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Cost Optimization of Underwater Wireless Sensor Network using Conventional Method and Fuzzy Inference System

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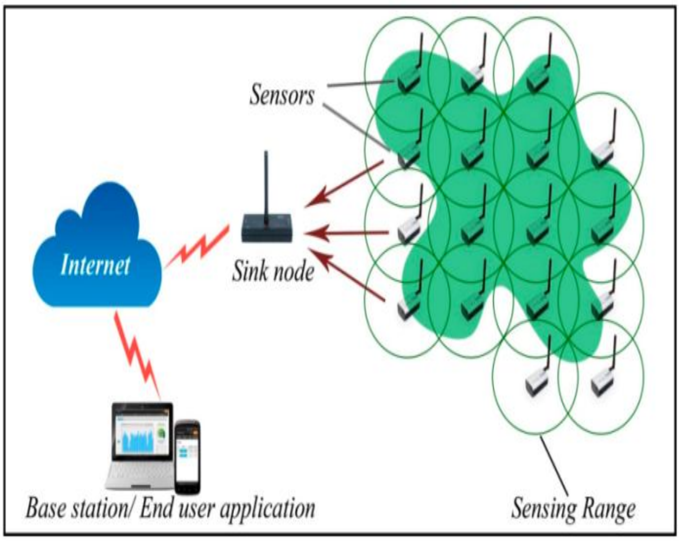
Abstract: In present era underwater wireless sensor networks (UWSNs) are gaining more popularity in the day to day life due to its key role in varieties of applications like, underwater monitoring, tsunami warnings, tactical surveillance offshore exploration, pollution monitoring, etc. But it faces lots of challenges for efficient and reliable communication protocols, due to its features like low available bandwidth, large propagation delay, high error probability and highly dynamic network topology. This paper presents a broad overview of the recent research trends on Underwater Wireless Sensor Networks, focusing on the lower layers of the communication stack, and envisions future trends and challenges. It analyzes the current state of-the-art on the physical, medium access control and routing layers also focus their security threads and surveys the currently proposed works. In this paper, we emphasize on Cost Optimization for routing at Network Layer. For the cost optimization we have implemented four different routing algorithms such as Distance to Zero, Distance to Previous Node, Tabu Search and Fuzzy Inference System. We have implemented the cost optimization algorithm in MATLAB We found that Fuzzy Inference system give better result in Cost Optimization based on parameter like, Node Degree, Node Distance, and Node Priority.
Keywords: WSN, Under Water Wireless Sensor (UWSN), Fuzzy Inference System, Tabu Search, Cost Optimization.

I. INTRODUCTION

WSN is composed of several sensors which are randomly or deterministically distributed for data acquisition and to forward the data to the gateway for further analysis [1]. WSNs are used in various industrial applications; in street lighting, in smart grid, water municipals, in health care for monitoring the health condition of a patient, in green house monitoring to monitor the condition of water, soil, temperature or humidity levels etc. The main importance of wireless sensor network in area of machine monitoring is they can be placed in a rotating machinery, or in a place which is un reachable for the engineer to take measurements by hard wired sensors. In today's world, wired sensors are being replaced by WSN because wireless sensors are cheaper as compared to their counterpart [2].

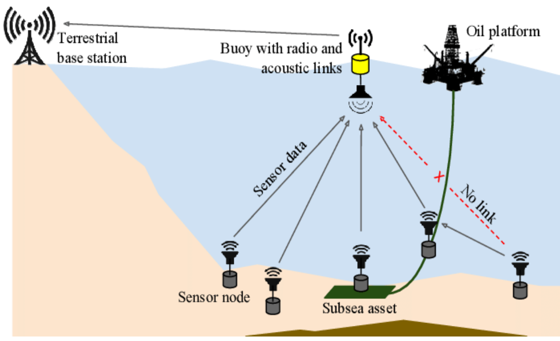


[Fig 1 Wireless Sensor Network]

