An Intelligent Gateway Scheme for Power Aware Routing in Mobile Ad Hoc Network

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Abstract: ***A Mobile Ad hoc Network commonly called as MANET provides the technical platform for efficient information sharing in emergency and rescue operations without any centralized access point and infrastructure. The nodes move arbitrarily and its topology also changes frequently and unpredictability. For ad-hoc networks every node communicates with other nodes in multi-hop manner through intermediate nodes directly or indirectly. Mostly mobile ad hoc network nodes are battery operated and in most cases they are installed in an environment where it may be impossible to retrieve the nodes in order to charge the batteries. Therefore, network nodes need to be energy conserving so that the battery life and hence the network lifetime can be maximized and it is important to minimize the power consumption of the entire network to have optimized power battery life. In this paper we propose an (IGPARS) intelligent gateway scheme for power saving features and a solution to reduce the number of collision so that minimum power will be required in routing. The selection process for determining the best gateway intermediate node carried out in order to efficiently route the data packets after a regular interval of time. This process helps in reducing the overall delay involve in transmission of message from source to destination node and the bandwidth is appropriately utilized.***

Keywords: Ad hoc Network, MTPR, Battery Power, Bandwidth, Power Consumption

1. Introduction

With recent performance advancement in Wireless technology, portable computing platforms and small wireless devices become indispensable devices of our daily life. The use of a portable device is constrained by its energy, making power conservation. The most of portable devices are battery–operated and extending the battery lifetime has become an important objectives.

Most devices in MANET are battery - operated, power is an important design issue. Because the speed of improvement in battery technology is significantly slower than that in computing technologies, power becomes one of scarce resources in mobile computing [1][14]. The size constraint and heat dissipation concern also limit the power capacity of nodes in MANET. There is a hot field called power aware computing whose goal is to extend the battery service life while meeting performance requirements.

In this paper we focused on designing a protocol that increases the life of nodes and whole network. The main functions of the network layer are routing packets and congestion control. For power-aware protocols in MANET, the network layer should add support for node mobility and power management. There are number of power routing protocols that are used for to extending the battery lifetime, these are Minimum Battery Cost Routing Protocol [MBCR], Minimum Total Power Routing Protocol (MTPR), Power–Aware Source Routing Protocol [PASR], Localized Energy Aware Protocol [LEAR], Online Power Routing. Protocol, Power Aware Localized Routing Protocol and Power Aware Routing Protocol [2] [3] [5]. All of above routing protocols are used to extending battery life of the mobile nodes.

A. Factors affects of MANET Routing Protocol

Bandwidth constraints and variable link capacity: Wireless link usually has lower capacity than wired link. Due to multi path fading, noise and signal interference, wireless link is very unstable [4].

Dynamic topology: Because of node mobility, a node can join, roam and leave the network. So network topology should be adaptive to current location of nodes. Depletion of battery capacity can also cause node failure [4].

Energy constraints: The major concern of this paper is to minimize the total energy consumption. The proposed work presents a protocol that tries to minimize the total energy consumption as well as minimize the total number of collision [8].

Multi-hop communication: Because of transmission power limit, a node will communicate with the nodes outside its transmission range via intermediate nodes [5] [6].

Limited security [4]: Wireless network is less secure than wired network in natural. The problem is worse since it lacks of central authority and there are limited computation and power capacity in each node.

1) Need for a new Routing Protocol:

A comparative study of existing power routing protocols indicate that these Protocols suffer from the following drawbacks:

- Unwanted wastage of power when no transmission and receiving process is done.
- All the existing power routing protocols select a gateway which is not done in an intelligent way.
- Most of the power aware routing protocols are not conserving power.
- In all of the existing routing protocols congestion is high.

B. Optimization of Matrices:

The bandwidth and battery power are important metrics in ad hoc networks besides end-to-end throughput and delay are the widely used performance metrics in wired and wireless networks. Routing in MANET depends on many factors including modeling of the topology, selection of routers, initiation of request etc. MANET's by nature are highly dynamic networks with scarce channels.

