iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3 **Issue:** V **Month of publication:** May 2015

DOI:

www.ijraset.com
IC Value: 13.98

Volume 3 Issue V, May 2015
ISSN: 2321-9653

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Multipath Routing With Directed Acyclic Graphs in MANETS

Boyapati Varaprasad Rao[1], Eluri Ramesh[2], Matta Asha Aruna Sheela[3]

[1]*Associate professor, Dept. of Computer Science & Engg, RVR & JC College of Engineering*

[2]*Assistant professor, Dept. of Computer Science & Engg, RVR & JC College of Engineering*

[3]*Assistant professor, Dept. of Computer Science & Engg, Universal College of Engineering*

Abstract: An approach for resilient multipath routing with independent directed acyclic graphs is presented in this paper and developed polynomial time algorithms to construct node independent and link independent DAGs using all possible edges in the network. In this multiple pairs of colored trees approaches to prove the validity of the algorithm. The IDAGs approach performs significantly better than the independent trees approach in terms of increasing no. of paths offered, reducing the probability of a two-link failure disconnecting a node from the destination and average link load. The trees based on the shortest paths on the IDAGs have better performance than that of the ITrees approach since the average shortest path length on the IDAGs is shorter than the average path length on the ITrees. Multiple pairs of colored trees approach is better in terms of the product of the no. of critical links and average link load compared to the ITrees and IDAGs approaches.

Keywords: Multipath Routing; ITrees; MANETs, Acyclic Graphs; Nodes;

I. INTRODUCTION

The multipath routing has been proposed to increase resilience against network failures or improve security in Mobile Ad Hoc Networks. The Optimized Link State Routing protocol has been adopted by several multipath routing strategies. They implement Multipoint Relay nodes as a flooding mechanism for distributing control information. Multipath routing protocols have proved to be able to enhance the performance of MANET in terms of reliability, load balancing, multimedia streaming, security, etc. However, deploying a QoS framework on top of such routing protocols is a complex task, requiring an appropriate QoS strategy to be developed and deployed. Multipath routing mechanism is vital for reliable packet delivery, load balance, and flexibility in the open network because its topology is dynamic and the nodes have limited capability. All nodes in an ad hoc network are required to relay packets on behalf of other nodes. Hence, a mobile ad hoc network is sometimes called a multihop wireless network. The physical layer must tackle the path loss, fading, and multi-user interference to maintain stable communication links between peers.

Multipath routing provided by directed acyclic graph increases system fault tolerance. Furthermore, clustering and multihop routing consider residual energy and routing cost, respectively; thus balanced energy consu-mption is achieved. Performance analysis shows that the message complexity disseminated in clustering and fault diagnosis is acceptable. Simulations demonstrate that the protocol has better energy efficiency compared with other related protocols. The interest in wireless sensor networks has been magnetized in the delay sensitive applications such as real-time applications. These time critical applications crave certain QoS requirements as though end-to-end delay guarantee and network bandwidth reservation.

Clustering provides an effective method for prolonging the lifetime of a wireless sensor network. Current clustering algorithms usually utilize two techniques; selecting cluster heads with more residual energy, and rotating cluster heads periodically to distribute the energy consumption among nodes in each cluster and extend the network lifetime. However, they rarely consider the hot spot problem in multihop sensor networks. When cluster heads cooperate with each other to forward their data to the base station, the cluster heads closer to the base station are burdened with heavier relay traffic and tend to die much faster, leaving areas of the network uncovered and causing network partitions.

