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Reliable Multicast and Energy Conservation in MANET: A Survey

Mr. R. Karthik M.E., Ramitha. M. A.,
Assistant Professor, P.G. Student,
Department of Computer Science and Engineering, SVS college of Engineering, Coimbatore, Tamilnadu, India

Abstract: *Mobile ad hoc networks are networks without any infrastructure and topology. They are self organized and battery powered networks with a large number of mobile nodes. Limited battery power is the most important issue considered during the design of a mobile ad hoc network. Frequent recharging or replacement of battery is not so easy and is impossible in some applications such as rescue operations. These networks are used in areas, where the infrastructure of communication is damaged due to some problem, to establish a communication media until infrastructure is restructured. To improve the life time of the network the conservation of energy in each node is very important. Each node act as a router and as a receiver simultaneously. This paper surveys some algorithms to improve the lifetime of the network and some algorithms to improve the reliability of the network. This paper surveys some energy conservation algorithms and some lightweight protocols to improve the reliability of the network.*
Keywords: *MANET, Multicast, Residual energy, Relay capacity, Energy conservation, Lifetime of the network, Lightweight services.*

I. Introduction

Computer networks are used to communicate data between two nodes. Computer networks can be classified into two, wired networks and wireless networks. The wired network uses cables to transmit the data while the in wireless networks no cables or wires are used and radio signals are used to transmit the data. The wireless networks can be further divided into infrastructure based networks and infrastructure less networks. The infrastructure less networks are further classified into Mobile ad hoc networks, Wireless sensor networks and wireless mesh networks.

Mobile ad hoc networks are wireless networks that utilize multi-hop radio relaying and are capable of operating without the support of any fixed infrastructure. It is often called as infrastructure less networking because nodes dynamically establish routing paths between themselves. There is no central coordinator or base station and nodes can move from one location to another that is Mobile ad hoc network consists of mobile devices. In such a network the mobile node is also act as a router.

1.1 Applications of mobile ad hoc networks

The applicationsof MANET, because of their high speed deployment capability, in several areas such as

1. Military applications
2. Collaborative and distributed computing applications
3. Emergency operations
4. Wireless mesh networks
5. Wireless sensor networks
6. Hybrid wireless architectures

1.2 Design issues of mobile ad hoc networks

The major issues that affect the design, deployment and performance of mobile ad hoc networks are

1. Medium access schemes
2. Routing
3. QoS
4. Transport layer protocols
5. Pricing schemes
6. Self organization
7. Security
8. Energy management
9. Scalability etc.

As mobile nodes are powered by batteries and it cannot be recharged or replaced frequently. Energy efficiency is an important issue in MANET. The nodes in Mobile ad hoc networks are constrained by the limited battery power for their operations. Battery power is considered as precious resource in order to avoid the early death of a node which leads to partitioning of the network.

1.3 Need for Energy Management in Mobile ad hoc networks

1. Difficulties for replacing the batteries
2. Absence of central coordination
3.Limited battery resource
4. Energy Reserve
5. Selection of Optimal Transmission Power and utilization.
6. Cannel Utilization

1.5 Characteristics of Wireless and Mobile Ad-Hoc Networks

1. Dynamic connection establishment
2. It uses radio or other wireless communication
3. Nodes relay data packets for other nodes and hence it has multi hop communication.
4. There is no restriction for network participants
5. The nodes and networks are Mobile and resource-constraint.

1.6 Objective

Mobile ad hoc networks consist of movable nodes and nodes are powered by battery. The frequent replacement of battery is not so easy and sometimes it is impossible to replace or recharge the battery. So the utilization of the battery power should be minimized to improve the performance of the network.

The main objective of this paper is to survey some protocols that minimize the utilization of battery power to conserve energy. This paper also try to survey the protocols used to improve the reliability of the network by makes use of the lightweight protocols and services.

Table 1: Power aware and reliable routing protocols.

Performance Metrics	Result
To improve lifetime	1. High Stable power awre multicast algorithm for MANET
	2.Intercontact Routing for Energy constrained Desaster Response Network
	3. A Novel Approach for Energy Management in Wireless Ad hoc Network Topology Control
	4.An Energy Optimization Algorithm for MANET
	5.Energy efficient Multicast Routing in Ad hoc Wireless Networks
	6. Algorithm for Energy Efficient Routing in Static Wireless Ad hoc Networks
	7.Energy-aware-self adjusted Topology Control Algorithm for Heterogeneous Wireless Ad hoc Networks
To improve Reliability	1. Reliable Adaptive Light weight Multicast Routing Protocol
	2. Congestion Controlled Adaptive Lightweight Multicast in Wireless MANET
	3. LMS - A Router Assisted Scheme for Reliable Multicast

II. Literature Review

Energy conservation is the most important issue in MANET due to their dynamic nature. Energy conservation techniques along with some lightweight services we can improve the reliability and the lifetime of the network. The two metrics we consider for survey are reliability and lifetime of the network.

