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A Review Article on Energy Efficient Routing Protocol for Minimizing Energy Consumption

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***Abstract:** Recent developments in the area of micro-sensor devices have accelerated advances in the sensor networks field leading to many new protocols specifically designed for wireless sensor networks (WSNs). Wireless sensor networks with hundreds to thousands of sensor nodes can gather information from an unattended location and transmit the gathered data to a particular user, depending on the application. These sensor nodes have some constraints due to their limited energy, storage capacity and computing power. Data are routed from one node to other using different routing protocols. There are a number of routing protocols for wireless sensor networks. In this review article, we discuss the architecture of wireless sensor networks. Further, we categorize the routing protocols according to some key factors and summarize their mode of operation. Finally, we provide a comparative study on these various protocols.*

***Keywords:** Wireless Sensor Network, TEEN protocol, isolated node.*

I. INTRODUCTION

WSN can be viewed as a network consisting of hundreds or thousands of wireless sensor nodes which collect the information from their surrounding environment and send their sensed data to Base Station or sink node [1].Routing is a process of determining a path between source and destination for data transmission. In WSNs the network layer is mostly used to implement the routing of the incoming data and Routing protocol is an important factor in design of a communication stack. In multi-hop networks the intermediate sensor nodes have to relay their packets towards Base Station [2]. Routing protocols, designed for sensor networks, must accomplish high reliability. There has to be multiple paths to relay the data from source node to the destination node in order to achieve robustness. Sensor nodes are constrained in energy supply and recharging sensor nodes is normally impractical due to their nature of deployment. Therefore, energy saving is an important design issue in Wireless sensor networks. While the objective of traditional networks is to achieve high quality of service, sensor network protocols must focus additionally on power conservation also to maximize the network lifetime. Flooding the network is a highly expensive operation with respect to energy consumption and should be avoided. Hence, efficient routing is a major challenge in the field of WSN [3,4, 5].

II. WIRELESS SENSOR NETWORK (WSN)

Wireless sensor network (WSN) is composed of many tiny sensor nodes (SNs) in a self- organizing wireless network (Ye et al., 2017; Zheng et al., 2017; Li et al., 2017). The SNs can sense, collect, process and transmit information on specific objects in the coverage area. Then they send data to the owner of the network. The fundamental objective of the WSN is to reduce energy consumption and prolong the network lifetime. However, due to the limitations of sensor battery capacity and its own computing ability, WSN would often be designed differently from conventional wireless routing protocols. Generally, the wireless sensor network routing protocol can be divided into the plane routing protocol, geographical location routing protocol and hierarchical routing protocol based on the network structure.

III. PROTOCOLS

The main purpose of LEACH is to improve the energy efficiency based on a cluster head (CH) round process. Power-efficient gathering in sensor information systems.

PEGASIS protocol adopts a chain structure to aggregate and to transmit data. Each node serves as a receiver as well as a sender, which means that each node receives and sends data packets within each round. The PEGASIS protocol is better than LEACH protocol in terms of the dynamic chain process and the data transmission mode. Therefore, the performance of PEGASIS protocol is better than LEACH protocol as well. Another classic reaction hierarchical routing protocol is threshold sensitive energy efficient network (TEEN).

The node will transmit data if it finds that the sensed-data is either greater than the hard threshold or the difference between continuously two-time sensed-data is more than or equal to the soft threshold. Therefore, the TEEN protocol is not suitable for scenarios that require continuous transmission of data. It also means that the TEEN protocol has less energy consumption than the LEACH protocol.

In wireless sensor networks (WSN), routing is quite challenging area of research where packets are forwarded through multiple nodes to the base station. The packet being sent over the network should be shared in an energy efficient manner. It also considers the residual power of battery to enhance the network life time. Existing energy efficient routing solutions and surveys are presented but still there is a need for Systematic Literature Review (SLR) to identify the valid problems. This paper performs SLR for energy efficiency routing with 172 papers at initial stage. Next, 15 papers are shortlisted after filtration based on quality valuation and selection criteria by ensuring relevance with energy efficiency. Initially, we present literature that includes schemes for threshold sensitive, adaptive periodic threshold sensitive, power efficient, hybrid energy efficient distribution and low energy adaptive mechanisms. Result of systematic review reveals that consumption of energy is the most fundamental issue in WSN however, is not noticed by the researchers and practitioners where as it can contribute for the improvement of the energy efficiency. It also elaborates the weaknesses of the existing approaches which make them inappropriate for energy efficient routing in WSN [6].

