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Energy Efficient and Scalable Routing in MANET using Ant Colony Optimization and Zone Based Routing Protocols

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Abstract - Mobile Ad Hoc Network (MANET) is a collection of wireless mobile nodes dynamically forming a network. There is no fix infrastructure in MANETs. Routing in MANET is biggest challenge for researchers.ACO algorithm uses mobile agents called ants to explore network. Ants support to find routes between two nodes in the network. ZRP is based on border casting of data which is also used in our work. In this paper our work is based on ants jump from one zone to the next zones which contains of the proactive routing within a zone (with 30mW power level) and reactive routing between the zones (with 60mW power level).

Keywords – Mobile Ad Hoc Network (MANET), Ant Colony Optimization (ACO), Zone Based Routing Protocols, ZRP, Power Management

I. INTRODUCTION

In MANET'S world, devices such as PCs, cellular phones, laptops, appliances with ad hoc communication capability link together on the fly to create a network. Today's most common communication problems such as having a centralized connectivity and stationary infrastructure can be solved by this technology.

Mobile Ad-hoc Networks (MANETs) are communication networks in which all nodes are communicate with each other via wireless connections. It is a self-configuring, self-organizing and infrastructure-less network of mobile nodes which allows the systems to be communicated without any wires. A few characteristics of MANETs are Packet should be forwarded via one or more intermediate nodes, Each node can function as both host and a router, Network topology may change randomly and at unpredictably, There is no centralized control of the network operations.

In this paper we propose power level based zone routing protocol with ant colony optimization. This algorithm uses the concept of two power level (with 30mw and 60mw) based zone for intra zone routing and inter zone routing using ant colony optimization approach. Our algorithm is more efficient as compared to simple zone based routing protocol (ZRP) in terms of Throughput, Packet Delivery Fraction and Energy.

II. LITERATURE SURVEY

Table 1. Literature Survey Table

Paper Title	Publication Year	Methodology	Parameter Improves	Limitation
Location Aided Zone Routing Protocol in Mobile Ad Hoc Networks [5]	IEEE-2015	Based on location of destination	End to End Delay, Routing Overhead	If destination location is wrong then whole path of routing is wrong.
Geographic Multicast Routing Protocol for Achieving Efficient and Scalable Group Communication over MANET [6]	IEEE-2014	Greedy selection approach based on weighting factor	Packet Delivery Ratio	If Zone representative fails may cause to whole network fails
Zone Based Multicast Routing Protocol for Mobile Ad-Hoc Network [7]	IEEE-2013	Uses virtual-zone-based two-tier infrastructure	Packet Delivery Ratio, Reduces Overhead	If zone head fails may cause to whole network fails
Zone Based Ant Colony Routing In Mobile Ad-hoc Network [9]	IEEE-2010	Max-Min D-cluster formation, Zone formation, Route establishment using ACO	Reduces Overhead, Hop Values, Increases Throughput	If cluster head fails may cause to whole network fails.

		(Zone based routing algorithm using cluster methods)		
A Hybrid Routing Algorithm Based on Ant Colony and ZHLS Routing Protocol for MANET [8]	Springer-2010	ACO + ZHLS Proactive routing within a zone, Reactive routing between the zones	End to End Delay, Packet Delivery Ratio	Its take more time to divide the network in to zones.
HOPNET: A hybrid ant colony optimization routing algorithm for mobile ad hoc network [10]	Elsevier-2009	Extracted from ZRP + DSR Size of the zone is determined by radius length measured in hops	End to End Delay, Packet Delivery Ratio	Its harder to find the nodes which is belongs to the same radius of network
Position-based Routing Protocol by Reducing Routing Overhead with Adaptive Request Zone for Mobile Ad Hoc Networks [11]	ECTI-2011	Zone may not be fixed but it can be chosen adaptively depending on the variation of distance between source node and destination node because those nodes may change the position (Based on location of destination)	Packet Delivery Ratio, Routing Overhead	If destination location is wrong then whole path of routing is wrong.
A Novel Grid Based Ant Colony Routing in Mobile Ad Hoc Networks [12]	IEEE-2009	Using GRID Approach	Packet Delivery Ratio, Reduces Overhead	Not proper work for heterogeneous network