II.LITERATURE REVIEW

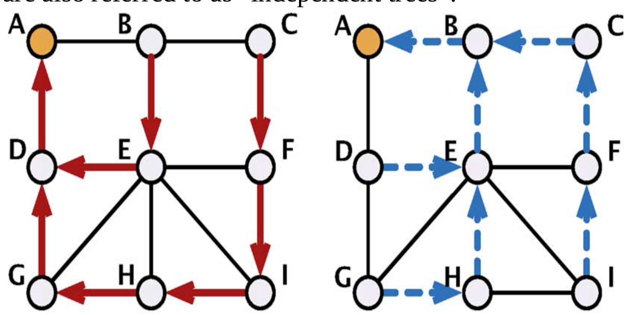
Multipath routing facilitates reliable data delivery in case of critical information since several years some of them are Gimer Cervera et al [1] proposed the multipath routing to increase resilience against network failures or improve security in Mobile Ad Hoc Networks. A.V. Sutagundar and S.S. Manvi [2] proposed an event triggered multipath routing in WSNs by employing a set of static and mobile agents. Every sensor node is assumed to know the location information of the sink node and itself. Omar Banimelhem and Samer Khasawneh [3] proposed a Grid based Multipath with Congestion Avoidance Routing protocol as an efficient QoS routing protocol that is suited for grided sensor networks. Mónica Aguilar Igartu et al [4] introduced a proposal called g-MMDSR (game theoretic-Multipath Multimedia Dynamic Source Routing), a cross-layer multipath routing protocol which includes a game theoretic approach to achieve a dynamic selection of the forwarding paths. Wenjun Liu et al [5] proposed an energy efficient data collection protocol which consists of clustering and multipath routing. Dan Jurc., Pascal Frossard [6] addressed the distributed path computation and rate allocation problems for video delivery over multipath networks. The streaming rate on each path is determined such that the end-to-end media distortion is minimized via multiple network channels to the streaming server. José Duato et al [7] examined the effect of faults on current solutions to deadlock-free routing and establishes limits on the inherent redundancy of direct networks. Asis Nasipuri [8] designed the physical transmission system, which are dependent on the characteristics of the radio propagation channel such as path loss, interference (co-channel), and fading. The crucial design issue in protocols is to detect when to initiate a preemptive route discovery to find a better route. Kevin J. Ma et al [9] resented three classes of techniques which have been proposed for improving the quality of Internet delivered video: network load reduction, network interruption mitigation, and network load distribution. John Apostolopoulos et al [10] presented an overview of path diversity of complementary media coding techniques, such as multiple description coding, and of their benefits and uses for improved media streaming. Soro, S., Heinzelman, W.B [11] proposed an Unequal Clustering Size model for network organization, which can lead to more uniform energy dissipation among the cluster head nodes, thus increasing network lifetime. Chen, G et al [12] proposed an unequal cluster based routing protocol and it groups the nodes into clusters of unequal sizes. Cluster heads closer to the base station have smaller cluster sizes than those farther from the base station, thus they can preserve some energy for the inter-cluster data forwarding. Ye, Z et al [13] proposed a deployment strategy that determines the positions and the trajectories of these reliable nodes such that we can achieve a framework for reliably routing information. Y. Challal et al [14] presented a new intrusion-fault tolerant routing scheme offering a high level of reliability through a secure multipath routing construction. Carlos T. Calafate et al [15] proposed an admission control strategy that can operate both over single and multipath routing protocols and QoS framework can perfectly coexist with multipath routing protocols. Srinivasan, R et al [16] developed the first distributed algorithm for constructing the colored trees whose running time is linear in the number of links in the network. Yang WANG et al [17] proposed a new multipath switch approach based on traffic prediction according to some characteristics of open networks and use wavelet neural network to predict the node traffic because the method has not only good approximation property of wavelet, but also self-learning adaptive quality of neural network. D.J Chen and P.Y Chang [18] presented a connection oriented routing scheme, the multipath routing, which allows multiple routes to be established between the source and the destination.

III. METHODOLOGY

A new approach for resilient multipath routing was developed and introduces the concept of independent directed acyclic graphs (IDAGs), an extension of independent trees. Link-independent (node-independent) DAGs satisfy the property that any path from a source to the root on one DAG is link-disjoint (node-disjoint) with any path from the source to the root on the other DAG. A algorithms is developed to compute link-independent and node-independent DAGs. The algorithm guarantees that every edge other than the ones emanating from the root may be used in either of the two node-disjoint DAGs in a two-vertex-connected network. A small number of edges will remain unused when link-independent DAGs are constructed. The edges that will remain unused in both DAGs are defined by the topological limitation of the network. Another approach was exploiting all possible links, that is, multiple pairs of colored trees technique to evaluate the performance of the IDAGs scheme. In the multiple pairs of colored trees technique, the red and blue trees are independent in a given pair; however we cannot guarantee that trees from different pairs are independent. The effectiveness of the proposed IDAGs approach was determined by comparing the performance of the key indices to that of the independent trees and multiple pairs of independent trees techniques.