Advanced threshold-sensitive energy efficient sensor network (A-TEEN) protocol A-TEEN optimized the cluster head election method compared with TEEN. Simulation result shows that compared with low-energy adaptive clustering hierarchy, TEEN increases the energy efficiency and extends life cycle of cognitive wireless sensor network. A-TEEN improves the energy efficiency and lifetime further operating in the same settings compared with the regular TEEN [2].

Homomorphic Encryption and Watermarking protocol proposed scheme enhances security by detecting the sinkhole attacker node before the attack is even activated. In addition, the proposed method ensures the integrity and authenticity of the sensed data while transmitting them from the sensor node until receiving it in the base station, and it can detect any tampering of the data. The proposed work has been evaluated using OMNETCC simulation environment to measure the proposed work performance in the following metrics: delay, packet delivery ratio, throughput, and average energy consumption [1].

Modify TEEN protocol in reactive protocol, such as TEEN protocol, one of the cause of the short life time of WSN are isolated node. In this paper, we try to modify TEEN protocol, so it could accommodate the isolated node. The simulation will be built as the test bed. The result from the simulation show that the modify TEEN protocol can decrease the energy consumption. The next work could be done for adding isolated node concept to another protocol [2].

Genetic Algorithm (GA) TEEN protocol Genetic Algorithm (GA) for multi hop scenario in extensive experiments with 20-90 nodes and analyze the performance of the proposed algorithm in terms of energy expenditures, scalability and longlivety of the SN. GA sinks nearly all packets in 18000 rounds as compared less efficient threshold sensitive energy efficient sensor network (TEEN) protocol under various deployments. In analysis for distance of multiple hops from/to the respective sink, the proposed algorithm performed fairly better than the TEEN approach in maximizing the sensor activity by saving energy resulting the increased lifetime of the network. Further, the algorithm is scalable and any number of nodes can produce the optimized results. The work can be extended to format some new scenarios and optimize routes with the help of GA and other algorithms typically used in optimization [3].

Adaptive soft thresholding based energy efficient sensor protocol the proposed protocol is investigated with correlated and uncorrelated sensed data, and it is compared with the other related and conventional protocols. Simulation results show that the performance of the proposed ASTEEN routing protocol in terms of network lifetime and energy consumption significantly outperforms those of the other protocols, especially with correlated sensed values [4].

Hybrid Approach for Energy Efficient Network protocol a hybrid protocol i.e. 'Adaptive Threshold Aggregation Distributed Energy Efficient Clustering (ATADEEC)' based on Adaptive Periodic TEEN (APTEEN) hierarchical protocol and Enhanced Distributed Energy Efficient Clustering (EDEEC) to enhance the performance of the network system by utilizing the energy of network nodes. MATLAB software has used to simulation of the proposed algorithm and to show that ATADEEC scheme is effective for overcoming of the energy consumption problem due to redundant data transfer in EDEEC and APTEEN used network [5].

LEER protocol Low Energy Adaptive Clustering Hierarchy (LEACH), Threshold Sensitive Energy Efficient sensor Network (TEEN) and Pairwise Energy Efficient Routing (PEER). The performance metrics considered are network lifetime, energy efficiency, the number of dead nodes per round and the time till first node is dead. The experiments we carried out proved our protocol to be much better compared to TEEN, LEACH and PEER [6].

Energy Efficient Dijkstra-Based Weighted Sum Minimization Routing Protocol proposes a scheme which considers K-means clustering in cluster formation phase and calculates a weight function for the cluster head selection process. Moreover, it considers an optimal fixed packet size with respect to radio parameters and channel conditions of the transceiver. In data transmission phase, it implements a multiobjective weight function as a link cost using traditional Dijkstra algorithm. This technique results in balanced and efficient energy consumption of nodes within the network. Simulation results show that proposed scheme is better than the CERP and TEEN routing protocol in terms of energy conservation of nodes in the network and increases the throughput of the overall system. It also indicates high scalability and packet delivery rate due to the efficient use of energy in the system [7].

