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A COMPARATIVE ANALYSIS FOR PERFORMANCE OF THE TORA ROUTING ALGORITHM

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Abstract:
The Temporarily Ordered Routing Algorithm (TORA) routing algorithm is a loop-free adaptive routing protocol that eliminates loops. The TORA routing algorithm makes use of a route reversal mechanism to achieve this goal. In this paper, we discuss and discuss the performance of the proposed algorithm and improvised TORA and find out how the new proposed algorithm is better as compared to previous implementations in terms of PDR, throughput, goodput, packet delivery ratio, residual energy. The work was observed using a well-established simulator refereed as NS2 and a series of simulations based on Design of Experiments (DoE) were undertaken. The results indicated that the proposed TORA is better than the conventional and references TORA based routing algorithms. It is suggested that an extensive testing bed should be developed so that deeper analysis of its performance can be done using current data and computationally intensive applications such as big data and deep learning models.
Keywords: MANETs, TORA, Routing, Packet Delivery Ratio, Design of Experiment, residual energy.

Introduction:

Mobile ad hoc networks (MANETs) emerged in 1999 and gained standardization efforts since 2003. Router performance, node handover, and relocation are key concerns in academic and industrial MANET research [2]–[4]. Techniques like opportunistic routing [5] and decentralized routing [6] have emerged. This field has grown into a vibrant area of investigation.

MANET routing in ad hoc wireless networking is rapidly expanding. Applications include vehicle networks [7], drones, and more [8], [9], impacting wireless capacity [2], [10]. Establishing the shortest route in a MANET is challenging due to dynamic wireless networks. Future trends include layer-2 bridging and ultra-narrow band LAN. MANETs, used in planes, ships, and handheld devices, deploy networks without pre-existing infrastructure due to their parallel nature.

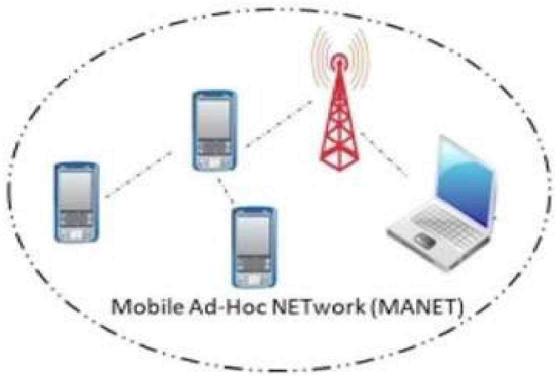

Fig1. MANET

Addressing MANET challenges relies on two core principles: finding short paths and minimizing energy use. Swift connections and dynamic networks highlight limitations. In the scientific community, MANET application is relatively young.

Routing algorithms pivot around determining shortest paths. An example is Dijkstra's [11]. Researchers seek efficient routes in dynamic contexts. Challenges lie in pathfinding amid shifting nodes and changing topologies. Energy efficiency is vital due to consumption during data transfer. Routing protocols like AODV, DSR, and TORA [12] enhance route selection. Our study implements TORA, minimizing loops via a route reversal mechanism. TORA's design reduces control message generation time. TORA uses a dynamic mechanism, contributing to complexity. Multipath capabilities enhance routing computations via TORA's DAG foundation. TORA uses a DAG to establish, maintain, and delete routes. An inter-hub "QUERY" package is dispatched for specific destination routes.

Review:

In this section, the evidence as regards to the different aspects and challenges in the context of development routing algorithms has been discussed. In this section, we discuss the various steps taken for obtaining the desired performance of a high-speed network in the context of routing algorithms work. [13]

A collection of nodes that communicate as a unit may be assigned a logical name depending on their intended function and the protocol layer via which they communicate. When several nodes work together, the collection of nodes may be given a logical name based on their intended use and the protocol layer via which they communicate. However, it is challenging to characterise the topology of such ad-hoc networks since the shape and existence of the network alter over time and in reaction to external events. To put it another way, a network having a dynamic topology can be defined as follows: The routing protocol or scheme of an ad-hoc network is defined by the rules governing the admission, readmission, and demission of new nodes from the network, as well as the rules governing node communication with one another. A MANET is a network of mobile phones or any other sort of mobile device capable of transmitting data or voice. The MANET can be classified into three types of routing protocols. Routing in the context of MANET has historically been implemented in three ways: a network with routing rules that apply to individual nodes while allowing nodes to make decisions independently (Proactive), routing controlled by a central entity in which individual nodes play a minor role, and routing operations performed with the assistance of a third-party entity or a hybrid approach.