II. UNDERWATER WIRELESS SENSOR NETWORK

Recently, with the development of wireless communication and the low power RF (Radio Frequency) designs widely used in sensor nodes, wireless sensor networks (WSNs) have received great attention due to their wide usage in environmental monitoring, transportation, disaster rescue and homeland security [3-4]. At the end of the twentieth century, wireless sensor networks became a hot research area. At the beginning, these networks covered only terrestrial applications. However, the earth is known to be a water planet, with 70% of its surface being covered with water (principally oceans). Only less than of the ocean volume has been investigated, while the volume majority remains unexplored. With the increasing role of oceans in human life, discovering all of the ocean parts became of prime importance. On one side, traditional approaches formerly used for underwater monitoring missions have several drawbacks [5] and on the other side, these harsh environments are not feasible for human presence as unpredictable underwater activities, high water pressure, predatory fish and vast areas are major reasons for unmanned exploration. Due to these reasons, Underwater Wireless Sensor Networks (UWSNs) attract the interest of many researchers lately, especially those working on terrestrial sensor networks [6].

Over the last three decades, significant contribution has been made in the area of scientific, commercial, and military applications [7]. In particular, highly precise real-time continuous-monitoring systems are essential for vital operations such as offshore oil field monitoring, pollution detection, disaster prevention, assisted navigation, mine reconnaissance, and oceanographic data collection. All these significant applications call for building Underwater Wireless Sensor Networks (UWSNs).



[Fig 2 Underwater wireless sensor network]

The work done in [8] is considered as the pioneering effort towards the deployment of sensor nodes for underwater environments. Though there exist many network protocols for terrestrial wireless sensor networks, the underwater acoustic communication channel has its unique characteristics, such as limited bandwidth capacity and high delays which require new efficient and reliable data communication protocols [9].

III. ROUTING PROTOCOLS

Actually, there are many routing protocols that have been proposed for terrestrial wireless sensor networks (TWSNs). However, these are not suitable for UWSNs, mainly because of specific characteristics of UWSNs, such as dynamic structure, narrow bandwidth, rapid energy consumption, and high transmission latency. Therefore, many novel routing protocols have been specifically proposed for UWSNs [10]. In this article we survey some of these routing protocols and provide a comparison table of the most important ones.

Usually, sensor nodes in UWSNs are mobile and freely float with the ocean current. There-fore, the established routing paths need regular updating and maintenance, which obviously introduces high energy consumption. However, it is generally known that all sensor nodes are energy limited, and hence it is challenging to build energy efficient routing protocols for UWSNs. In routing protocols for UWSNs,

In computer communication theory relating to packet-switched networks, a distance-vector routing protocol is one of the two major classes of routing protocols, the other major class being the link-state protocol. A distance-vector routing protocol uses the Bellman-Ford algorithm to calculate paths. A distance-vector routing protocol requires that a router informs its neighbors of topology changes periodically and, in some cases, when a change is detected in the topology of a network. Compared to link-state protocols, which require a router to inform all the nodes in a network of topology changes, distance-vector routing protocols have less computational complexity and message overhead. Distance Vector means that Routers are advertised as vector of distance and direction. 'Direction' is represented by next hop address and exit interface, whereas 'Distance' uses metrics such as hop count

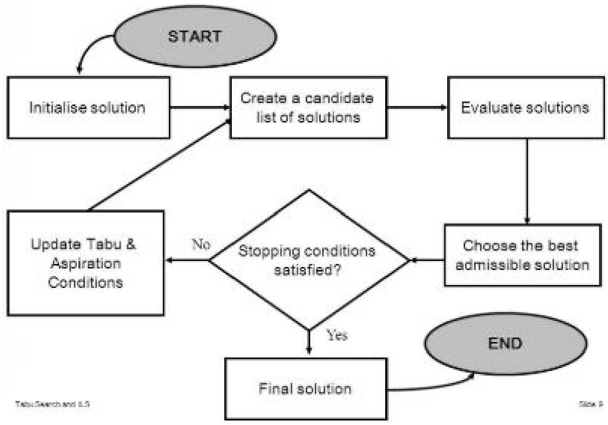
A. Distance Vector Algorithm

A router transmits its distance vector to each of its neighbors in a routing packet. Each router receives and saves the most recently received distance vector from each of its neighbors. A router recalculates its distance vector when: It receives a distance vector from a neighbor containing different information than before. It discovers that a link to a neighbor has gone down. The DV calculation is based on minimizing the cost to each destination [11]