2.1. High Stable Power Aware multicast Algorithm for Mobile Ad hoc Networks.

This paper presents a new algorithm to increase the lifetime of the node and network. For multicasting packets it considers the residual battery of the node and the relay capacity of the node.

A source chooses a node with high residual capacity and relay capacity if it wants to send packet to a destination.

$$BC_i(t) = a_i - b_i - c_i - d_i$$

Where $BC_i(t)$ is the residual battery capacity of the node i, a_i is the initial Battery of i, b_i is the number of packet transmitted by i, c_i is the number of packet received by i, d_i is the number of packet transmitted by i as an intermediate node at time t.

If more than one intermediate node has same residual capacity then it selects a node with high relay capacity as

$$RCi(t) = \sum_{t=0}^{Ti(t)} Nc(t) + \sum_{t=0}^{li(t)} Nc(t)$$

Metrics	Result
Node lifetime	Increases
Network lifetime	Increases
Throughput	Increases with no mobility and less number of nodes and decreases with mobility and large number of nodes
Energy Consumption	High energy consumption
Delay	Increases

Table 2: Evaluation of High stable power aware multicast algorithm for MANET

2.2. Intercontact Routing for Energy Constrained Disaster Response Network.

To ensure communication in post disaster scenarios this paper makes use of natural recurrent mobility and contact pattern in the network. It estimates routes delays and delivery probability to identify routers and to control message replication.

Recurrent contacts and routing tables can be used to deliver a message to a destination and this reduces redundant copies. The regularities in disaster scenes and static points are used for message transmission and intercontact routing estimates more accurate delay and delivery ratio and identifies reliable paths.

It also allows differentiated services by assigning priority to messages. Post Disaster Mobility Model is used to represents the post disaster scenarios.

Table 3: Performance of ICR

Performance Metrics	Performance of ICR
1. Message overhead	Lowest and doesn't changes much
2. Delivery ratio	Drops when delay become high
3. Average message delivery delay	Increases
1. order of performance	R-R>S-R>S-S
2. Delivery ratio	Survivers have least delivery ratio

Table 4: Result in energy constrained environment.

Performance Matrics	Result of ICR
Energy consumption	Low
Lifetime	High
Message delivery performance	High
Service provided	Energy differentiated services
Total number of messages generated	Dependson the initial energy

2.3. A Novel Approach for Energy Management in Wireless Ad hoc Network Topology Control.

Topology control is used to minimizethe maximum power and minimizes the total power in this paper. This paper considers such problems via minimizing the maximum power and minimizing the total power. This paper gives an overview of topology control problem in wireless ad hoc networks.

The power of each node is different from each other. To maintain the network connectivity a suitable routing scheme should be designed.Consider the following transmission power model:

$$tp_{i,j} = d_{i,j}^{\propto}$$

Where $tp_{i,j}$ transmitting power required for node *i* to reach mode *j*, $d_{i,j}$ is the distance between *i* and *j* and α is a parameter having values between 2 and 4.

The network connectivity between two nodes depends on their transmission range and power.The information that other nodes can here or reach is exchanged to obtain the local information. The main problem associated with this technique is that sometimes the information required is not the local information and the exchange of information is an overhead and sometimes feedback is required for communication.

2.4. An Energy Optimization Algorithm for MANET.

Optimized energy OLSR optimizes the energy consumption and increase the network lifetime. This protocol selects a node with high residual energy as MPR and avoids node with minimum residual energy for the transmission of a packet.

Each node declares its ability to become MPR on its residual energy. This paper uses two thresholds to differentiate between MRP and normal nodes.

If residual energy> 80% then node then node have high MPR will. If the residual energy is < 10% then the node is declared as dead. By avoiding the minimum energy node, the life time of the network can be improved.

QoS Parameters	**Result**
Number of dead nodes	Less
Network performance	Enhances
High node dencity	Less number of dead nodes
High speed	Increasethe number of dead nodes

Table 5: Performance of an energy optimization algorithm for MANET

2.5. Energy Efficient Multicast Routing in Ad hoc Wireless Networks.

This protocol provides a multicast tree that minimizes the total cost of multicast tree for a given multicast request. It provides Minimum Energy Multicast is NP-Hard and increase the energy efficiency by Node-Joint-Tree and Tree-Joint-Tree algorithm. Builds

For a directed graph G= (V, A) and a given multicast request (s, D) where s is the source and D is the destination with transmission power p(v), the total energy cost of the T is given by

$$C(T) = \sum_{v \epsilon NL(T)} p(v)$$

The Node- Joint-Tree (NJT) builds a multicast tree in a top down manner. It uses 3 sets where C (Cover set) contains the non leaf nodes, candidate set (N) is the union of all neighbors in C and Uncovered set (U) contains the nodes that are not in C and N.