When it comes to proactive routing protocols in MANETs, the DSDV [14] and GSR protocols are the most widely employed. The reactive routing protocols [15] AODV and DSR are the ones that have received the most attention. In many academics' research endeavours, ZPR is a central topic since it is a hybrid routing protocol that they employ as a central topic. This is accomplished primarily through the use of two types of algorithms that preserve the state of affairs within the network. These protocols are divided into two categories: those that maintain a log or table database and those that store information about the various paths based on the quality or condition of the links.

Actually, the Destination Sequenced Distance Vector Routing Protocol is based on the Bellman-ford routing algorithm. Due to the count-to-infinity problem, the distance vector routing protocol was not suitable for mobile ad-hoc networks. As a result, the Destination Sequenced Distance Vector Routing Protocol (DSDV) was developed as a solution. Each node's routing table contains a destination sequence number associated with each routing item. A node's updated route to a destination with a higher sequence number will be included in the table only if the entry contains the new updated route. As a result, the destination node with the lower number does not need to update the route, as the new update will be handled by the nodes that already have the updated route. This also alleviates the node's processing load. The Global State Routing Protocol (GSR) is built on the logic of Dijkstra's routing algorithm's shortest path computations [16]. The Link State Routing Protocol was not designed for mobile ad-hoc networks since it requires each node to flood the link state routing information directly into the whole network, a process known as global flooding, which can result in network congestion caused by control packet congestion. As a result, an improvisation called as may result in control packet congestion in the network. As a result, an improvisation dubbed the Global State Routing Protocol (GSR) was created. Global state routing does not swamp the network with link state routing packets. Each mobile node in GSR maintains one list and three tables: the adjacency list, the topology table, the next hop table, and the distance table. When routing information is generated in a network in response to specified situations, the term "reactive routing system" is used. When a scenario develops, the algorithm keeps a route state and determines the shortest pathways on it. DSR , DYMO and AODV are examples of reactive routing schemes [17]. However, it can also be observed that OLSR, TORA are extensively used in the industry in commercial networking products such as CISCO routers.

Contemporary literature gives hints that, ideally, the routing algorithm (s) must match the current needs of the technology savvy users. For this evaluation of the network is done multiple parameters such as scalability, reliability, adaptability, overhead and many more. The estimation, measurements, assessment and evaluation of these factors gives input for the design of the routing algorithms. Scalability is computed using mainly three variables, required throughput, resources usages (CPU, disk space. Etc.) and cost. Little law has been instrumental and helpful to many network managers for taking decisions on scalability. According to Little's law, if a box (the main processing unit of the network) has an average of N users and each user spends an average of ‘R’ seconds in the box, the box's throughput X can be using X = N/R mathematical expression. However, contemporary literature and best practice manuals in networking field shows that statistical techniques such as trend analysis and predictive machine algorithms are dominating this area for using the current usage of resources. The applications at the same time are highly mobile in nature. Hence, after every benchmark is crossed there is need to rethink in terms of the Scalability, Reliability, Energy Utilisation, Adaptability and Self-Management , Centricity {data, address , application specific, peak time}, mobility , overall overhead , Parallel Input and output channels , efficiency in resolving the dead locks etc.,

A network is said to be stable and reliable if it is able to withstand the infrequent events such DDOS attacks and issues such as sinkhole and at the same time can self-heal whenever there is an issue in the firmware [18]. From the current feedback front of the network industry it is apparent a single stack , rules and protocols cannot suffice current challenging business scenarios. Hence, beyond doing an exploratory investigation of current research work, the goal of this research is to develop an experimental bed that can be utilised to improve the performance of the traditional TORA routing algorithm. This endeavour has been selected because there is abundant evidence in the present literature that there is a pressing need to improve the TORA routing algorithm as a result of environmental conditions, and hence this endeavour has been chosen. In order to improve upon the conventional algorithm, the robustness of the method is taken into consideration throughout the data transmission life cycle. Aside from the application of load balancing energy parameters and the modification of the routing table, the robustness of the algorithm is characterised by five elements [19], [20] . Technical improvements will be made to the route selection mechanism, and the effects of these improvements will be measured in terms of residual energy, throughput, goodput, and packet delivery fraction [21]. Instead of concentrating on 'hop count,' the emphasis is placed on residual energy and a multipath strategy.