Self Power Analysing Energy Efficient Protocol (SPAEEP) Research proposes novel idea of Self Power Analyzing Energy Efficient Protocol (SPAEEP) with energy model (EM). EM is applied to CH which adaptively decides to initiate next round based on balanced energy. Adaptive decision will help in reducing the number of rounds (r). Application of the same to the nodes will lead to fault tolerant network with proper hand over mechanism. Concept is also extended to 802.15.4 protocol, as it follows standard network architecture. Our results reveal that new method suggested will reduce energy consumption of CH and hence the increased life span of network. The outcome is fault tolerant network [10].

Enhanced PSO-Based Clustering Energy Optimization Protocol proposes an Enhanced PSO-Based Clustering Energy Optimization (EPSO-CEO) algorithm for Wireless Sensor Network in which clustering and clustering head selection are done by using Particle Swarm Optimization (PSO) algorithm with respect to minimizing the power consumption in WSN. The performance metrics are evaluated and results are compared with competitive clustering algorithm to validate the reduction in energy consumption [11].

IV. APPLICATIONS

The applications for WSNs involve tracking, monitoring and controlling. WSNs are mainly utilized for habitat monitoring, object tracking, nuclear reactor control, fire detection, and traffic monitoring. Area monitoring is a common application of WSNs, in which the WSN is deployed over a region where some incident is to be monitored. For example, a large quantity of sensor nodes could be deployed over a battlefield to detect enemy intrusions instead of using landmines. When the sensors detect the event being monitored (heat, pressure, sound, light, electro-magnetic field, vibration, etc.), the event needs to be reported to one of the base stations, which can than take some appropriate action (e.g., send a message on the internet or to a satellite). Wireless sensor networks are used extensively within the water/wastewater industries. Facilities not wired for power or data transmission can be monitored using industrial wireless I/O devices and sensor nodes powered by solar panels or battery packs. Wireless sensor networks can use a range of sensors to detect the presence of vehicles for vehicles detection. Wireless sensor networks are also used to control the temperature and humidity levels inside commercial greenhouses. When the temperature and humidity drops below specific levels, the greenhouse manager can be notified via e-mail or a cell phone text message, or host systems can trigger misting systems, open vents, turn on fans, or control a wide variety of system responses. Because some wireless sensor networks are easy to install, they are also easy to move when the needs of the application change [7].

V. TEEN ROUTING PROTOCOL

TEEN is a reactive clustering routing protocol which is improved by LEACH. The cluster head (CH) of each cluster collects data from its cluster members. CHs fuse and process data and send data to the BS or higher level CH. All of the nodes only need to transmit data to their CH and only the CHs need to aggregate data which is the advantage of the clustering routing protocols. It is energy-saving. All nodes take turns becoming the CH in order to evenly distribute the energy consumption. CH election uses the random selection mechanism. Once clusters are formed, CHs allocate a time slot for cluster members in which the cluster members can transmit their data.

Unlike LEACH, in TEEN routing protocol, CHs broadcast HT and ST to their members to control the quantity of data transmission. HT is set based on the range of interest value of users; only when current value of sensed attribute is greater than the value of HT will the nodes transmit sensed data to CH in the current round. Then, sensed attribute is stored in the sensed value (SV) which is an internal variable. Nodes sense attribute continuously; only when the next value differs from SV by an amount equal or greater than the ST will it be transmitted. The ST reduces the frequency of data transmission by abandoning little change of sensed attribute. The value of ST can be changed according to the needs of users. Setting a smaller ST makes the network more accurate, at the cost of increased energy consumption. Thus, users must adjust the size of ST to control the trade-off between energy efficiency and accuracy.

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A. TEEN (Threshold sensitive Energy Efficient sensor Network)

TEEN [8] is a cluster based hierarchical routing protocol based on LEACH. This protocol is used for time-critical applications. It has two assumptions [10]:

1) The BS and the sensor nodes have same initial energy
2) The BS can transmit data to all nodes in the network directly.