IV. INDEPENDENT TREES

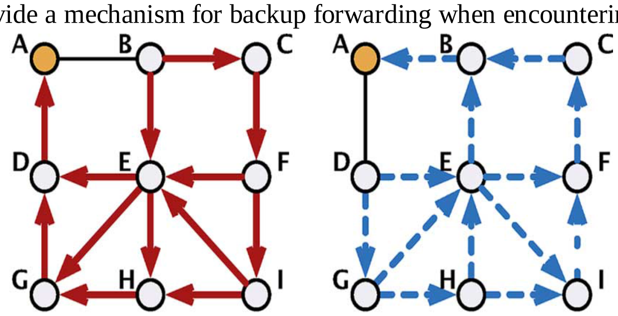
One approach that offers resiliency to single link failure and provides multipath routing to some degree is “colored trees”. In this approach, two trees are constructed per destination node such that the paths from any node to the root on the two trees are disjoint. The trees may be constructed to obtain link-disjoint or node-disjoint paths if the network is two-edge or two-vertex connected, respectively. This approach is similar to those employing multiple routing tables, except that only two tables are required. Every packet may carry an extra bit in its header to indicate the tree to be used for routing. This overhead bit may be avoided by employing a routing based on the destination address and the incoming edge over which the packet was received, as every incoming edge will be present on exactly one of the trees. The colored tree approach allows every node to split its traffic between the two trees, thus offering disjoint multipath routing. In addition, when a forwarding link on a tree fails, the packet may be switched to the other tree. A packet may be transferred from one tree to another at most once as the colored tree approach is guaranteed to recover from only a single-link failure. The colored trees are also referred to as "independent trees".



(a) (b)

Figure 1: Illustration of node-independent trees for the ex. network (a) Red tree. (b) Blue tree. Node A is the root (destination) node.

Figure 1 shows an example network where red and blue trees, rooted at node A, are constructed. This tree construction enables recovery from a single link failure by switching from one tree to another. For example, consider a packet that is forwarded from node F to node A on the blue tree. When there are no failures, the packet would take the path F–C–B–A. If link C–B fails, then node C would reroute the packet on the red tree, thus the packet will follow the path F–C–F–I–H–G–D–A. Assume that a second link failure occurs on link I–H. As only two independent trees were constructed and recovery from arbitrary two link failures cannot be guaranteed, the packet will be dropped when the second link failure is encountered. One approach to enhance the robustness is to allow the packet to be switched multiple times between the trees. Such an approach will fail in the example considered above. The packet will be rerouted back and forth on the path I–F–C. Our goal is therefore to utilize the additional links available in the network to improve robustness. To this end, we seek to construct independent directed acyclic graphs rooted at each node. Figure 2(a) and (b) shows two independent directed acyclic graphs rooted at node A. Observe that node I has two red forwarding edges available. Thus, in the earlier example, if link I–H fails, the packet may be forwarded on link I–E to reach the destination. Maximum Alternative Routing Algorithm (MARA) constructs a DAG that utilizes all edges in the network to increase the number of paths significantly. However, the algorithm does not provide a mechanism for backup forwarding when encountering a single link or node failure.



(a) (b)

Figure 2: Illustration of node-independent DAGs in an ex: network where node A is the root (destination) node. (a) Red DAG. (b) Blue DAG.

