of sensor nodes in the network for two parameters: lifetime and rate of fall energy. The simulation results show the performance of the proposed protocol when du ty cycle is applied to the nodes and compared the same without applying duty cycle .This helps to measure the lifetime of the network and energy efficiency as shown in Figure 4, shows the results of lifetime of the network, simulated for 100,150 and 200 nodes.

Figure 4, the lifetime of the network with duty cycle is ended at 82 with 100 nodes, and without duty cycle it is ended at 31. Similarly for 150 and 200 nodes, the lifetime is ended at 61, 18 and 70, 28 respectively. From the above simulation it can be concluded that the lifetime of the network is 35.8% more efficient when nodes are applied with duty-cycle.

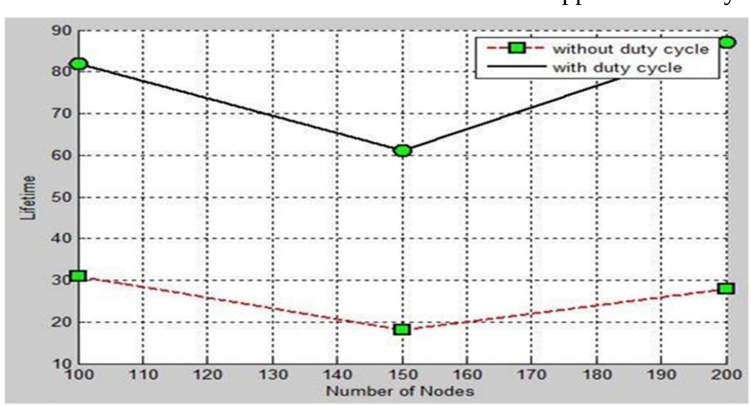

Fig. 4. Lifetime comparisons for 100,150,200 nodes

Figure 5.represents the results of rate of fall of energy of nodes, simulated for 100,150 and 200 nodes.Figure 5.indicates that the rate of fall of energy decreases when the duty-cycle is applied. For 100 nodes the rate of fall of energy of nodes with duty cycle is 0.002871J and 0.009355J without duty cycle. Similarly for 150 and 200 nodes, the rate of fall of energy is 0.002283 J, 0.006286J and 0.001600 J, 0.004643 respectively. From the above results it can be concluded that the rate of fall of energy is 34% more efficient when nodes are applied with duty-cycle.

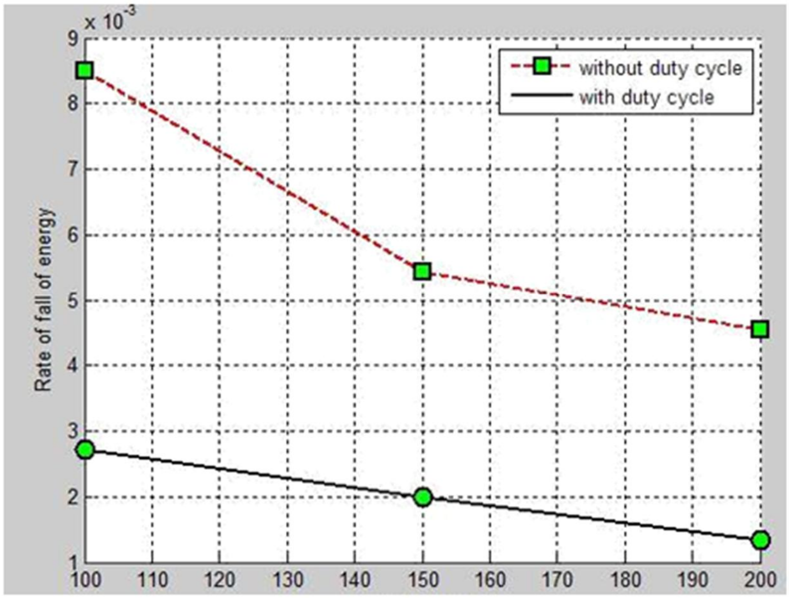

Fig.5: Rate of fall Energy comparisons for 100,150,200 nodes

Figure 6,represents the results of lifetime of the network, simulated for 250,300 and 350 nodes.In thegraph shown below, the lifetime of the network with duty cycle is ended at 89 with 250 nodes, and without duty cycle it is ended at 19.Similarly for 300 and 350 nodes, the lifetime is ended at 82, 41 and 94, 38 respectively. From the above results it can be concluded that the lifetime of the network is 30.8% more efficient when nodes are applied with duty-cycle