In this protocol, nodes sense the medium continuously, but the data transmission is done less frequently. The network consists of simple nodes, first-level cluster heads and second-level cluster heads. TEEN uses LEACH's strategy to form cluster. First level CHs are formed away from the BS and second level cluster heads are formed near to the BS.

A CH sends two types of data to its neighbors—one is the hard threshold (HT) and other is soft threshold (ST). In the hard threshold, the nodes transmit data if the sensed attribute is in the range of interest and thus it reduces the number of transmissions. On the other hand, in soft threshold mode, any small change in the value of the sensed attribute is transmitted. The nodes sense their environment continuously and store the sensed value for transmission. Thereafter the node transmits the sensed value if one of the following conditions satisfied:

a) Sensed value > hard threshold (HT).
b) Sensed value ~ hard threshold >= soft threshold (ST).

TEEN has the following drawbacks:

- A node may wait for their time slot for data transmission. Again time slot may be wasted if a node has no data for transmission.
- Cluster heads always wait for data from nodes by keeping its transmitter on.

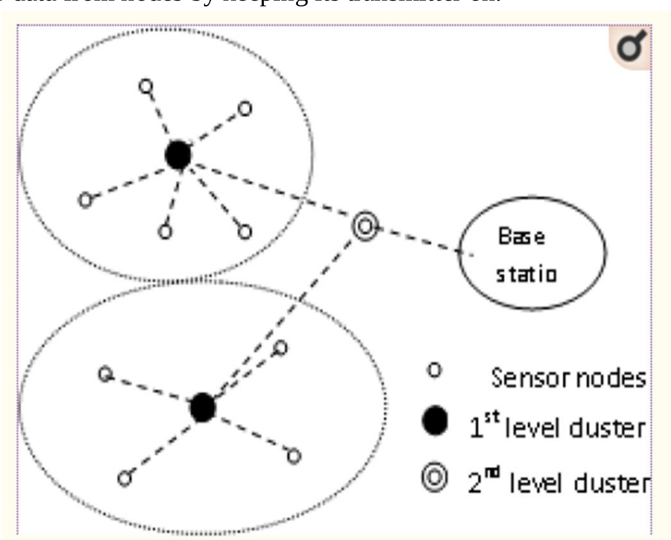

Fig (1) Hierarchical clustering in TEEN and APTEEN Protocols.

VI. PROTOCOL CHOICE IN WIRELESS SENSOR NETWORK, THRESHOLD SENSITIVE ENERGY

Efficient Sensor Network (TEEN) protocol is widely used, which develops from LEACH protocol. The main idea of TEEN is: cluster head nodes are randomly selected from the wireless sensor network, and other common nodes join the cluster randomly by Proximity Principle, then a virtual cluster forms to assign the whole network energy load evenly to each sensor node [8]. By above methods, the energy consumption of sensor nodes can be decreased and life cycle of the network can be prolonged. During the process of building cluster, cluster head nodes will broadcast hard threshold and soft threshold to common nodes. By adjusting two thresholds, the TEEN protocol can achieve a balance between the precision of transmitted data and network energy consumption. The existing simulations show that the TEEN protocol is superior to most of routing protocols in prolonging life cycle of the network [9].

VII. COMPARATIVE RESULT AND SIMULATION

Table (1) Comparison between previous methods

Method	TEEN energy consumption
Encryption protocol[1]	0.5
modify TEEN protocol[2]	0.12
Encryption S protocol[1]	0.9
Multihop protocol[3]	0.7
LEACH[6]	0.0637
TEEN[6]	0.0403
PEER[6]	0.0614
LEER[6]	0.0698
coding model basing on TEEN[9]	0.77

