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Comparative Analysis of Energy-Saving Strategies and Throughput of SMR, MP-DSR, and ROAM

Kalu Ram Yadav
Research Scholar, Faculty of Engineering & Technology, Suresh Gyan Vihar University, India

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ABSTRACT

MANET is an auto-configuring, framework-less network of movable units connected through air. In a MANET, nodes communicate with each other without depending on a skeleton infrastructure such as central stations or access points. MANETs faces unique challenges like node mobility, limited power resources, and the need for efficient routing protocols. MANET requires adaptive routing algorithms to cope with changing network topologies and the absence of a fixed infrastructure. MANETs is suitable for the applications where setup of fixed infrastructure is impractical or expensive, such as army battlefield, rescue operations during natural disaster etc.Many on demand routing protocols for MANETs aim to establish and maintain efficient communication paths among mobile nodes have been designed in recent many years. Energy-efficient communication is essential to prolong the battery life of mobile nodes. We have been analysis three existing on demand multipath routing protocols (MP-DSR SMR and ROAM and) utilizing Network Simulator-2(NS-2). Here we analyzed above three protocols on Energy and throughput metrics parameters. We consider the network size 800mx800m in which nodes are randomly deployed. For simulation we use 25, 50 and 100 number of nodes. SMR exhibits a higher energy conservation rate, saving 4% more energy than ROAM and 8% more energy than MP-DSR in the presence of 25 nodes within the network. As the network expands to 50 nodes, MP-DSR outperforms ROAM by conserving 1.4% more energy and surpasses SMR by 2% in energy savings. In the context of 100 nodes, ROAM takes the lead in energy efficiency by preserving 4.5% more energy compared to MP-DSR and 5.5% more energy compared to SMR. These findings underscore the varied energy-saving capabilities of the protocols under different network sizes. Our simulation results also show that the throughput of ROAM is found to be superior to MP-DSR and SMR under different network sizes.

Keywords : MANET, ROAM, AODV, AOMDV, DSR, DUAL, DAG

I. INTRODUCTION

Wireless networks are categorized based on different criteria such as their size, range, infrastructure, and purpose [1, 2]. Based on Infrastructure it can be classified as Infrastructure-based system and Infrastructure-less system. Infrastructure-based system needs access points or base stations for communication like Wi-Fi networks. In Infrastructure-less networks do not require any infrastructure setup to communicate, they can connect directly. MANET is a type of infrastructure-less network.

The task of data transmission in MANET among the various nodes can take place in one only one Hop if nodes are direct connected to each other and it may takes help of intermediate nodes if communicating nodes are not in direct range of each other [3, 4].It is responsibility of routing algorithm to identify best path and also maintain it until transmission is not finished. A routing algorithm performs many tasks to discover and maintain the routes until data transmission are not completed.

MANET has wide range of applications such as: establishing networks in situations like Forest fire, disaster rescue operations etc. without infrastructure.

II. CLASSIFICATIONS OF ROUTING APPROACH

MANET is a collection of nodes, in which some node may be mobile. These nodes want to connect other nodes in lack of a fixed infrastructure. It is the responsibility of individual nodes to dynamically determine which other nodes they can interact directly. To communicate needs a routing protocol, this can find the best path by incorporating the mobile behavior of nodes. The routing protocol should be designed with considering the limitations of MANET like mobility, infrastructure support, random topological changes etc.

We can classify MANET routing in following three classes namely: Proactive approach, Reactive (On-Demand) approach, and Hybrid approach [4,5].

2.1 Proactive approach [5, 6]

This approach maintains routing tables for each source –destination nodes pair. A node that wants to send data it can immediately use these tables to construct routes for that. These nodes update their routing table information periodically. High message and storage overhead is occurred for update their routing tables. Due to high mobility nature of MANET proactive approached is not so much suitable. Few examples of it are DSDV, OLSR etc.

2.2 Reactive (On-Demand) approach [5]

As the name of this scheme indicates that route is only discover when source wants to communicate with other nodes. Source node floods the Route Request message in the network to find the route. Few examples of it are AODV, DSR etc

2.3 Hybrid approach [7]

This approach of routing includes the advantages of both reactive and proactive approaches. These algorithms are intended to improve scalability. For example there is a large ad hoc network and it is divided into zones and they can employ proactive routing for neighboring nodes. One node from a zone is elected as a head node and a reactive routing is carried out between head nodes. Few examples of it are ZRP, TORA etc.