Methodology:

In this section, steps taken to achieve the aforementioned goals of the study are discussed. The NS simulator was used in this research, and a series of simulations based on Design of Experiments (DoE) [22] were undertaken. NS is a programme for simulating event-driven networks that was developed at the University of California, Berkeley. It encompasses a variety of network elements, including protocols, applications, and the behaviour of traffic sources. The NS is a component of the VINT project, which has been funded by DARPA since 1995. All the experiments were conducted using TCP packets. The details of the parameters used are as follows:

S.No	Simulation Parameter(s)	Value
1	Simulation Area	860 X 860
2	Number of Nodes	7,14,21,28
3	Max Beacon Period	300
4	Beacon Period	30
5	Routing Protocols	Ref-TORA,TORA, Proposed TORA
6	Traffic Source Model	Constant
7	Packet Size	4000 bits
8	Frame /Round	30
10	Initial Energy	100 J
11	Mobility Model	Random Way Point

Table 1: Parameters Used in the Simulation

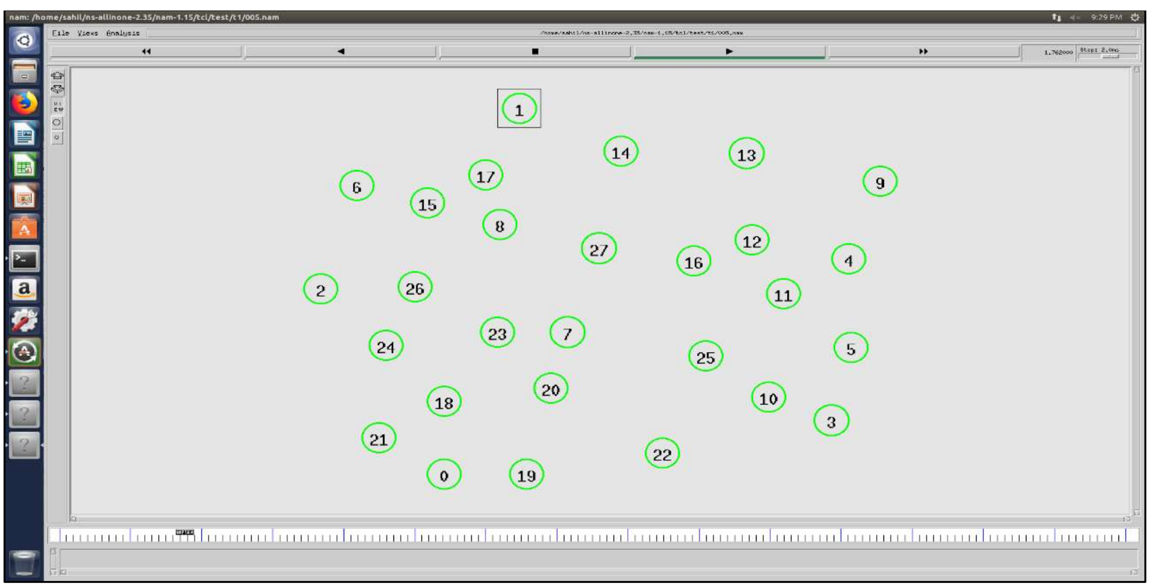

Figure 1: Running Simulation NS2

In this study, we have built the new TORA routing module in the NS-2 simulator [23], which we hope will be useful. There was a total of 25 nodes in the simulation, which ran for 500 seconds over a network region of 860 X 860 m. The network traffic was represented by ten CBR sources, with data being transmitted in 512-byte packets at a rate of four packets per second from each source. For each amount of pause time, seven different movement patterns were generated using a random waypoint model: 0, 10, 20, 30, 40, 50, and 60 s. Each movement pattern was generated using a random waypoint model. The total energy of all the nodes is 40J at the start of the game. For medium access protocol, the IEEE 802.11 Distributed Coordination Function (DCF) is used. The interface queue is a drop-tail priority queue with a capacity of 50 packets. Each point on the plotted results is obtained by taking the outcomes and averaging them over a period of time. The output of the running simulation can be observed from Figure 1.

Proposed Routing algorithm:

Step:1

First if node has greater residual energy than threshold, node sends a modified Query message with its own residual energy appended to it.

Step-2

After receiving Multiple mod query packet destination follow link reversal algorithm and send back UDP packet with whole path energy information to source.

Step-3 : With the help of this modified Update message source node first stores energy of individual nodes & calculates energy of whole path. Finally calculate the cost function.

st = α [E min/E total] + (1-α) [1/hc] , where α is constant between 0 to 1.