III. ANT COLONY ROUTING ALGORITHM

The principle of the ACO is that ants can release some special chemical substance which is named pheromone. Moving ants deposits a certain amount of pheromone in the environment thus making the path by a trail of substance. First ants can choose random way for nest to food. After that if we put the obstacle on the way of nest to food. Then ants can select the shortest path. The longer the route ants gained, the smaller amount of pheromone they deposited. Then, when ants for a second time arrive at the intersection later, each of them prefers in possibility to choose the path richer in pheromone rather than the poorer one. So, the pheromone trail on the better paths gets stronger and stronger, and ants that choose those paths get more and more, while that of other paths fades away by iteration gradually, and ants choose them get less and less. Finally the ants get shortest path from nest to food [3].

IV. ZONE ROUTING PROTOCOL (ZRP)

The Zone Routing Protocol (ZRP) aims to address the problems by combining the best properties of proactive and reactive routing approaches. ZRP can be classed as a hybrid routing protocol. ZRP can be categorized as a flat protocol because the zones overlap. Hence, optimal routes can be detected and network congestion can be reduced [4]. A routing zone is defined based on radius in terms of hop counts. Here we take radius 2 (hop count 2). We can take any radius r for defining zones.

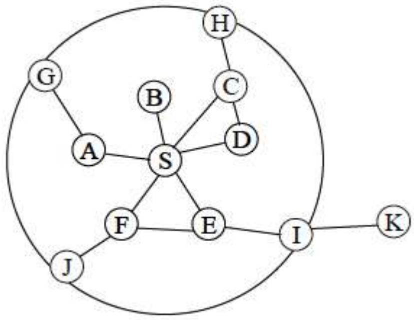

Figure 1. Example routing zone with r = 2 [4]

An example routing zone is shown in Figure, where the routing zone of S includes the nodes A–I, but not K. In the diagrams, the radius is marked as a circle around the node. It should however be noted that the zone is defined in hops, not as a physical distance.

The nodes of a zone are divided into peripheral nodes and interior nodes. Peripheral nodes are nodes whose minimum distance to the central node is exactly equal to the zone radius r. The nodes whose minimum distance is less than r are interior nodes. In Figure, the nodes A–F are interior nodes, the nodes G–J are peripheral nodes and the node K is outside the routing zone.

ZRP refers to the locally proactive routing component as the IntrA-zone Routing Protocol (IARP). The globally reactive routing component is named IntEr-zone Routing Protocol (IERP). IERP and IARP are not specific routing protocols [4].

V. LIMITATIONS OF ZRP

Two Major limitations of Zone Routing Protocol (ZRP) which is mention as below :

Power Consumption

In ZRP, the packets are sent with full power without considering the node's position inside the zone or outside the zone. According to Inverse Square Law, the power received by the receiving node is inversely proportional to square of the distance between the nodes (i.e).

$$\gamma = Pt / 4\pi r2 \text{.....[13]}$$

The node could waste power if the distance between the sender and the receiver node is less [4].

Bandwidth Deployment

As the distance between the sender and border nodes increases, the zone area will also increase, which means the radio coverage of the sender node will not be able to reach the border nodes in the zone. For that reason, the sender node will increase the number of broadcasts to find the border nodes in the zone, which will obviously increase the bandwidth utilization [4].

VI. PROPOSED ALGORITHM

Step 1: In network when nodes switches on its creates zone.

Step 2: Set two different power level for each node (30mW for intra zone routing & 60mW for inter zone routing).

Step 3: If the destination is in the same zone then routing using the 30mW power with ant colony optimization. Destination is out of zone then routing using the 60mW power with ant colony optimization.