Initially 'C' contains 's' and ' U' contains 'D' and all neighbors of 'C ' is removed from ' U ,and placed to' N' . A node in 'N' is selected as candidate and added to 'C' until 'U' becomes empty. The selection of anode is based on the cost function

Tree-Joint-Tree builds multicast tree in a bottom up fashion. Initially each node D is a sub tree and least energy sub trees are merged to form bigger tree until all sub tree merged to form a single sub tree where s is the root. To remove a sub tree, the quotient function is used.

2.6. Algorithm for Energy Efficient Routing in Static Wireless Ad hoc Networks.

This paper introduces a new algorithm for defining tree when transceiver resources are limited. The transmitter power is directly proportional to the energy usage. Each node can choose its power level that not exceed P_{max} and the connectivity of the network is depends on the transmission power. The power required to support link between two nodes (P_{ij}) separated by a range 'r'

$P_{ij} = r^{\alpha}$ (i,j is the distance between i and j and αtakes value between 2 and 4).

Wireless Multicast Advantage for P_{ij} is the Max (P_{ij},P_{jk}) that is enough to reach node i and j .To construct sub optimal multicast tree in wireless network, this paper utilize Wireless Multicast Advantage. This protocol also utilize admit all admission control policy.

This paper tries to analyses some performance matrices to improve the energy efficiency such as average multicast value per unit energy, multicast efficiency, the yardstick metrics, blocking probabilities, link based and load based costs etc.

This paper also tries to introduce some algorithm which considers the above performance matrices such as

I. A unicast-based multicast algorithm
1. Least unicast cost (algorithm 1):A minimum-cost path to each reachable destination is established.

II. Algorithms based on pruning MSTs
2. Pruned link-based MST (algorithm 2): To obtain the multicast tree, the MST is pruned by eliminating all transmissions that are not needed to reach the members of the multicast group.
3. Pruned node-based MST(algorithm 3) : This algorithm requires the determination of the minimum-energy spanning tree that is rooted at the Source node. The wireless multicast advantage is taken into consideration in the determination of the power needed to sustain the tree.
4. Pruned node-based spanning tree (algorithm 4) : Its transmission power is chosen to maximize the following "*n/p*" metric:

   n /p= Number of "new" destinations reached/ Total power required to reach them.

III. Additional algorithms with high complexity
5. Least multicast cost (algorithm 5) : paths to all reachable destinations are established, regardless ofthe cost required to do so.
6. Maximum local yardstick (algorithm 6) : The local yardstick function *yi*is computed for each arriving multicast request *i*.

Metrics	Worst performance	Best performance
Global yardstick as a function of ʎ	Algorithm 2	Algorithm 6
Multicast efficiency as a function of ʎ	Algorithm 6	All other algorithms
Blocking probability as function of ʎ	Algorithm 2	Algorithm 6

Table 6: Evaluation of various algorithms

2.7. Energy-aware-self adjusted Topology Control Algorithm for Heterogeneous Wireless ad hoc Networks.

ESATC extends the network lifetime by considering the power consumption and residual energy of a node and builds a topology those changes according to the variation in the node energy. This paper does not consider about the location information and information collected locally.

According to the locally collected information nodes build their local view of topology. For an arbitrary node u with transmission power of u , maximum andinitial transmission power are p(u) and P_{max} (u) and EI(u) respectively. Then 0<= P (u) <= P_{max} (u)

If max (u)>P (u,v)>P_{max} (v) then there exist a link between u to v.No node is about its location and its neighbors. From signal power received from other node is used to find out the location of the node.

The cost of path (u,v,Ĝ)

$$C(path(u,v,\bar{G})) = \sum_{i=0}^{n-1} Cost(v_i, v_{i+1})$$

If c (path*(u.v,Ĝ))<= c(path(u.v,Ĝ)) then c(*path**(u.v,Ĝ)) is the path with minimum cost. According to the residual energy each node adjusts its transmission power.

The four phases of ESATC algorithm are
1. Link cost: The energy consumption for sending receiving and current residual energy should be considered.
2. Information collection: Several rounds of Neighbor Detection (ND) and Detection Reply (DR) message, node u obtain information about the reachable neighbors and construct a local topology sub graph.