Step-4 : Using this cost function each node create an entry in routing table and maintain successor and feasible successor paths for particular destination

Results and Discussion:

Modern connectivity is achieved through satellites, undersea cables, and last-mile connections, driving technical evolution on the internet and subnets. Despite advancements in speed and reliability, new applications and paradigms continually demand algorithmic shifts. This section delves into the TORA routing algorithm's performance, comparing it to an improvised version. We assess the proposed algorithm's superiority over prior implementations in terms of Package Delivery Ratio (PDR), Throughput, Goodput, and Residual Energy.

Evaluation Metrics:

Package Delivery Ratio (PDR): PDR gauges the proportion of sent packets from the source node to the destination sink. Calculated as the sum of received packets divided by sent packets.

Goodput: Goodput quantifies the usable data rate transmitted through a link, excluding retransmissions and protocol overhead. Expressed in bits per second (bps).

Throughput: Throughput is the data rate crossing a link, encompassing all data, useful and non-useful (e.g., retransmissions), at a specific time.

Residual Energy: Residual energy is the difference between a node's current estimated energy ('Erc') and its original or maximum energy capacity**.**

Packet Delivery Ratio Analysis:

Packet Delivery Ratio (PDR) is a critical metric defining routing scheme reliability. Traditional TORA associates PDR with hop count, while our study highlights the significance of the height parameter in network performance.

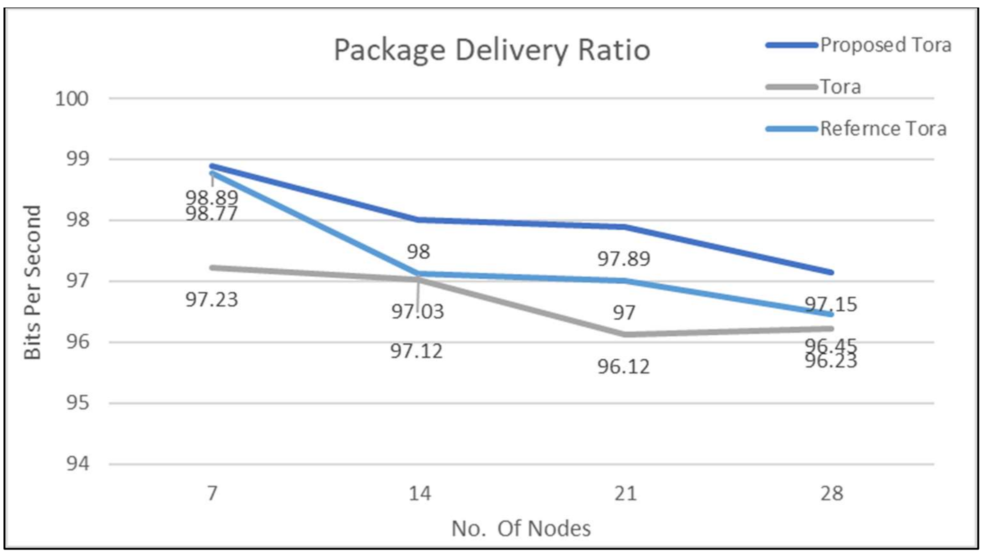

Figure 2: Packet delivery ratio automatically increases and so does the throughput.

It can be seen from Figure 2: that, in the case of the proposed approach, PDR consistently has a higher range of values (98.89–97.15), which is compatible with the suggested algorithm. The traditional TORA has the lowest PDR values as compared to all other types of TORA implementations. As the network size is increased to 21, the performance of the standard/Referenced TORA first appears to be satisfactory (97.23), but the value of the PDR decreases to 96.12 when the network size is increased to 21 again. When the number of nodes in the referred TORA is counted, it follows a similar pattern to the one observed in the previous TORA. The reference TORA values begin at 98.89 and decrease by an average of 96.25 percent over the course of the study.

Throughput Analysis:

The throughput of the network is defined as its maximum throughput given a homogeneous traffic pattern, as defined by the bandwidth "T". Several observations were made during the process. For interconnection network applications where bandwidth must be maintained despite aggressive traffic, worst-case throughput is an important metric to consider. Traffic was significantly increased to reproduce the opposite conditions on the network and test our hypothesis. Worst case network bandwidth is defined as the lowest possible network bandwidth across all traffic models. Therefore, instead of trying to achieve the highest worst-case throughput, systems tend to optimize for the network's average throughput. We managed to do this by improvising the traditional TORA algorithm by changing the Height parameter. As a result, we have achieved excellent results compared to the conventional TORA method.