C. Proposed an (IGPARS) intelligent gateway scheme for power aware routing for MANET

Thus a new routing protocol called IGPARS for MANET is being proposed that not only overcomes the shortcomings of existing routing protocols but also provides loop avoidance, minimizes channel overhead and increases the scalability of the network and provides an intelligent way to select a gateway that have much more information than the protocols are proposed till date.

In a new routing protocol nodes are select the next neighboring nodes on the basis of BGT (Best Gateway Table) and Best Count, which nodes have the value of Best Count is maximum, we select that nodes as the next neighboring nodes. The nodes in the ad-hoc network repeat the process of gathering the BGT (Best Gateway Table) entries in the table until every node has details about their neighboring nodes. In fact, the nodes to forward data packets use this information. Whenever due to mobility of mobile nodes there is a packet loss, the BGT entries are updated. However, after a regular interval of time, every node within a cell retransmits a gateway Request packet in order to read just the network information about its neighboring nodes. The new power routing protocol solves the above two problems;

- Maximum number of nodes is in the sleep mode and this protocol useful for extending the lifetime of the battery
- Reduce the congestion among the nodes.

2. Power Routing Protocol

The number of power routing protocols such exit as Power Aware Source Routing, Localized Energy Aware Routing, Minimum Total Power Protocol, Minimum Battery Cost Routing, Power Aware Routing Protocol and Online Power Routing Protocol. These all power routing protocols are used to maximize the battery power of a mobile node [7] [11].

A. Minimum Total Power Routing

Minimum total power routing (MTPR) [10] [15] If the total transmission power for route R is PR, then the route can be obtained from min {MTPR R, S P R□}where S is the Set containing all possible routes. Due to the fact that transmission power scales with transmitted distance as d_2 to d_4 depending on environmental conditions, this routing approach will in most cases tend to select routes with more hops than others. Thus, more overhead may be wasted network-wide since more nodes are now involved in routing, as all nodes that are neighbors to these intermediate nodes will also be affected.

- The network will be congested.
- More number of nodes has to participate in forming a routing path.
- It will always select its nearest neighboring node.

The MTPR protocol is to minimize the total transmission power consumption for the multi-hop communication. Since the transmission power is the proportion to the transmission distance between two neighboring nodes, therefore MTPR protocol always selects a route with minimum total power but with more hops, although the Dijkstra's shortest path algorithm was attempted to be used in MTPR protocol [15].

B. Minimum Battery Cost Routing

Minimum battery cost routing (MBCR) [7] uses the inverse of the remaining battery capacity as the cost function. It uses the sum of cost for all intermediate nodes as the metric for route selection. However, since it just minimizes the sum, some hosts may still be over used because a route containing nodes with little remaining battery capacity may still be selected.

C. Power Aware Routing

Power Aware Routing Protocol [9] [13] makes three basic assumptions, which are as follows:

- All nodes are located with in the maximum transmission rage of each other.
- Radios are capable of dynamically adjusting their transmission power on a per-packet basis.
- PARO comprises of two core algorithms that support overhearing and redirecting

3. Proposed Work

A. Data Packet (DP) Header

This packet is used for exchange of data between the mobile nodes. In which each data packet header will have several fields like packet type, source address of the node that sent the packet, destination address of the node to which the packet must be finally handed, a list of addresses of previously visited nodes and a hop count of the no. of intermediate nodes during the process of data transmission.

Table 1: Format of Data Packet Header

Packet type	Source Address	Destination Address	Visited Nodes	Hop Count	Data

B. Best Gateway Table (BGT)

Each node in a cell maintains information about its neighboring nodes by broadcasting a hello request and reply packet So it is assumed that all the nodes has information about the neighboring nodes .The format of request packet is given.

Table 2: Format of Best Gateway Table (BGT) Header

Packet Type	Source Address	Destination Address	Entries of Nodes

Where packet type identifies the packet as a gateway request packet, source address contains the IP address of the sender node and destination address contains the broadcast IP address. Entries of nodes contains list of IP address of neighboring nodes in the network Every recipient node adds the information of sender into a table called Best Gateway Table where the entries of nodes are stored in the decreasing order of their strength towards becoming a gateway.