III. REVIEW OF AD HOC MULTIPATH ROUTING PROTOCOLS

In On-Demand multipath routing routes are discover only when source node wants to send data to destination node. Source node floods the Route Request message in the network to find the multiple routes. These protocols aim to provide network reliability, load balancing, and fault tolerance by creating alternative routes. We will analysis these three on-demand multipath routing protocols: ROAM SMR and MP-DSR.

3.1 Split Multipath routing protocol (SMR)

Non-overlapping and entirely separate paths are establishes discovered by SMR [8]. The start of finding a route happens, when a node intends to transmit information's, and at that moment, there are no viable paths available. The discovery process identifies multiple routes. The initial node disseminates the RREQ packet to its adjacent nodes through broadcasting. An intermediate node performs the below given tasks in response to the Route Request (RREQ) message:

- ✓ Intermediate nodes refrain from responding to the RREQ indeed in the event that they have valid path to the destination.
- ✓ Otherwise RREQ forward to the neighboring nodes.
- ✓ Intermediate nodes dispatch the replicated RREQ under specific conditions like:

- Duplicate RREQ arrives via distinct links and
- The number of hops is the same or less than the previous RREQ.
- ✓ The intermediate nodes will refrain from forwarding the Route Request (RREQ) message under different conditions.
- ✓ A reply message sent back from destination to source node..The furnishing details on two distinct routes are:
- Path with the minimum delay, which called primary route and
- The path that is most distant from the main route.

Traffic load in SMR allocate too many different routes using a system that gives each packet of data its own allocation (per-packet). It is method of distributing network traffic load across multiple routes on a packet-by-packet basis. This scheme involves dynamically assigning individual packets to different routes in order to achieve load balancing and enhance network performance. With a per-packet allocation scheme, each packet is independently routed through the network along a specific path, allowing for better utilization of available routes and avoiding potential congestion on a single route. This approach aims to evenly distribute the traffic load, improve network efficiency, and enhance fault tolerance by utilizing multiple paths simultaneously.

If a link stops working, the source node eliminates the entry from routing table of the all intermediate nodes those are part of failure route and verifies the availability of an alternative path. According to research findings, the performance of SMR is enhanced when the search for a path begins only after the failure of both paths.SMR reduce control overhead messages due to reduction in the frequency of the path-finding process. This approach does the more efficient utilization of resources.

3.2 MP-DSR Algorithm

This protocol is also called Multipath version of DSR. The working nature of MP-DSR is distributed. It builds upon the foundation of the DSR protocol [11]. The MP-DSR algorithm improve the end-to-end reliability, so data transmission is also increased.MP-DSR only computes paths those meet a specified minimum E-to-E reliability requirement (P_u) ,where P_u **is:** $0 <= P_u <= 1$.The selected path preserves this consistently during the lifespan the transmission. In MP-DSR during the path finding process two parameters are calculated:

- M_0 **:** Total number of paths discovered and
- P_u **(**π_{lower}**):** The path reliability requirements.

Most suitable paths among the source and destination are chosen based on the relationship between M_0 and π_{lower}.A direct relationship exists between M0 and πlower. In scenarios with fewer available channels, a preference is given to more reliable channels, leading to a higher πlower. Conversely, in situations with more available channels, the preference may shift, resulting in a lower πlower. The source node transmits **M_0** RREQ packet to explore potential channel. The RREQ packet incorporates information like π_{lower} , the traversed path (T), and the reliability associated with that specific route. After reaching an RREQ message, an intermediate node conducts a verification process to determine the specified path reliability criteria, specifically ensuring that (i.e. 1-i, > π_{lower}). REEQ will be rejected by node if the conditions are not meet. In another situation, the REEQ packet is modified by intermediate node by including itself in T (Traversed path) and transmits several copies to adjacent nodes. The number of copies of RREQ will remain identical to the number of nodes those meets the path reliability. **M_0** also imposes a restriction on the quantity of duplicates to control the extent of message propagation within the network. Once the destination obtains the RREQ messages, it chooses several disjoint channel and dispatches RREP packet to the source node by using these selected paths. The initiating node initiates the transmission of data along these routes. Based on the research results, MP-DSR demonstrates a more reliable end-to-end transmission with a reduced number of errors.