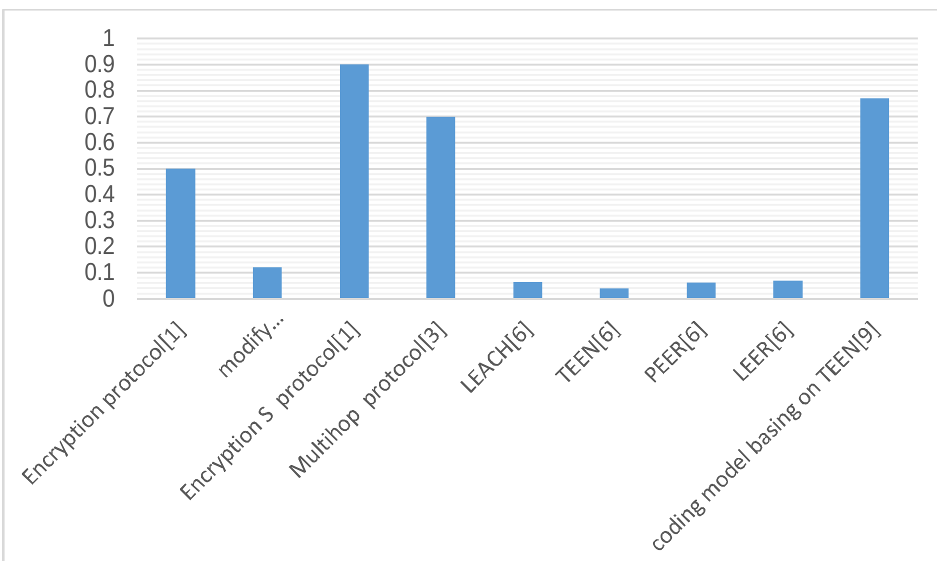

Fig (2) Energy comparison Graph.

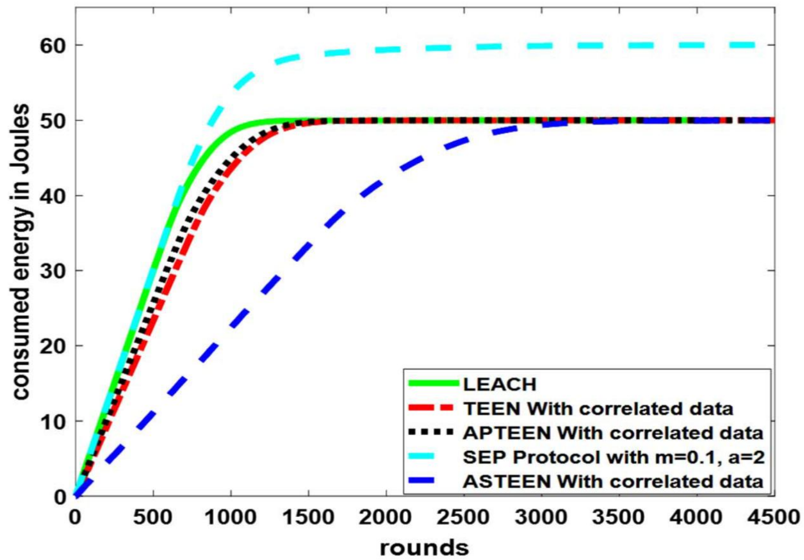

Fig (3) Consumed energy versus transmission rounds [4].

VII. CONCLUSION

This paper aimed to present a systematic literature review with the purpose of obtaining the state of the art of approaches, methods, and methodologies whose goal is the use of AC principles in wireless sensor network applications in order to optimize network resources.

Therefore, we defined the SLR protocol and presented the search and the results from this review. As a result, we have found that selected studies address AC principles based on its self-* properties: self-configuration, self-healing, self-optimization, and self-protection. Also, we have found studies with different development approaches: context-based reasoning, policy-based reasoning, feedback control loop, mobile agents, and model transformation and code generation.

More than the half of the selected studies propose solutions for self-configuration property, but few of them address self-protections and self-optimization properties. Most of the feedback control loop solutions use context-based reasoning for monitoring process and policy-based reasoning to execution an action plan. The selected studies that implemented a combination of these development techniques were better able to handle the four self- properties.

Deploying WSN in insecure environments and using the wireless transmission and the node limited sources keeping the security of data and control information is an important open issue for WSN. We noticed a lack of solutions for self-protection in WSN. Some security requirements of self-protection are authentication, integrity, and confidentiality. It is necessary to propose solutions to defend the sensor network against correlated problems arising from malicious attacks or cascading failures that remain uncorrected by self-healing measures and to propose mechanisms to anticipate problems based on early reports from sensors and taking steps to avoid or mitigate them. One of the main challenges is to define mechanisms able to detect many types of unknown and known attacks.