Step 4: Reached Packet at destination.

Example for Proposed Algorithm

Note that, for routing in intra zone and inter zone we use ant colony optimization. From the below figure it can be seen that every node generates their own routing zones and in the beginning when the node switches ON, it creates the zone with 30mW and 60mW, since that is the threshold power level set initially by the protocol. But if a node is unable to find a border node since the node's threshold power level is high (30 & 60mW), then the corresponding node will start dropping its threshold power level until it's able to find the border node. If we consider the above figure, if node 1 wants to talk with node 3 then node 1 should pass through one of its border nodes to reach the neighboring zone, they are nodes 2, 4 or 5. To calculate the power consumption, consider node 1 wants to forward a packet to destination node 8.The source node sends a border cast with 60mW to all its border nodes (i.e) nodes 2, 4 and 5. Then the corresponding nodes check their own routing table and in that node 2 can reach node 8 since it is the border node of node 2's zone. After seeing that, node 2 sends a unicast packet to destination node 8 with 60mW. Therefore, the source node found the destination node by shedding only 60mW in the modified ZRP protocol. But in the actual ZRP protocol the node would have spent 100mW to reach the destination since all the nodes form zone with respect to hop count and it always forwards the packet with full power level (100 mW). So as the number of broadcasts increase, the power usage will also increase according to the formula

P=C*N, Where C=Transmit power and N=Number of Broadcasts...[14]

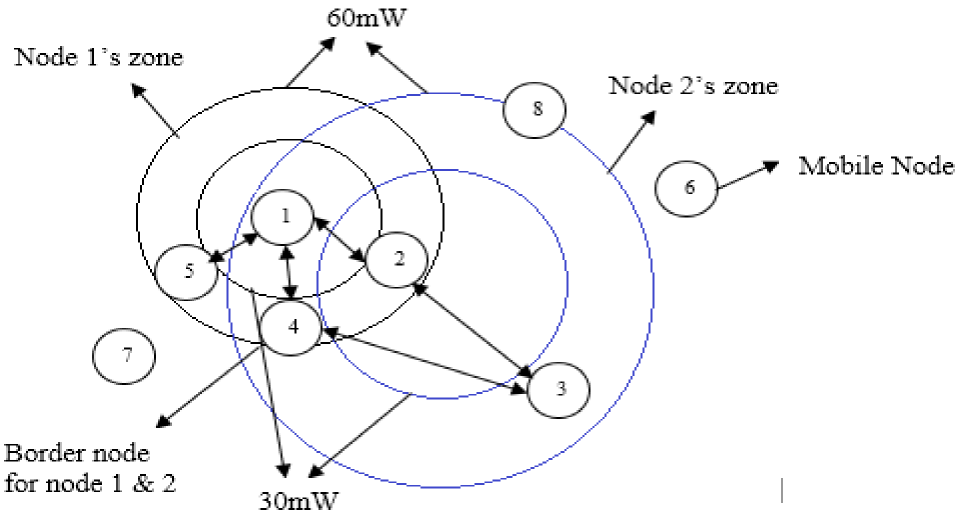

Figure 2. Proposed Algorithm Example

VII.SIMULATION RESULT ANALYSIS

In order to validate our analysis result, we have implemented a series of experiments trough simulation. We have used NS2 network simulator version 2.33. Table show the environment used in our experiments. Here we have used random waypoint mobility model. An extensive simulation model having scenario of n (user defined) mobile nodes and n cbr/tcp connections is used to study inter-layer interactions and their performance implications.