Another approach is to employ multiple pairs of colored (independent) trees, however such a technique will require the packet to carry information on which pair is being used for routing. Our goal in this paper is to develop an elegant solution to: 1) achieve multipath routing; 2) utilize all possible edges; 3) guarantee recovery from single-link failures; and 4) reduce the number of overhead bits required in the packet header. Moreover, the use of multiple non disjoint paths is advantageous in load balancing and preventing snooping on data, in addition to improving resiliency to multiple link failures.

V.RESILIENT ROUTING WITH IDAGS

The network is assumed to employ link-state protocol; hence every node has the view of the entire network topology. Every node computes two DAGs, namely red and blue, for each destination and maintains one or more forwarding entries per destination per DAG. The DAGs may be used in two different ways to achieve resilient routing. In the first approach, referred to as Red DAG first (RDF), the packets are assumed to be forwarded on the red DAGfirst. When no forwarding edges are available on the red DAG, the packet is transferred to the blue DAG. When no blue forwarding edges are available, the packet is dropped. The DAG to be employed for routing is carried in an overhead bit (DAG bit) in every packet header. In the second approach, referred to as Any DAG first (ADF), a packet may be transmitted by the source on the red or blue DAG. In addition to the DAG bit, every packet also carries an additional bit that indicates whether the packet has been transferred from one DAG to another (Transfer bit). A packet is routed on the DAG indicated in its packet header. If no forwarding edges are available in that DAG and if the packet has not encountered a DAG transfer already, it is transferred to the other DAG. If no forwarding edges are available on the DAG indicated in the packet header and the packet has already encountered a DAG transfer, the packet is dropped. In both of the approaches described above, a node may forward the packet along any of the available forwarding edges in the DAG indicated in the packet header. Note that if the red and blue DAGs are (link- or node-) independent, then the network is guaranteed to recover from a single (-link or -node) failure when the packet is transferred from one DAG to the other. In addition, the network may tolerate multiple failures as some nodes may have many forwarding entries in each DAG.
Given a destination node in the network, we seek to construct two independent DAGs rooted at the destination. Our goal in the construction process is to utilize every edge available in the network in either of the two DAGs. Construct two node-independent DAGs in a two-vertex-connected network involving every edge, other than the edges emanating from the destination, in either of the two DAGs and construct link-independent DAGs in two-edge-connected networks employing all but a few edges were emanating from the articulation nodes.

A. Complexity

The construction of the base DAGs may be achieved in time using depth-first-search numbering and low-point values. The global ordering may be computed in time. The complexity of the NI-DAG construction is for Example: Consider the nine-node network shown in Figure 3(a), where we seek to compute IDAGs rooted at node. The base DAGs are computed by considering the cycle A–D–E–B followed by paths D–G–H–E and H–I–F–C–B for augmentation and are shown in Figure 3(b) and (c). These paths result in the following partial orders: 1) A∞D∞E∞B; 2) D∞G∞H∞E; and 3) H∞I∞F∞C∞B. Out of many possible global orderings that satisfy these partial orders, we obtain one global order as: A∞D∞G∞H∞E∞I∞F∞C∞B. With this global ordering, we compute the direction of the edges that were not considered in the base DAGs. Figure 2(a) and (b) shows the final independent DAGs that are constructed.

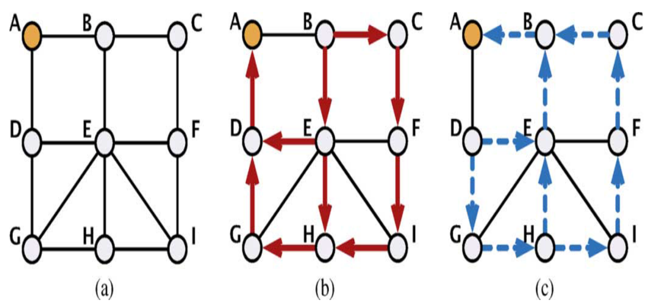


Figure 3: Illustration of the construction of node-independent DAGs. (a) Example network. (b) Base red DAG. (c) Base blue DAG. Fig. 2(a) and (b) shows the final red and blue DAGs, respectively