B. Tabu Search Algorithm

Tabu Search is a Global Optimization algorithm and a Metaheuristic or Meta-strategy for controlling an embedded heuristic technique. Tabu Search is a parent for a large family of derivative approaches that introduce memory structures in Metaheuristics, such as Reactive Tabu Search and Parallel Tabu Search. The objective for the Tabu Search algorithm is to constrain an embedded heuristic from returning to recently visited areas of the search space, referred to as cycling. The strategy of the approach is to maintain a short term memory of the specific changes of recent moves within the search space and preventing future moves from undoing those changes. [12]

Tabu search is a me la-heuristic that guides a local heuristic search procedure to explore the solution space beyond local optimality [13]. TS goes beyond local search by solutions with improved objective function values are permitted. The key aspect of Tabu search approach is the use of special memory structures, which serves to determine N*(x). and hence to organize the way in which the space is explored. To avoid cycling. Tabu search prohibits certain moves from being re-instantiated for a period of time by utilizing a special short-term memory structure called recency-based memory, which is implemented by means of a Tabu list. The span of iterations during which an attribute is maintained as Tabu is called the Tabu.



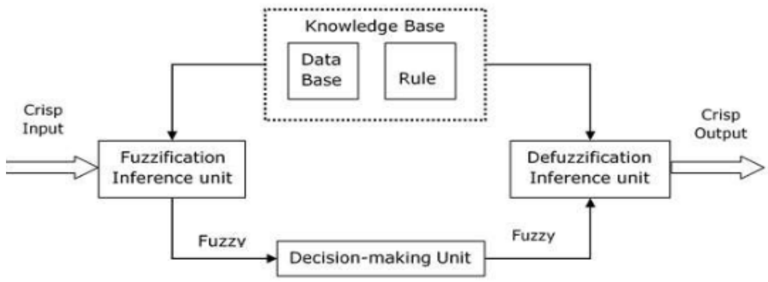
[Fig 3 Tabu Search Algorithm]

C. Fuzzy Inference System

Fuzzy Inference System is the key unit of a fuzzy logic system having decision making as its primary work. It uses the “IF…THEN” rules along with connectors “OR” or “AND” for drawing essential decision rules. [13]

Following are some characteristics of FIS-

The output from FIS is always a fuzzy set irrespective of its input which can be fuzzy or crisp. It is necessary to have fuzzy output when it is used as a controller. A defuzzification unit would be there with FIS to convert fuzzy variables into crisp variables.



[Fig 4 Fuzzy Inference System]

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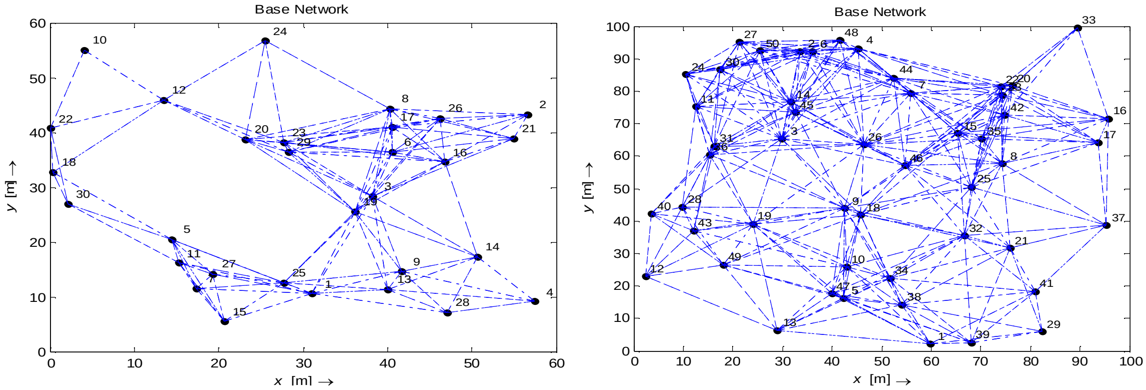
The working of the FIS consists of the following steps –