Table 2. Simulation Environment

Channel	Wireless Channel
Simulation Run time	200 seconds
Area in which nodes move	500*500
Packet size	1024 bytes
Routing protocol	ZRP, ZRP with (30mW & 60mW)
No. of Nodes	7,14,21,28
Propagation Model	Two Ray Ground
N/W interface type	Wireless Physical
MAC type	Mac/802.11
Antenna type	Omni Antenna

Throughput Comparison for ZRP and Proposed ZRP (30mW & 60mW)

From this graph we can conclude that throughput of ZRP is less as compare to the intra-zone routing of modified ZRP. In ZRP for inter-zone and intra-zone all the resources are waste same in terms of energy and power of network. But when we use the modified ZRP then we can save bandwidth utilization of network using two different routing with two different power level. Graph clearly mention that the throughput for the intra-zone in modified ZRP is better than the ZRP.

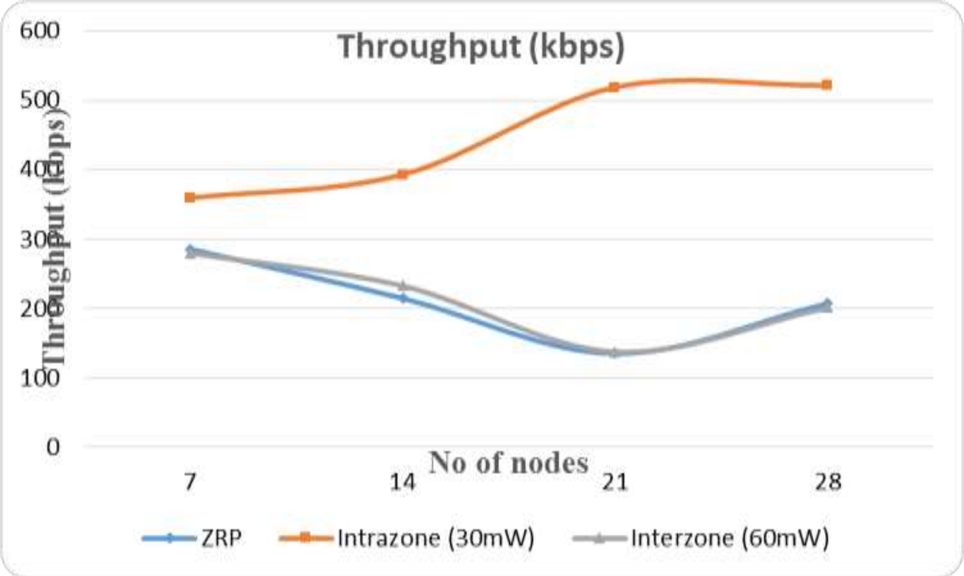

Figure 4. Throughput Comparison for ZRP and Proposed ZRP

PDF (Packet Delivery Fraction) Comparison for ZRP and Proposed ZRP (30mW & 60mW)

From this graph we can conclude that PDF (Packet Delivery Fraction) of ZRP is less as compare to the intra-zone routing of modified ZRP. In ZRP for inter-zone and intra-zone all the resources are waste same in terms of energy and power of network. But when we use the modified ZRP then we can save bandwidth utilization of network using two different routing with two different power level. Graph clearly mention that the pdf for modified ZRP is better than the ZRP.