Table 3: Format of Reply Packets

Packet Type	Source Address	Destination Address	Count

C. Gateway Request for Packet Reply

From the below figure 1, Node 1 will broadcast its gateway request packet to nodes 3, 4, 2. The packet will be having a format as shown above:

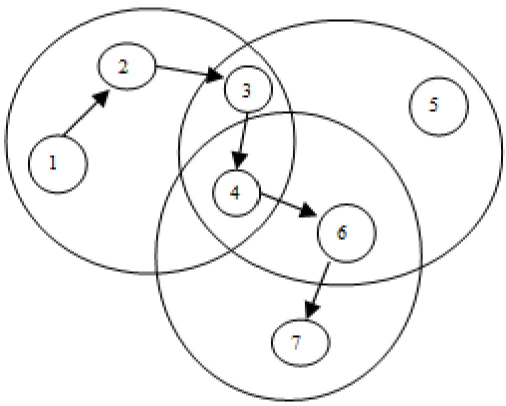

Figure 1: Packet move from source node 1 to destination node 7

From the above figure 1, Node 1 will broadcast its gateway request packet to nodes 3, 4, 2. The packet will be having a format as shown under in the Table IV. For the sake of simplicity the nodes number instead of nodes IP address.

Table 4: Gateway Request Packet of Node 1

Request Packet	node 1	Node 2	2	3	4

Similarly each node 3, 4, 2 carries out the similar process The entries of the nodes are matched with the entries stored in the gateway request packet and if the entries of the destination is matched with the source, power of the node is greater then the threshold energy then the value of variable count is incremented, which is initially set to zero.

Table 4: Best Gateway Reply Packet of Node 2

Reply Packet	Node 2	Node 1	Count = 0

Calculate computation of the variable count. Let's say node 2 replies back the gateway reply packet after appropriate computation.

- The node 1 sends its entries to the node 2 about its neighbor entries now the node 2 checks its entries. The node 2 has entries of the nodes 1, 3, 4 as according to the above figure.1. The node 1 has entries about the nodes 3,4,2 .The node 2 entries are matched with the received node 1 entries .The all entries of node 2 matches with the node 1so the value of variable count is = 0
- Similarly it sends its entries to the other nodes also like 3, 4, and the variable count is generated the values of count are for node 3, 4 are 2, 3. These values are explained in the table format as shown under;

Table 5: Showing how the Variable Counts Generated

Source Nodes	*Neighboring*						*Count for source node 1*
1	2	4	3				
2	1	4	3				0
3	1	2	4	5	6		2
4	1	2	3	5	6	7	3

The above table is created in each node according to the variable count in non-decreasing order as shown in the table below:
Similarly node Best Gateway tables are created for the other nodes by this mechanism. This all process has been explained algorithmically as shown under;

1. Broadcast reg_req_pkt to all the neighboring nodes
2. Apply string matching process /*destination string is matched with the source
String .The number of entries that does not match with the source contributes towards count */
3. if (Power of visited node >= Threshold power)
{
Evaluate count
Generate gateway reply packet
}
else
{
discard that node
}
4. Create BGT entries for the nodes

4. Simulation and Results

The nodes in the ad-hoc network repeat the process of gathering the BGT (Best Gateway Table) entries in the table until every node has details about their neighboring nodes. In fact, the nodes to forward data packets use this information. Whenever due to mobility of mobile nodes there is a packet loss, the BGT entries are updated. Gateway request packet is in order to read just the network information about its neighboring nodes. The simulator is designed in C++ and maintaining the data in MS-Excel.

A. Route Request Packet Format

This packet format shows the path from source node to the destination node along with intermediate node. Where packet type identifies the packet as a gateway request packet, source address contains the IP address of the sender node and destination address contains the broadcast IP address and intermediate nodes contain the list of all the intermediate nodes from source to destination.

Table 6: Route Request Table

Packet Type	Source Address	Destination Address	Intermediate Node

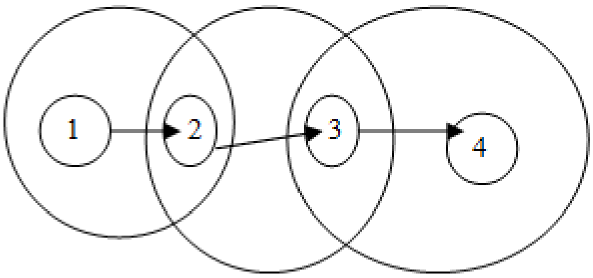

Figure 1. Path from source node 1 to destination node 4

B. Route Reply Packet Format

This packet format shows the path from destination node to the destination node along with the intermediate nodes.