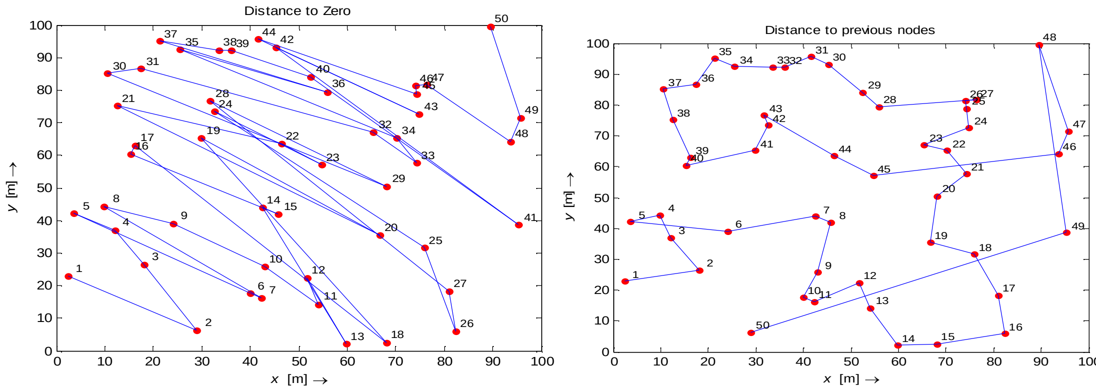
1) A fuzzification unit supports the application of numerous fuzzification methods, and converts the crisp input into fuzzy input.
2) A knowledge base - collection of rule base and database is formed upon the conversion of crisp input into fuzzy input.
3) The defuzzification unit fuzzy input is finally converted into crisp output.

IV. EXPERIMENTAL RESULT

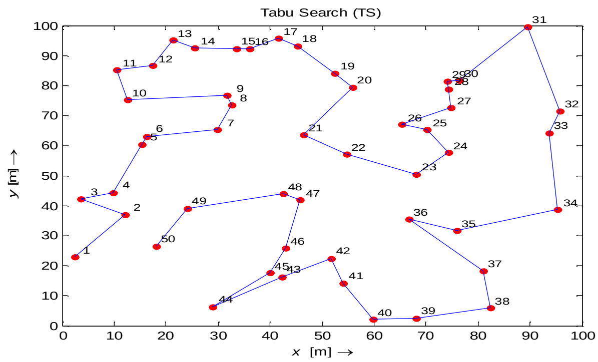
The comparative analysis of cost optimization for different method has been analyzed with the experimental data resulted from the MATLAB implementation. The discussed method have been implemented with MATLAB R2014b. Matlab has the capacity of mimicking submerged condition for three dimensional organize arrangement and executed as a fix over. It embraces a sensible model of the submerged acoustic channel, including multipath impacts, time-fluctuating deferral, weakening, and Doppler scaling The experimental result as follows:



[Fig 5 Base Network with (a) 30 Nodes (b) 50 Nodes]



[Fig 6 (a) Cost optimization with Distance to Zero (n=50) (b) Distance to previous node (n=50)]



[Fig 8 Cost optimization using Tabu Search]