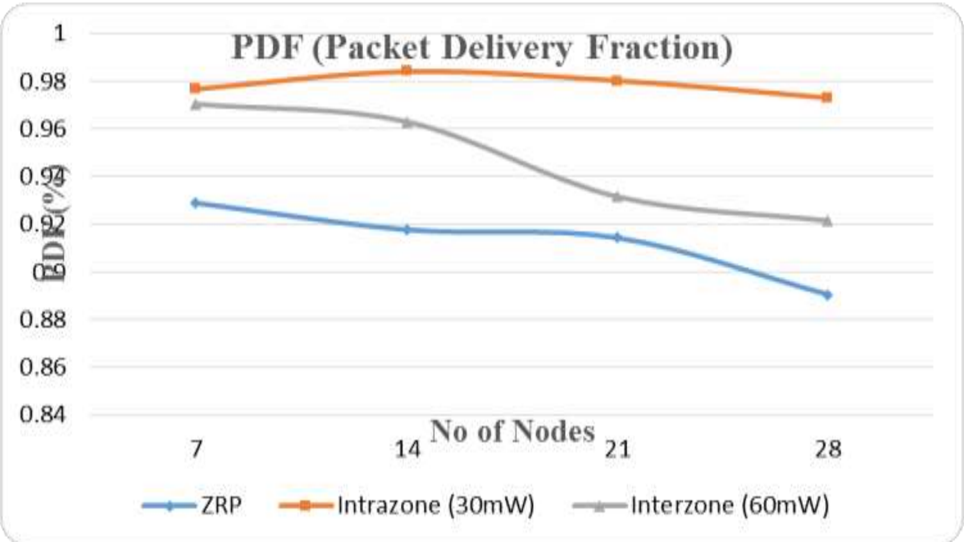

Figure 5. Packet Delivery Fraction (PDF) Comparison for ZRP and Proposed ZRP

E2EDelay Comparison for ZRP and Proposed ZRP (30mW & 60mW)

From this graph we can conclude that E2EDelay of ZRP is more as compare to the intra-zone routing of modified ZRP. In ZRP for inter-zone and intra-zone all the resources are waste same in terms of energy and power of network. But when we use the modified ZRP then we can save bandwidth utilization of network using two different routing with two different power level. Graph clearly mention that the E2EDelay for modified ZRP is less than the ZRP.

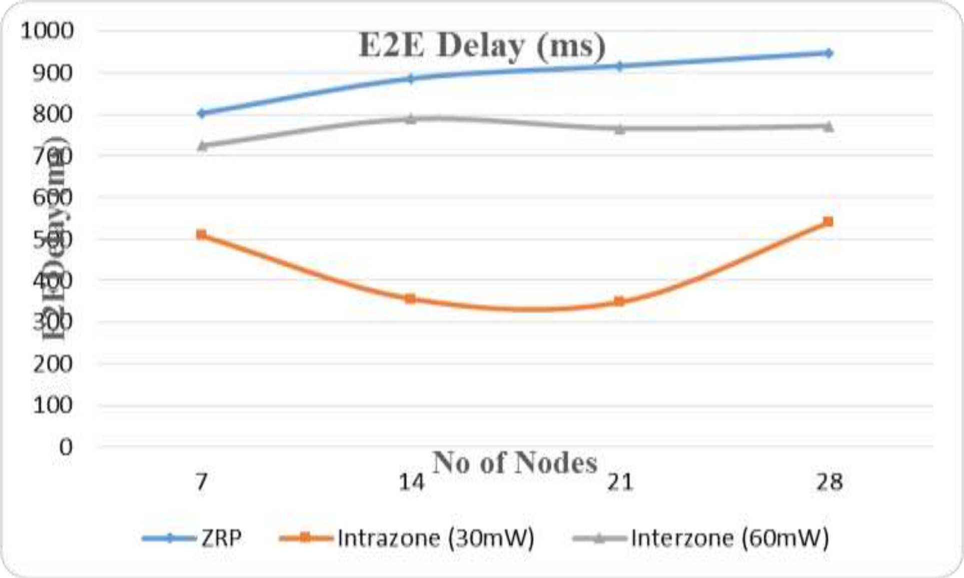

Figure 5. E2EDelay Comparison for ZRP and Proposed ZRP

VIII. CONCLUSION

We proposed an energy efficient and scalable routing algorithm for MANETs. In our work, the network is divided into two zones. The algorithm supports reactive routing between zones and proactive routing within a zone. There are two power values used for intra (30mw) and inter (60mw) based on the radius. Each node consumes power to transfer the data. In intra-zone direct communication is possible between source and destination, so we fix low power. For inter-zone, there are several intermediate nodes are present, so it consumes more power compare to intra-zone routing. To obtain shortest path in inter-zone, the ACO algorithm is used. In this way by the simulation results we can say our proposed algorithm is perform better in terms of throughput, pdf and e2edelay.

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