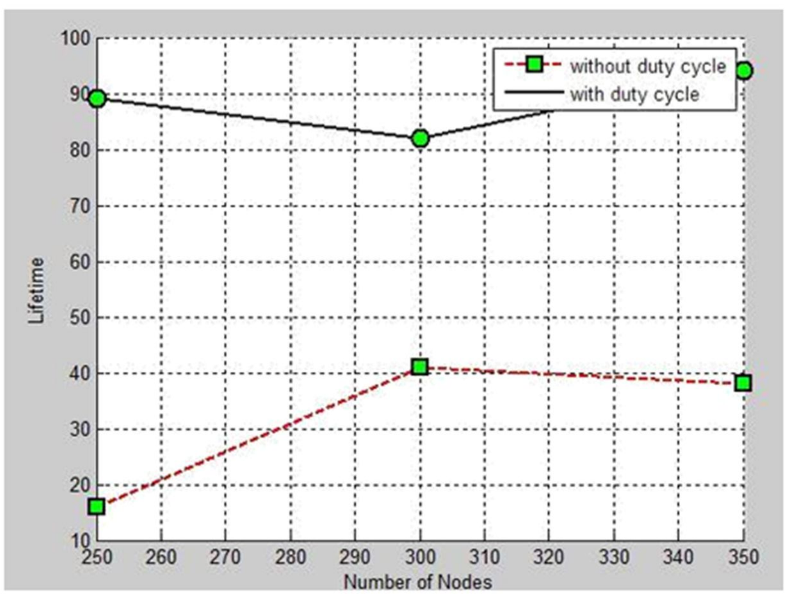

Fig.6: Lifetime comparisons for 250,300,350 nodes

IV. CONCLUSIONS

On the basis of results and discussion following conclusions are drawn:

1) Comparative Probabilistic simulation of EAMMH and other protocol for the 50, 100, 150 and 200 nodes over the number of rounds of simulations conducted at respective intervals at different scenarios and probabilities at 0.05, 0.1 and 0.2 shows that EAMMH protocol performs better than others in majority of the scenarios because EAMMH protocol consists of a inter cluster routing mechanism which will helps make the network energy aware and survive for a longer time.
2) EAMMH protocol performs with much better energy efficiency than other protocols in cases where more number of nodes are involved in the given network, due to the usage of multi-hop-multi-path and hierarchical routing parameters and techniques employed as proposed in the EAMMH protocol.
3) Proposed HEEPSCC Protocol bridges the gap between stability and energy efficiency in heterogeneous WSN and delay the death of the first node in the network thus increasing the stability period in the network lifetime by using stable concentric clustering by the way of choosing cluster head based on the position of the advanced nodes and the combined rating, leveraging K-therom.
4) For HEEPSCC Protocol,as the number of nodes in the network increases, the number of dead nodes at the end of 8000 rounds is far less when compared to the other protocols in Heterogeneous WSN.
5) For PSCCP protocol, with the usage of probabilistic equation, by choosing the Cluster Head based on its residual energy, can delay the death of the first node in the network thus increasing the stability period in the network lifetime when compared to the other protocols such as SEP.
6) By applying duty-cycle in the combined algorithm for WSN, can survive for a longer time compared to nodes without applying duty-cycle in this algorithm. When LEACH and DCHS are combined together and by applying duty-cycle, gives 32% of average increase in lifetime and 34% of average increase in the energy efficiency.