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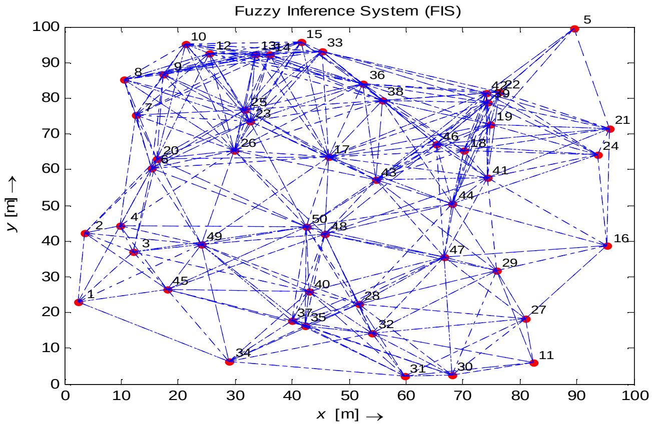
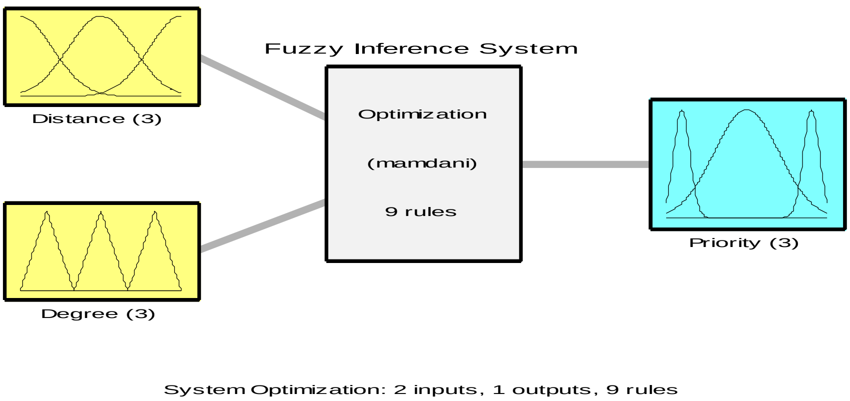
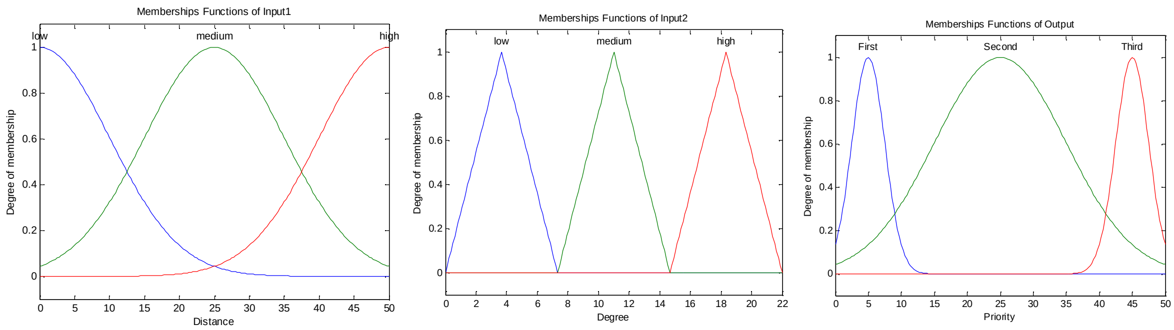


[Fig 9 Cost optimization using Fuzzy Inference System]



[Fig 10 Fuzzy Inference System with 2 input and 1 output]



[Fig 11: Input 1, Input 2 and Output membership Function

Command Window

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Cost of Default Network:                          2584.6253
Cost of Distance of Each Nodes to Zero:           1490.8758
Cost of Distance of Each Nodes to Previous Nodes: 761.6529
Cost of Fuzzy Inference System:                   609.2269
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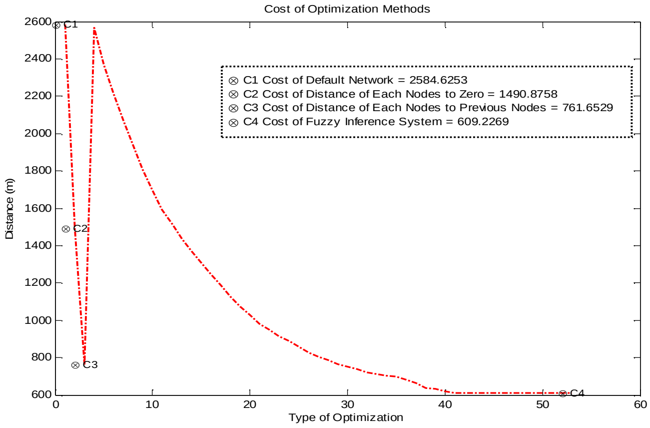

[Fig 12 Cost Comparison among between all the methods]

In the experiments we have implemented cost optimization techniques have been implemented. The evaluation has been done based on Distance to zero. Distance to past Node, Tabu Search and Fuzzy Inferenece system. From the experimental result we found that among the calculations utilized. Fuzzy Inference System demonstrates the good results among the methods compared in the means of Cost Optimization in Under Water Sensor Networks (UWSN).

V. CONCLUSION

UWSN has becomes the most recent research area among the researches. In spite of limitation like low available bandwidth, large propagation delay, high error probability and highly dynamic network topology, still it getting focus from the researches. In this paper emphasize has been given on Cost Optimization for routing at Network Layer. For the cost optimization four different routing algorithms such as Distance to Zero, Distance to Previous Node, Tabu Search and Fuzzy Inference System has been implemented. The overall comparison has been drawn on the basis of experimental result simulated in MATLAB.