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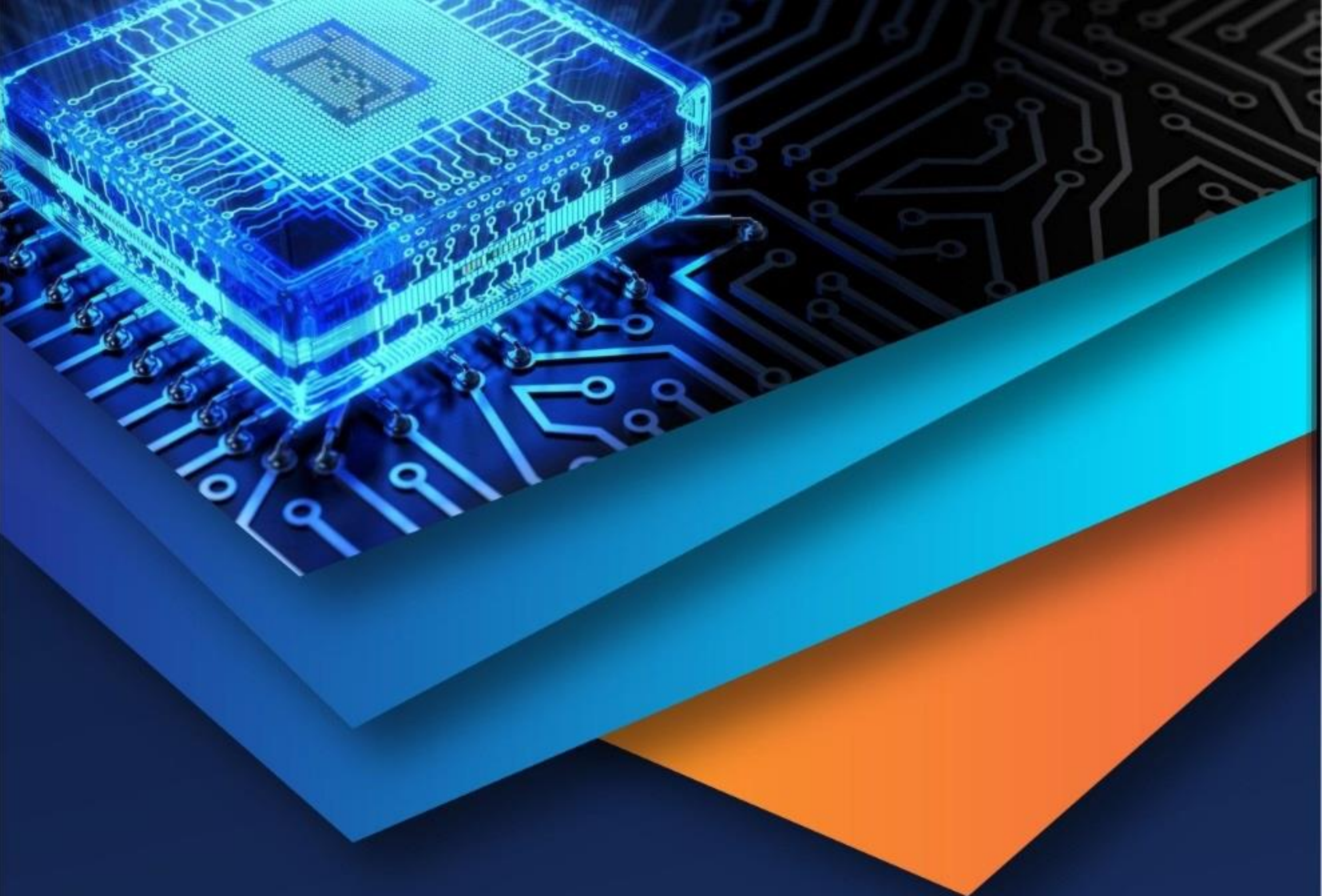

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