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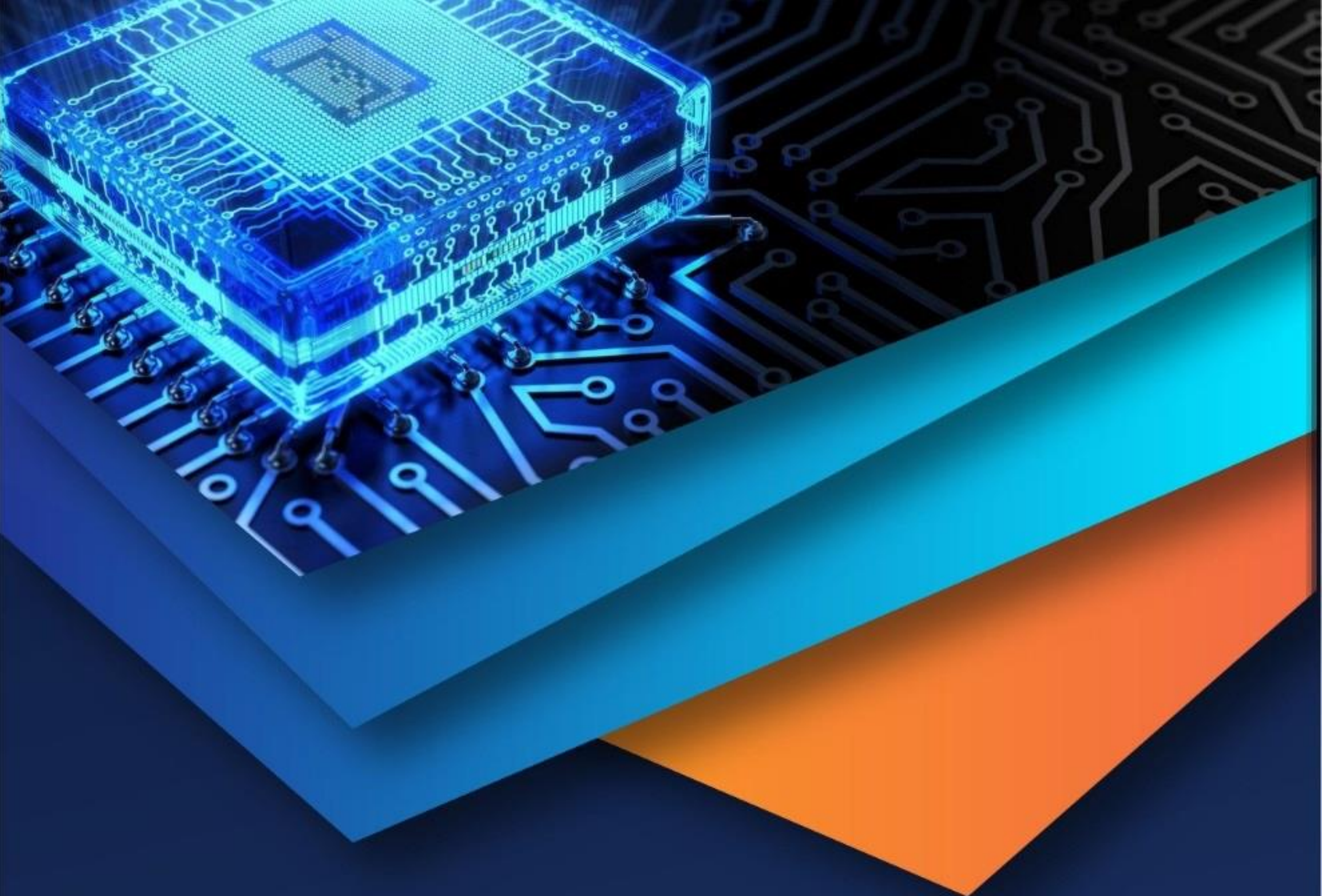

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