VI. CONSTRUCTING LINK INDEPENDENT DAGS

Two-edge connectivity is a necessary and sufficient condition for constructing two link-independent DAGs. Similar to the requirement of node-independent DAGs, the necessary part of the requirement follows from the independent tree construction. We show the sufficiency part of the requirement by constructing the desired DAGs.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Procedure LI-DAGs Construction

1) Divide the network into two-vertex-connected (2V) components.
2) In each 2V-component, identify the unique articulation node through which every path from any node in that component must traverse to reach *d*. We refer to this articulation node as the root node of the component. In the component that contains node *d*, we assume that the root node of the component is node *d* itself.
3) In each 2V-component, construct two node-independent DAGs to the root node of that component.
4) Merge all the node-independent DAGs to obtain the link-independent DAGs.

Figure 4: Procedure to construct two link-independent DAGs rooted at destination in a two-edge-connected network.

Figure 4 shows the procedure to construct two link-independent DAGs. We first divide the network into two-vertex-connected (2V) components (Step 1). A node may appear in more than a 2V-component, and the removal of such a node (articulation node) would disconnect the graph. In addition, any two 2V-components may share at most one node in common. Given a destination node, we identify the root node for every component the unique node through which every path connecting a node in that component and must traverse (Step 2). In components that do not contain node, there is a unique articulation node that will be assigned the root of that component. Let denote the root node of component that does not contain the destination node. Observe that a link, where, may not be used as a forwarding edge on any DAG. As every path from to has to traverse, the addition of would result in a cycle. Thus, the only edges that cannot be assigned to any DAG are those edges emanating from the root node of a component. In each 2V-component, we compute two node-independent DAGs to the root of that component (Step 3). We then merge these node-independent DAGs to obtain the desired link-independent DAGs (Step 4). As every network has a unique two-vertex-connected decomposition, hence unique root nodes for every 2V-component, the number of edges that cannot be used in either DAG is unique and is a property of the given network topology. It is straightforward to see that the procedure LI-DAGs construction avoids only the edges emanating from the articulation. Although every network topology has a unique two-vertex-connected decomposition, irrespective of the destination node considered, the node selected to be the root node in a component is dependent on the destination node and is unique for a given destination node.

VII.PERFORMANCE EVALUATION

The performance of two independent DAGs against two colored trees and multiple pairs of colored trees on two real-life network topologies: 1) MESH-4 4; and 2) NJ-LATA shown in Figure 5 and Figure 6.

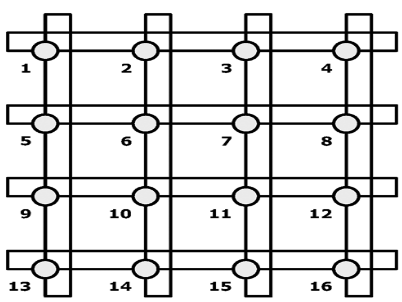


Figure 5: Real-life network topologies MESH-4 4 (16 nodes, 32 links)

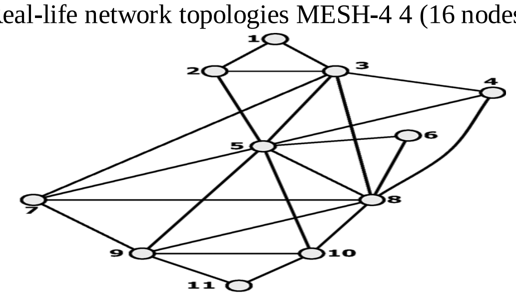


Figure 6: Real-life network topologies NJ-LATA (11 nodes, 23 links)

The nodes to be the destination and compute independent trees and DAGs rooted at that node. The simulation results for the multiple pairs of colored trees technique, which is another ITrees application and is used to exploit all possible links in a network. These analyses expand our understanding of the resilient multipath routing. Let us consider four performance metrics: 1) average path length; 2) number of paths; 3) number of scenarios where an intruder can observe two distinct links and observe all traffic sent by a source; and 4) average link load. For IDAGs, the expected path length from a source to the destination is computed by assuming that the source and an intermediate node would forward a packet on one of its outgoing DAG edges with equal probability. The average expected path length over all nodes in the network. In the case of two independent trees, every node has exactly one path on each tree, thus the average path length computation is straightforward. The number of paths from a source to the destination is computed as the sum of the number of paths from each of its forwarding neighbor to the destination, in a recursive fashion.