Table 6: Route Request Table

Packet Type	Source Address	Destination Address	Intermediate Node

Where packet type identifies the packet as a gateway reply packet, source address contains the IP address of the sender node and destination address contains the broadcast IP address and intermediate nodes contain the list of all the intermediate nodes from source to destination.

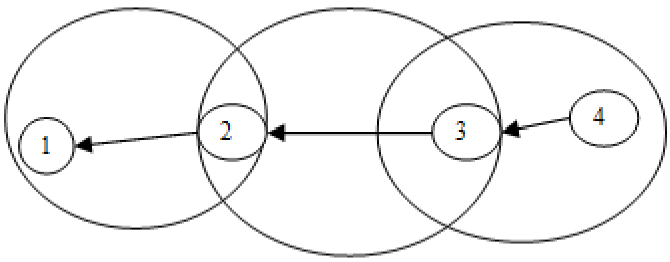

Figure 2: Path from source node 1 to destination node 7

Table 7: Route Request Table

Reply Packet	Source Node 4	Destination Node 1	Intermediate Nodes 2,3

C. Proposed Intelligent Scheme for Power Aware Routing

Any power aware routing scheme can be used under this proposal with certain modification as shown under and can work as the intelligent gateway. In the proposed routing scheme, a node will be active when it is periodically true and it can receive the route request packet from other nodes and send route reply packet to other nodes, otherwise nodes are goes into the ideal mode.

```
While (true)
        {
        If ( packet = = true)
          {
            Make Node Active ( )
          }
 /*Periodic Update */
        Else
          {
            Make Node Sleep ( )
          }
        }
```

From Figure 4&5 the data packets can be forwarded from source to destination using the proposed routing Scheme. Each node constructs its BGT table. How packet are move from source node 1 to destination node 7. According to the MTPR and Intelligent Gateway Proposed Routing Scheme.

The distance between the nodes are given as distance from node 1 to node 2 is 10, node 2 to node 3 is 5, node 3 to node 4 is 5, node 4 to node 6 is 7, node 6 to node 7 is 5, node 1to node 4 is 14 and node 4 to node 7 is 10.

D. Intelligent Gateway Power Aware Routing Scheme Apply

Firstly we have to create the best gateway tables for each node to find the best count of each node and select the next node by using the best count.

The values of count are shown in the table and according to that the BGT list is prepared as shown below:

Table 8: Creation of Gateway for Node1

Source Nodes	*Neighboring*						*Count for source node 1*
1	2	4	3				
2	1	4	3				0
3	1	2	4	5	6		2
4	1	2	3	5	6	7	3

Table 9: Gateway Table of Nodes

Source	*Best gateway (decreasing order)*		
1	4	3	2

- Node 4 has the maximum value of count so this node is placed in the first position in the BGT table.
- The nodes 3 have the less values of count they are placed arbitrarily in the middle of BGT table.
- The nodes 2 have the least values among of count they are placed arbitrarily in last of BGT table.

The data packet will be routed from node 1 to node 4 since it was having maximum count value. The path follows by source node 1 to destination node 7 is given below Node 1-Node 4-Node 7

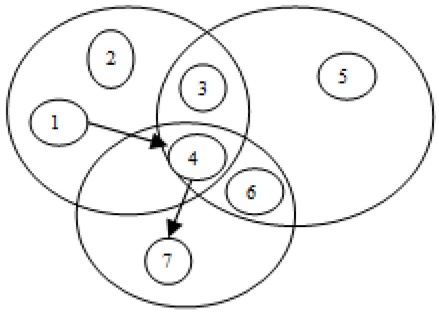

Figure 3: Showing the routing of data packet from node source node to destination.

Overall nodes participate in Proposed Routing Scheme are:

Node 1-Node 4-Node 7 = 03 nodes

Total Energy Consumed from Source Node 1 to Destination Node 7 is:

Total Energy = (14 *14) k+ (10*10) k =296 k

Total Number of Nodes are in Active modes are 14, and 7.