3. Topology Construction: With the local topology sub graph node build the local topology shortest path tree and node s selects its entire one hop neighbor as its logicalneighbor.
4. Transmission power adjustment: By reducing the power consumption node u adjust the transmission power.

Evaluation Metrics	Result
Network lifetime	Extended remarkably
Topology	Based on Minimum cost property dynamically
Transmission power	Nodes self adjust transmission power accrding to the Residual enrgy of each node

Table 7: Evaluation of ESATC

2.7. Reliable Adaptive Light Weight Multicast Routing Protocol.

A receiver list is maintained by each multicast source and up on the reception of an NACK that node is added to the receiver list of the receiver and enters into loss recovery phase. These nodes are removed from the receiver list as the receiver receives a NACK.

The source selects a receiver (feedback receiver) from the receiver list to transmit the lost packet. On reception of these packets the receiver sends a unicast ACK to the sender and removes it from the receiver list. This process repeats until the receiver list becomes empty.

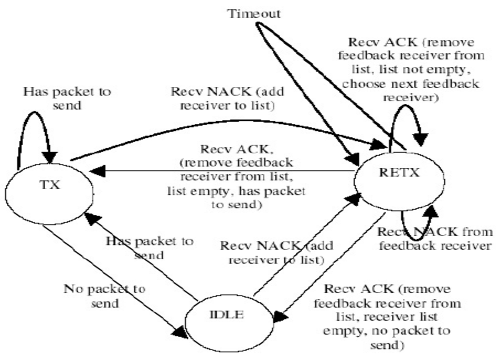

Figure1: State diagram of RALM

Scenarios	Performance metrics	Result
Traffic rate	Packet delivery ratio	100% for all traffic rates
	Control overhead	Less
	end to end delivery	improves on hogh traffic rates
Mobility	Packet delivery ratio	100% for all mobility speed
	Control overhead	Same as UDP
	end to end delivery	Same as UDP
Senitivity to random errors	Packet delivery ratio	Little effect
	Control overhead	Little effect
	end to end delivery	Up to 4% is negligible and in 40% delay remains in a reasonable range

Table 8: Performance evaluation of RALM

2.9. Congestion Controlled Adaptive Light Weight Multicast in Wireless MANET.

A receiverlist is provided by every source node and on the reception of an NACK that node is added to the receiver list of the source and enters in to congestion control phase.

Source selects a node from the receiver from the receiver list. If an ACK receives before time out then it indicates no congestion.

If the receiver doesn't receive N consecutive packets, then the receiver unicasts NACK to source. If high reliability is the goal then N plays an important role. It reduces the multicast delivery ratio.

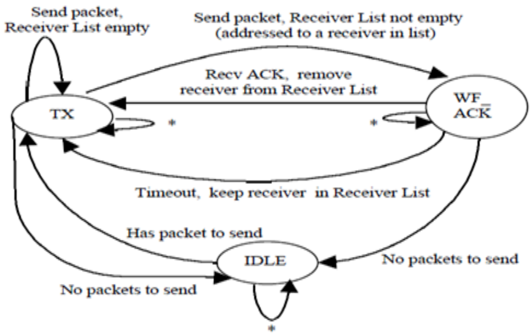

Figure 2: State diagram of CALM

Scenario	parameters	Result
Traffic rate	Delivery ratio	Upto 300ms near perfect reliability and above 300mn degrades
	Throug put	Above UDP
Number of receivers	Delivery ratio	Has no effect on CALM as UDP
	Throug put	
Mobility	Delivery ratio	Little effect
	Throug put	

Table 9: Performance evaluation of CALM

2.10. Light weight Multicast Services- A Router Assisted Scheme for Reliable Multicast.

LMS is an IP enhancement technique that contains a small set of forwarding services. The error recovery function is divided in to a two component process-transport and forwarding components. The transport component is moved from router to a surrogate (replier). The replier is selected according to some replier selection criterion.

The requester that sends the NACK is served by a replier and the result is unicasted to the turning point and the turning point router broadcast this to its down link nodes and hence to the requester.

The processes included in the process of LMS is selecting replier, replier selection criterion, steering messages to repliers, request handling at routers and direct multicast.

Evaluation Metrics	LMS Result
Latency	30-60%
Exposure	0.50%
Related Retransmission	none

Table 10: Performance evaluation of LMS

III. Conclusion and future Work

MANET is a topology less, infrastructure less, dynamic network with self adjusting capabilities.Thereare so many advantages and disadvantages for these features of MANET. But the most important issue that should be taken in to consider are Energy conservation and reliable multicast. This paper surveys some algorithms that are used to conserve energy by conserving the energy while others are about to improve the reliability of the network.

By combining both of these aspects we can improve the performance of the network by improving the lifetime of the network improving the reliability of the network.

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