VIII. CONCLUSION

The concept of independent directed acyclic graphs (IDAGs) is introduced to achieve resilient multipath routing in this paper. Link-independent (node-independent) DAGs satisfy the property that any path from a source to the root on one DAG is link-disjoint (node-disjoint) with any path from the source to the root on the other DAG. Given a network, we develop polynomial time algorithms to compute link-independent and node-independent DAGs. The effectiveness of the IDAGs approach is determined by comparing key performance indices to that of the independent trees and multiple pairs of independent trees techniques through extensive simulations.

REFERENCES

[1] Gimer Cervera., Michel Barbeau., Joaquin Garcia-Alfaro., Evangelos Kranakis “A multipath routing strategy to prevent flooding disruption attacks in link state routing protocols for MANETs” Journal of Network and Computer Applications, Volume 36, Issue 2, March 2013, pp 744–755

[2] A.V. Sutagundar and S.S. Manvi “Location aware event driven multipath routing in Wireless Sensor Networks: Agent based approach” Egyptian Informatics Journal, Volume 14, Issue 1, March 2013, pp 55–65

[3] Omar Banimelhem and Samer Khasawneh “GMCAR: Grid-based multipath with congestion avoidance routing protocol in wireless sensor networks” Ad Hoc Networks, Volume 10, Issue 7, September 2012, pp 1346–1361

[4] Mónica Aguilar Igartu., Luis J. de la Cruz Llopis., Víctor Carrascal Frías., Emilio Sanvicente Gargallo “A game-theoretic multipath routing for video-streaming services over Mobile Ad Hoc Networks” Computer Networks, Volume 55, Issue 13, 15 September 2011, pp 2985–3000

[5] Wenjun Liu., Shukui Zhang., Jianxi Fan “A Diagnosis-Based Clustering and Multipath Routing Protocol for Wireless Sensor Networks” International Journal of Distributed Sensor Networks, Volume 2012, Article ID 504205, pages 11.

[6] Dan Jurc., Pascal Frossard “Distributed media rate allocation in multipath networks” Signal Processing: Image Communication, Volume 23, Issue 10, November 2008, pp 754–768

[7] José Duato., Sudhakar Yalamanchili and Lionel Ni “Chapter 6 – Fault-Tolerant Routing” Interconnection Networks, An Engineering Approach, 2003, pp 287–357

[8] Asis Nasipuri “Chapter 3 – Mobile Ad Hoc Networks” Handbook of RF and Wireless Technologies, 2004, pp 59–100