3.3 ROAM Algorithm

It is also known as Acyclic On-Demand multipath routing. It is a multipath routing protocol in which routing is initiated by source node. It is designed for dynamic network environments. The main motive to develop ROAM protocol is to improve End-to-End transmission reliability by smartly using multiple paths [12].It initiate path finding process when any node wants to transmit data. In ROAM route discovery initiated by source it means it is source initiated algorithm. Route discovery identifies multiple routes between source-destination pair. The discovered route does not construct loops due to acyclic structure of ROAM. It means ROAM provides loop free paths for efficient communication. To avoid looping in routes ROAM algorithm uses the *feasible distance* concept. The feasible distances of all discovered routes are calculated. Feasible distance represents the metrics such as delay, which is associated with a particular path. The path is selected for data transfer on the bases of its feasible distance, due to this selected path is loop free and optimal. We know that in MANET many nodes are in mobile condition, so the topology of network is change dynamically. So it is necessary to periodically calculate and update the feasible distances for the paths.

DUAL is routing protocol and ROAM is enhanced version of its which discover multiple paths. A directed acyclic graph (DAG) is a directed graph without directed cycles. The concept of DAG is used in ROAM to find the distance between source-destination node pair. The ROAM algorithm solves the problem of searching to infinity by discontinuing multiple floods when the intended destination is no longer accessible.

In ROAM, every node preserves entries in its routing table for each destination. ROAM detects new network partitions by broadcasting update information when the distance to the destination surpasses a predefined threshold value. These updates, however, are not transmitted to active nodes in order to minimize overhead. Upon receiving a request for destination j, routing table is modified:

- Adds j into it.
- Modifies the distance to j, involving changes from the current distance to j and ∞.
- Decides to cancel the live entry for j.

When a node in a network gets a message, diffusing search is triggered. The data packet intended for a destination that lacks a route in its list of paths. The data packet's origin or any intermediary router can be source of diffusing search on the way from where it starts to where it ends. The diffusing search in the

MANET accomplished hop by hop from the source until it reaches a router that possesses an entry for the intended destination. At this point, the router responds by furnishing the distance to the specified destination. At the end of the search:

- Finite distance to the destination from the source either obtains or
- Destination is unreachable by all nodes within the same linked component.

The ROAM protocol minimizes the necessary update frequency, thereby reducing the overall number of updates.

IV. RESULTS EVALUATION

4.1 Simulation Scenarios

Employed various parameters and different network sizes in the implementation of the present MANET many Multipath Routing protocol [13]. We plan to use NS2 (Network Simulator) for simulating a network with different node quantities. The parameters for the simulation are detailed below:

Nodes in the Network	25,50,100
Size of Network	800mX800m
MAC	802.11
Multipath Routing	SMR,MP-DSR
Radio range	250m
Mobile nodes	10
Traffic Type	CBR
Simulation time	50 Sec
Mobility model	Random Way Point
Queue length	50
Simulation Time	Start- 5 Sec ,Stop-
Rate	100Kb
Number of Connections	4
Antenna Used	Omni Directional

We did tests using three different basic setups. In the first setup, 25 nodes are randomly distributed within an 800m × 800m rectangle. In the second scenario, 50 nodes are placed in random spots within an 800m × 800m region, while in the third configuration, 100 nodes are randomly distributed within an 800m × 800m area.

V. RESULTS AND ANALYSIS

The way current protocols work is examined in network scenarios with varying numbers of nodes. We employ the Throughput and Energy parameters to assess the way the ROAM, MP-DSR and SMR protocol works. We consider the network which consist 25, 50, and 100 nodes. The simulation carried out using NS-2. The simulation result is analyzed on two parameters: Energy & Throughput.

5.1 COMPARISON OF ENERGY-BASED MP-DSR, ROAM, AND SMR:

The energy level of a node is a crucial factor in MANET routing algorithms for ensuring sustained network operation over an extended period. Nodes possessing an adequate energy level are chosen for routing to minimize the risk of route failure caused by battery discharge. Before selecting a node as a member of a route, we calculate its remaining energy. A node is chosen to participate in the route discovery process, if its residual energy meets a predefined threshold value; otherwise, it is rejected. This approach helps optimize energy utilization and enhance the overall reliability of the network. Residual Energy (RE) can be calculated using the following formula:

Residual Energy (RE) =Initial Energy (IE) –Energy Consumed (EC)

Where:

Initial Energy: Initially energy of node

Energy Consumed: Energy used by node

For participating a node in communication a threshold value of its energy is decided. During the transmission the residual energy of that node is compare with predefined threshold value. The node is considered to have sufficient energy level only if RE of its equal to or more than the limit, then it is eligible for participation in the route discovery process; otherwise, it is rejected.