E. Minimum Total Power Routing Protocol

This protocol is to minimize the total transmission power consumption for the multi-hop communication. Since the transmission power is the proportion to the transmission distance between two neighboring nodes, therefore Minimum Total Power Routing always selects a route with minimum total power. According to this protocol select the next node on the basis of the distance, which node have the minimum distance select that node as the neighboring node and this procedure goes up to the destination node [14].

The path follows by source node 1 to destination node 7 is given below

Node 1-Node 2-Node 3- Node 4-Node 6-Node 7

Total Energy Consumed from Source Node 1 to Destination Node 7 is:-

Total Energy = (10*10)k+(05*05)k +(05*05)k+(07*07)k+(05*05)k = 224 k

Overall nodes participate in MTPR are:
Node 1-Node 2-Node 3- Node 4-Node 6-Node 7 =06 nodes

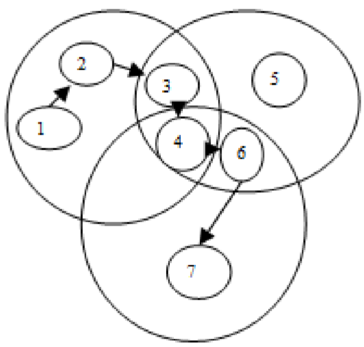

Figure 4: Showing routing of data packet from node source to destination using MTPR

F. Comparison between MTPR and Proposed (IGPARS) Routing Scheme

If node is in transmission and receiving mode it consume 13 mw energy and when it is in sleep mode it consume 2mw and now total overall energy consume from source node to destination node in Proposed Routing Scheme and MTPR Routing Protocol after n second of time interval given below:

1) Total Energy Consumption in IGPARS

Numbers of node in active mode are:

Node 1-Node 4-Node 7 = 03 nodes

Numbers of node in sleep mode are:

Node 2-Node 3-Node 6 = 03 nodes

Total Energy = (13*3) + (3*2) =45n

2) Total Energy Consumption Minimum Total Power Routing Protocol

Numbers of node in active mode are:

Node 1-Node 2-Node 3- Node 4-Node 6-Node 7 =06 nodes

Total Energy = (13*6) =78 n

So difference between power consumption in Proposed (IGPARPS) Routing Scheme and MTPR given below:

45n +296 k <= 224 k+ 78n
72<= 33n
72 / 33<= n units

If the data to be send for a time period more than n second than intelligent gateway scheme will consume less power than MTPR.

Example : Let suppose when a node is in transmission and receiving mode it consume 13 mw energy and when it is in sleep mode it consume 2mw and now total overall energy consume from source node to destination node in Proposed Routing Protocol and MTPR Routing Protocol after n second of time interval given below:

Total Energy Consumption Proposed intelligent gateway power aware Routing Scheme is:

Numbers of node in active mode are:

Node 1-Node 3-Node 6-Node 8-Node 9 = 05 nodes

Numbers of node in sleep mode are:

Node 2-Node 4-Node 7 = 03 nodes

Total Energy = (13*5) + (3*2) =71n

Total Energy Consumption MTPR Routing Protocol is:

Number of node in active mode is:

Node 1-Node 2-Node 3-Node 4-Node 6-Node 7-Node 8-Node 9 =8 nodes

Total Energy = (13*8) =104 n

So difference between intelligent gateway power aware routing scheme power consumption and MTPR given below:

71n +513 k <= 316 k+ 104n
197<= 33n
197 / 33<= n units

If the data to be send for a time period more than n second than (IGPARS) intelligent gateway power aware routing will consume less power than minimum total power routing (MTPR).

On the basis above work, distinguish between Proposed Intelligent gateway Routing Scheme and Minimum Total Power Routing Protocol given below in table.