The experimental result from MATLAB reveals that the Fuzzy inference based system optimized the cost to a minimum values in an underwater wireless sensor network. From the experiments fuzzy inference based system gives approximately 609 unit cost which is lower than other method in a 50 nodes underwater wireless sensor network (UWSN).

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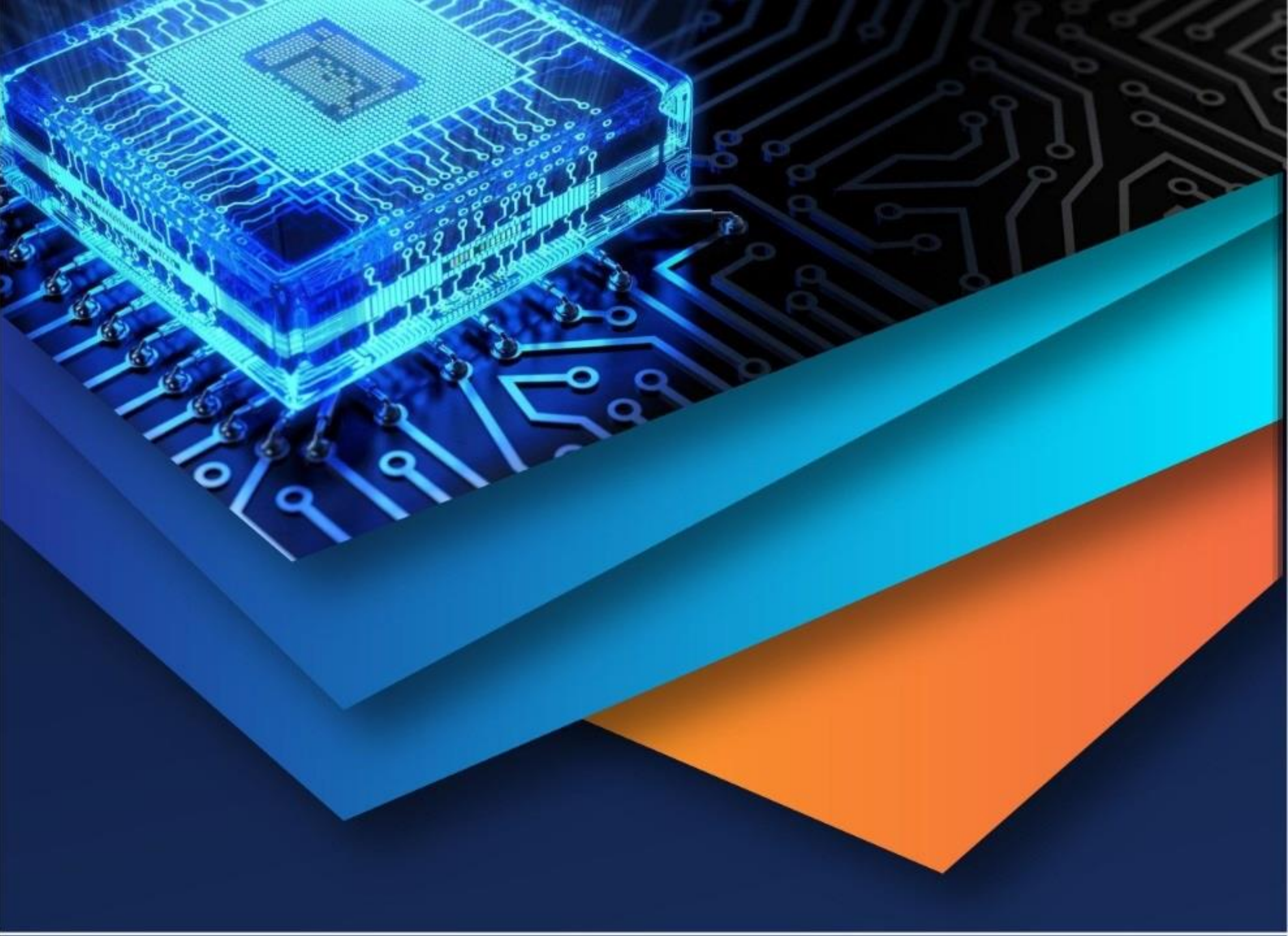

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