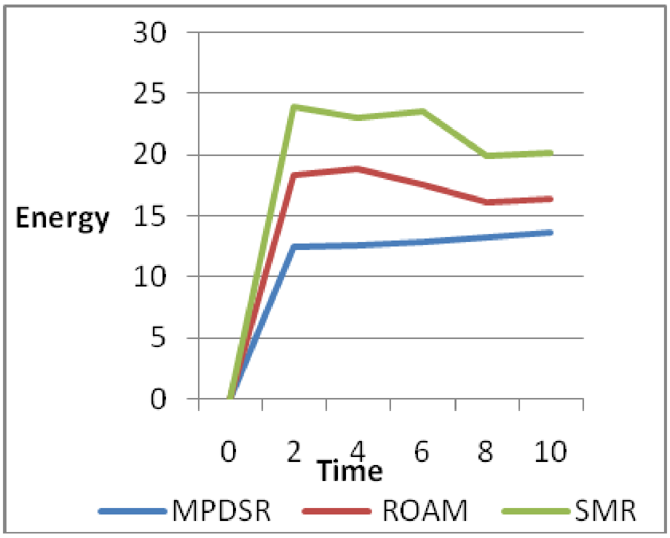

Fig.1: 25 Nodes

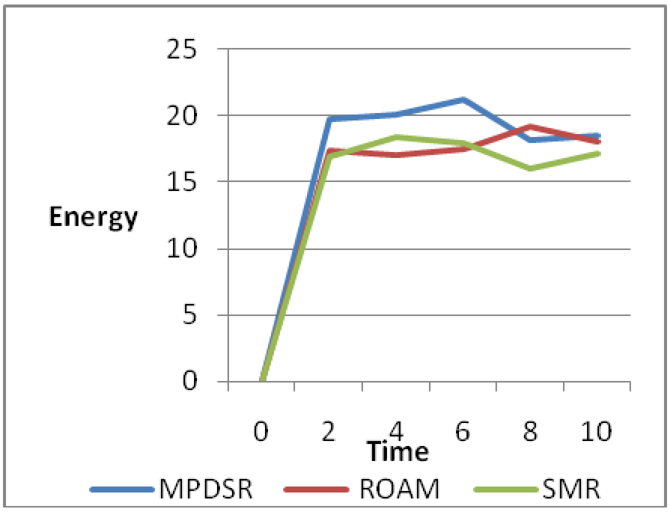

Fig.2: 50 Nodes

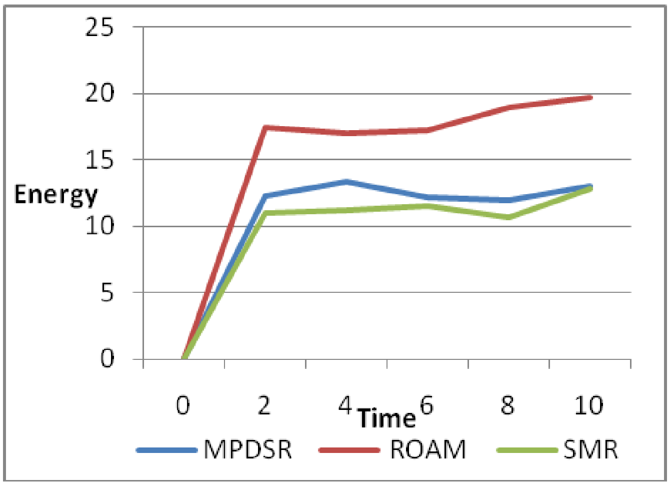

Fig.3: 100 Nodes

Conclusion: SMR conserves 4% more Energy compare to ROAM and 8% more Energy compare to MP-DSR when the network contains 25 nodes.MP-DSR conserves 1.4% more Energy compare to ROAM and 2% more Energy compare to SMR when the network contains 50 nodes. ROAM conserves 4.5% more Energy compare to MP-DSR and 5.5% more Energy compare to SMR when the network contains 100 nodes.