Table 10: Comparisons between MTPR and Proposed IGPARS

	MTPR	*Proposed Intelligent Gateway Power Aware Routing Scheme*
1	Maximum number of nodes in active mode.	Less number of nodes are in active mode.
2	Overall nodes participate from source node to destination node are maximun.	Overall nodes participate from source node to destination node are minimum.
	Congestion is more.	Less Congestion.
3	Minimum N0. of nodes are in Ideal Mode	Maximum No. of nodes are in Ideal Mode
4	Total Power consumption in MTPR is less.	Total Power consumption in the power aware intelligent gateway routing scheme routing is less than MTPR protocol in the n second of the time intervel.
5		

5. Conclusion

We compared to existing routing protocols, the proposed intelligent gateway power aware routing scheme consumed less power for transmission of data from source node to destination node. In the case of power aware intelligent gateway routing scheme maximum numbers of nodes are in idle mode in comparison to the existing power aware routing protocols. The packet is routed from a path which has the maximum probability to find the destination hence power is also saved up to 33% thus we may conclude that this new routing protocol for MANET is actually a table driven routing protocol that attempts to reduce power consumption. Also avoids the formation of loops. In the case of proposed (IGPARS) intelligent power aware routing gateway scheme less congestion as comparison to the existing power aware routing protocols. In the case of proposed power aware intelligent gateway routing scheme the minimum number of nodes is participates for data transmission from source node to destination node but on the other hand in the case of existing power aware routing protocols the maximum number of nodes are participates for data transmission from source node to destination node.

References

[1] Murthy and J.J. Garcia-Luna-Aceves,"An Efficient Power Aware Routing Protocol for Wireless Networks". Pp.213-245, October 1994.

[2] Elizabeth M. Royer, C-K Toh, "A Review of routing protocols for Ad-hoc Mobile Wireless Networks" Proceedings of IEEE SICON'97, pp. 197-211, April 1997

[3] C.-C. Chiang, H.K.Wu, W. Liu, and M. Gerla, "Routing in Clustered Multi hop, Mobile Wireless Networks with Fading Channel," Proceedings of IEEE SICON'97, pp. 197-211, April 1997.

[4] C. E. Perkins and E. M. Royer, "Ad-hoc On-Demand Distance Vector Routing," Proceedings of 2nd IEEE Workshop on Mobile Computing Systems and Applications, February 1999

[5] D. B. Johnson and D. A. Maltz, " Minimum Battery Cost Routing in Ad-Hoc Wireless Network, "Mobile Computing, ed. T. Imielinski and H. Korth, Kluwer Academic Publishers, pp. 153-181, 1996.

[6] C-K. Toh, "Minimum Total Power Routing in Ad-Hoc Mobile Computing, "Proceedings of the 1996 IEEE Fifteenth Annual International Phoenix Conference on Computers and Communication, pp. 480-486, March 1996.

[7] Jaydeep Punde, NikiPissinou, Kia Makki, "Power Aware Localized Routing in Ad-Hoc Networks", Proceedings of the 28th Annual IEEE International Conference on Local Computer Networks (LCN'03)

[8] K. Wu and J. Harms, "Power Aware Source Routing in MANET," 2001.

[9] S. Chen and K. Nahrstedt, "Power Aware routing in ad hoc networks", IEEE Journal on Selected Areas in Communication, vol. 17, no. 8, 1999.

[10] D. D. Perkins and H. D. Hughes, "On Line Power Routing Protocol in mobile ad hoc networks," Wireless Communications and Mobile Computing, 2002.

[11] Hannan XIAO, Winston K.G. SEAH, Anthony LO and Kee Chiang CHUA "Flexible Quality Service Model for Ad-HOC Networks". In proceedings of the IEEE Vehicular Technology Conference, Tokyo, Japan, May 2000.

[12] R. Sivakumar, P.Sinha, and V. Bharghavan, CEDAR: A Core Extraction Distributed Ad Hoc Routing Algorithm, In IEEE JSAC, Special Issue on Ad hoc Networks and Applications, Vol 3 N 8, august 1999.

[13] VD Park and MS Corson "A highly adaptive distributed routing algorithm for mobile wireless networks", Proc. INFOCOM'97, Apr. 1997, 9 pages.

[14] Ad Hoc Networks, www.adhocnetworks.cfm.htm

[15] Dharam Vir, S. K. Agarwal, S. A. Imam , Lalit Mohan "Performance analysis of MTPR routing protocol in power deficient node" International Journal on Ad Hoc Networking Systems (IJANS) Vol. 2, No. 4, October 2012.

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