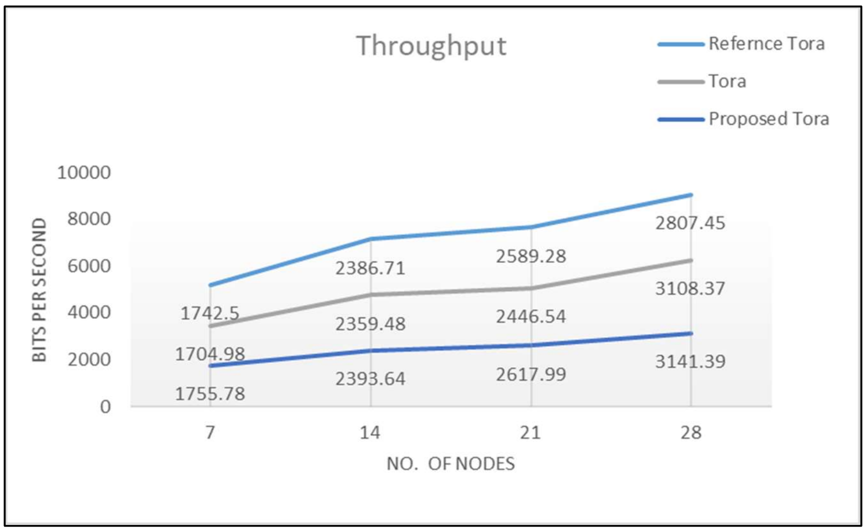

Figure 3: Comparative Analysis Throughput

At all four inflection points in Figure 3, which correspond to network sizes of 7, 14, 21, and 28, the average throughput in the case of the proposed algorithm is at its highest. For traditional and cited implementations of the TORA, values all follow a similar trend (i.e., they increase as the network size grows), but they are much lower than the numbers for the proposed TORA.

Goodput Analysis:

The analysis of Goodput Analysis gives a view of the actual efficiency in terms of transmission from end-to-end point of a network. The routing protocol governing rules, conditions and operations such as acknowledgement of the transmission between the end point does cost in terms of overhead.

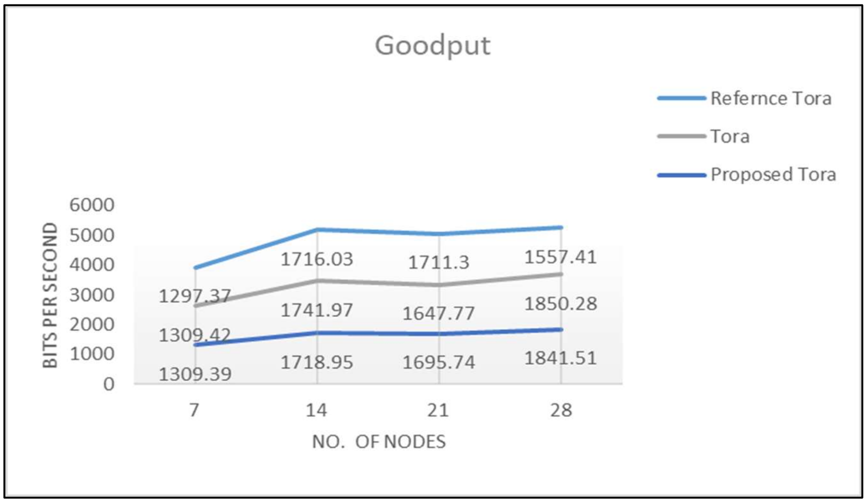

Figure 2: Comparative Analysis Goodput

Figure 4, gives graphical information on the performance of the Goodput as per the multiple simulation rounds. It can be observed that when the network is idle then also to maintain the quality links operational messages keep on going. The number of such messages increases if there are changes in states of link more frequently. It can be observed that it is only the case of Proposed TORA the goodput remains high.

Residual Energy Analysis:

The goal of the routing algorithm has always been to keep the network operational for as long as is physically viable. The nodes' overall life duration and survival are significantly influenced by energy use and conservation measures. Estimating the network's remaining energy on a regular basis is the most accurate method for figuring out how long it will last. In several series of trials, a consistent traffic model was applied to each of the three algorithms, and the outcomes were recorded for each series of research.

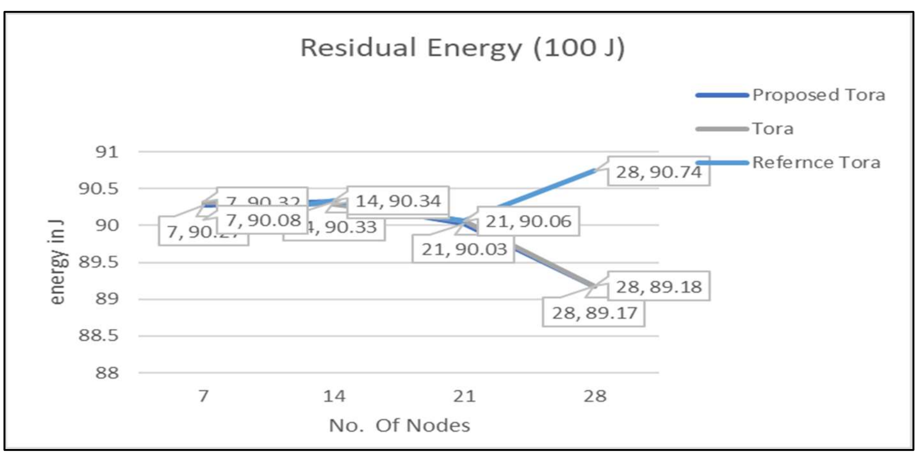

Figure 4: Comparative Analysis Residual Energy

As shown in Figure 4, the proposed TORA produces a greater residual energy value after the 21 nodes used in this simulation work. TORA also reaches the level of TORA, although it begins +91 95749 50004at a lower level and gradually decreases to an average of 0.5 in succeeding rounds. The other algorithm Reference TORA retains some residual energy as a result of energy dissipation over rounds, but only Proposed maintains a fair level of residual energy by the end of most of the simulation evaluations. The residual energy graph reveals that the total number of nodes alive over time, which represents the network's longevity, will be greater for the proposed TORA than for the other two routing protocols, as they will be unable to maintain a healthy energy level in the nodes.

To be sure, the protocols presented in this paper represent a substantial step forward in comparison to the standard TORA versions. This improved routing algorithm is flexible in the sense that it is easy to generate many different paths. The way in which it is flexible is in that the connection between two systems is able to switch to a new path if the new path is discovered to be more advantageous. One of the most prominent benefits of Proposed TORA is its ability to use the length of a path between two hubs as a basis for route optimality.

Impact of Height Factor:

By adjusting the height parameter, we significantly enhance the routing algorithm's performance. The Proposed TORA algorithm demonstrates remarkable stability, boasting an independent routing table independent of the network's topology, and swift responsiveness to changing network conditions. This stability arises from its reliance on subsystem count, rather than path length, for guidance. Unlike other algorithms that use global marking, TORA employs localized network marking, selecting a course segment by segment, and storing it solely in the generating hub's routing table.

The rapid response of Proposed TORA is due to its establishment of new courses between neighbouring hubs. A previously used route is replaced only if it's no longer viable. The time required for a new course depends on the distance between hubs. Each course begins with a QUERY package sent by one hub, followed by another hub's response. The 'infinite' routing table in QUERY evaluates the shortest path from sender to destination. Responses to QUERY either locate the destination in the routing table or the neighbours. An UPDATE package establishes the course if found in the routing table, while a CLEAR package does so if in the neighbours.

To provide the shortest path between hubs, the generating hub attaches its routing table with the intended route in QUERY. When an UPDATE packet arrives, the recipient calculates the shortest route to the destination. This proactive calculation allows it to assess if a shorter route exists before broadcasting the update to other nodes.

Conclusion and Future Scope

This study comprehensively assessed the proposed routing algorithm and conducted a rigorous statistical analysis using the ns2 simulator. Throughput, goodput, packet delivery ratio, and residual energy were evaluated, confirming the superior performance of the proposed TORA algorithm compared to conventional and reference TORA methods.

The contributions of this research offer advantage in terms of deployment, decentralization, and self-configuration, making mobile ad-hoc networks (MANETs) significant in wireless networking. Simulation-based monitoring and enhancements demonstrated the algorithm's effectiveness in improving network performance.

The research identified a critical gap in the TORA algorithm related to throughput and end-to-end packet delivery. By modifying the TORA algorithm's height parameter, this gap was successfully addressed, leading to enhanced network performance.

For future directions, creating an extensive testing environment is recommended to further analyse performance using real-world data and computationally intensive applications like big data and deep learning models. This approach will provide deeper insights into the algorithm's capabilities and possibilities for further improvements.

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