5.2 Throughput based MP-DSR, ROAM, and SMR Comparison

Throughput of MANET routing protocols refers to the aggregate of data that can be successfully transmitted in a given period of time through the network. It is a key performance metric that indicates the efficiency and capacity in terms of data transport. The unit for measuring throughput is bits per second (bps). The throughput (T) can be expressed using the following formula:

$$T = S/RTT$$

Where:

- **T** is the throughput,
- **S** is the size of the data being transmitted,
- RTT means the total time it takes for a message to go from one computer to another and then back again.

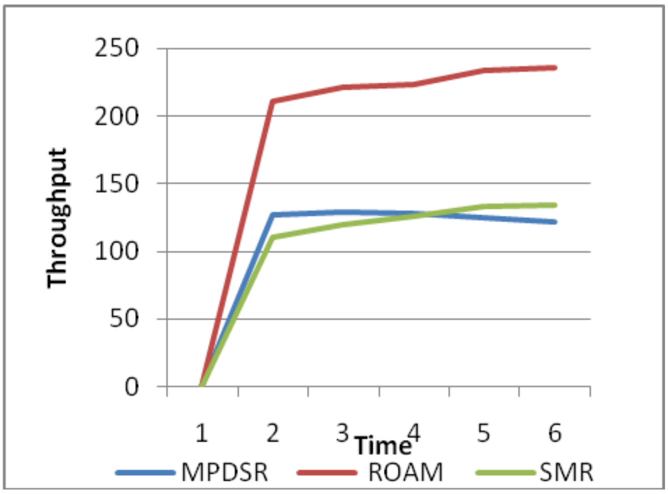

Fig.1: 25 Nodes

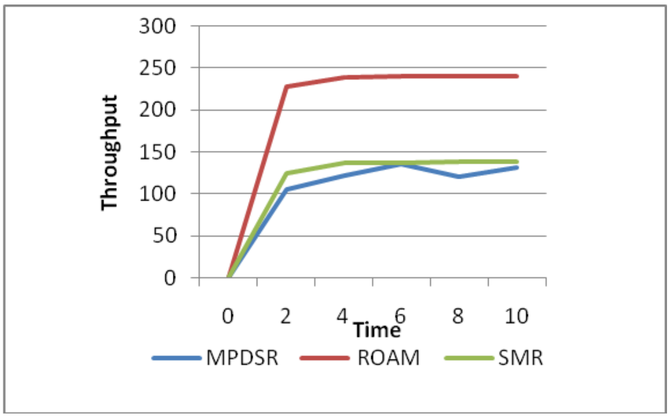

Fig.2: 50 Nodes

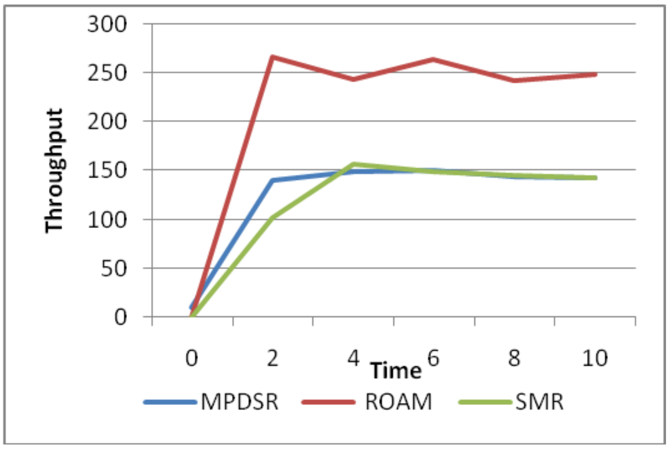

Fig.3: 100 Nodes

VI. Conclusion

The efficiency of the ROAM protocol surpasses that of both SMR and MP-DSR. The throughput of ROAM is found to be 43.97% superior to that of MP-DSR and 44.68% better than SMR when the network comprises 25 nodes. The throughput of ROAM is found to be 48.43% superior to that of MP-DSR and 42.81% better than SMR when the network comprises 50 nodes. The throughput of ROAM is found to be 51.66% superior to that of MP-DSR and 45.02% better than SMR when the network comprises 100 nodes. The simulation results highlight ROAM's notable advantage in data transfer speed over the other protocols in the specified network scenario.

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