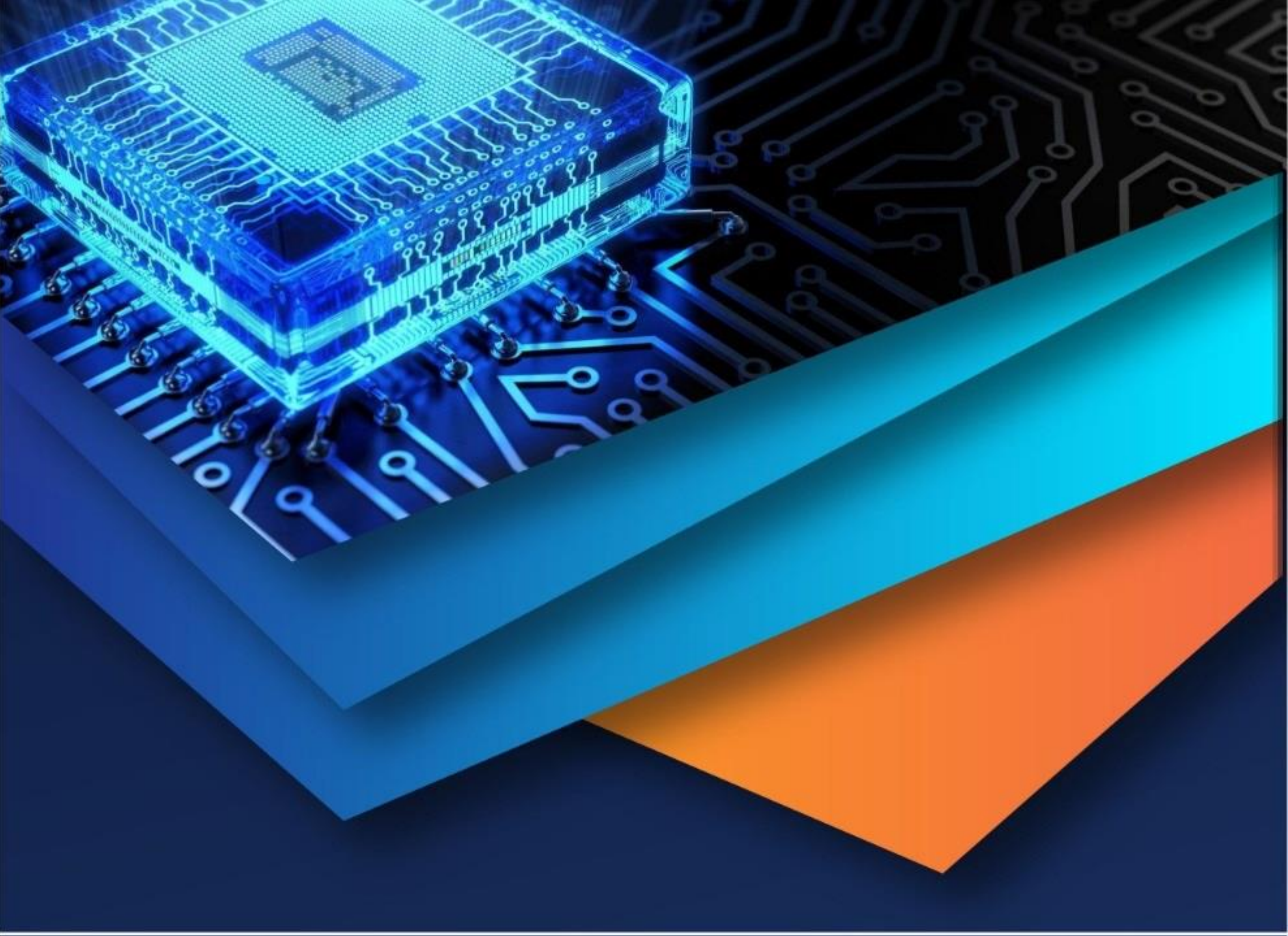
[9] Kevin J. Ma., Radim Bartoš., Swapnil Bhatia “Dependable Multimedia Communications: Systems, Services, and Applications” Journal of Network and Computer Applications, Volume 34, Issue 5, September 2011, pp 1572–1586

[10] John Apostolopoulos., Mitchell Trott., Wai-Tian Tan “Path Diversity for Media Streaming: The Use of Multiple Description Coding” Multimedia over IP & Wireless Networks, 2007, pp 559–590

[11] Soro, S., Heinzelman, W.B “Prolonging the lifetime of wireless sensor networks via unequal clustering” Proceedings - 19th IEEE International Parallel and Distributed Processing Symposium, IPDPS 2005, Volume 2005, Article number1420160

[12] Chen, G., Li, C., Ye, M., Wu, J “An unequal cluster-based routing protocol in wireless sensor networks” Wireless Networks, Volume 15, Issue 2, February 2009, pp 193-207

[13] Ye, Z., Krishnamurthy, S.V., Tripathi, S.K “A framework for reliable routing in mobile ad hoc networks” Proceedings - 22nd Annual Joint Conference on the IEEE Computer and Communications Societies; San Francisco, CA; United States; 30 March 2003, Volume 1, March 2003, pp 270-280



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY