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A Study on Energy Efficient Routing Protocols in MANETs with Effect on Selfish Behaviour

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ABSTRACT: Mobile Ad-Hoc Networks (MANETs) are characterized with dynamic topology. This dynamism leads to mobility of nodes, interference, multipath propagation and path loss. A more challenging goal in MANET is to provide energy efficient routes as it is one of the major limiting factors in mobile nodes. MANETs are typically powered by batteries which have limited energy reservoir and it may not be easily replaced or recharged on the way. Hence, power consumption becomes an important issue and this lack of power with nodes leads to selfish behavior among nodes in case of commercial MANET. This work provides an indepth analysis of literature for routing protocols in MANETs and their effect on selfish behaviour of nodes

Keywords: MANETs, Routing Protocols, Mobile Agents, Selfish Behaviour, Energy Efficient Routing.

I. INTRODUCTION

Mobile Ad- Hoc Networks (MANETs) have evolved rapidly in the field of wireless networks. These are infrastructure less networks where routers and hosts providing access points are not fixed. In case if a mobile user away from an access point needs to send or receive data packets, this is facilitated by radio transmission and receiving ability of mobile phone with help of other nearby existing nodes creating dynamic networks. In literature MANETs are defined as "an autonomous system of mobile routers (and associated hosts) connected by wireless links – the union of which form an arbitrary graph" [1].

They generally have routable networking environment on top of a Link Layer ad hoc network. Since the participating nodes here are not fixed it leads to dynamic change in MANET topology as per the availability of nodes. Also for transmission of packets intermediate nodes plays very important role because transmission of whole information is with cooperation among the nodes which are engaged in transmitting and forwarding the packets. But in some situations cooperative behaviour of nodes may be lost or a mobile node may be failed to cooperate other nodes in network. Such situations are: moving out of the transmission range of its neighbours, exhausting battery power, malfunctioning in software or hardware, or even leaving the network. Exhausting battery power affects efficiency of nodes the most. The nodes in MANETs depend on some means of energy or power. The energy resources are limited and can't be preserved for longer time as a result, nodes in MANET may stop transmitting and/or receiving for arbitrary time period. This is called selfish behaviour of nodes [20]. Cooperative nodes are active in data forwarding in route. But selfish nodes may deny forwarding a packet for saving their own energy. Selfish behaviour of network nodes causes inefficient data transmission. This paper is organized as follows: Section 1 provides applications of MANETs , open research issues, review of routing protocols and their analysis. Section 2 presents concept of energy consumption in MANETs and energy consumption approaches. In section 3 concludes this work with directions for future research.

A. HISTORICAL VS COMMERCIAL APPLICABILITY OF MANETS

MANET provides an extremely flexible way of communications in dynamic/urgent situations. Commercial applications of MANET involve cooperative exchange of data packets among mobile nodes.

Historically, mobile ad hoc networks have primarily been used for tactical network related applications to improve battlefield communications/ survivability. The dynamic nature of military operations required such a service since

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military personal cannot rely on access to a fixed pre-placed communication infrastructure in battlefield. Pure wireless communication also suffered from limitation that radio signals are subject to interference and radio frequency higher than 100 MHz rarely propagate beyond line of sight (LOS)[2]. The earliest wireless ad-hoc networks were the packet radio networks (PRNET) in 1970's, developed by DARPA under ALOHA net project. Presently MANET is finding wide applicability in mobile communications. Some applications are listed in the Table below [3]:

TABLE 1
APPLICATION OF MANETS [3]

Application:	**Possible Scenarios / services**
Tactical networks	• Military communication and operations • Automated battlefields
Emergency services	• Search and rescue operations • Disaster recovery • Replacement of fixed infrastructure in case of environmental disasters • Policing and fire fighting • Supporting doctors and nurses in hospitals
Commercial and civilian	• E-commerce: electronic payments anytime and anywhere environments • Business: dynamic database access, mobile offices • Vehicular services: road or accident guidance, transmission of road and weather conditions, taxi cab network, inter-vehicle networks • Sports stadiums, trade fairs, shopping malls • Networks of visitors at airports
Education	• Universities and campus settings • Virtual classrooms • Ad hoc communications during meetings or lectures
Entertainment	• Multi-user games • Wireless P2P networking • Outdoor Internet access • Robotic pets • Theme parks
Home and enterprise	• Home/office wireless networking networking • Conferences, meeting rooms • Personal area networks (PAN), Personal networks (PN) • Networks at construction sites
Sensor networks	• Home applications: smart sensors and actuators embedded in consumer electronics • Body area networks (BAN) • Data tracking of environmental conditions, animal movements, chemical/biological detection
Context aware services	• Follow-on services: call-forwarding, mobile workspace • Information services: location specific services, time dependent services • Infotainment: touristic information
Coverage extension	• Extending cellular network access • Linking up with the Internet, intranets, etc.

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B. RESEARCH ISSUES IN MANETS

As is clear from above discussion that MANET are useful in many areas of importance .Despite this wide applicability there are some issues still prevailing in this field. This section explores such open research challenges [1].

- The time varying statistical behavior affected by various factors like the physics of propagation medium, inner city fading characteristics and shadowing have impact on wireless links.
- Since participating nodes are not fixed, they are moving thus quality of wireless link is unpredictable.
- Due to node mobility and constantly changing neighbourhood connectivity, MANETS have more severe convergence problem than wired network.
- Ad hoc networks are more vulnerable to security problems due to nasty neighbour relaying packets.
- Mobile nodes participating in MANET may become selfish at any time.
  An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it.

C. ROUTING IN MANETS

MANETs routing protocols could be broadly classified into two major categories based on the routing information update mechanism [4]:

- *Proactive Routing Protocols:* Proactive protocols also known as table driven routing protocols maintain routing information of every other node in the network before it is needed. Nodes can get knowledge of topology of the network by exchanging topological information among the network nodes. Thus, this information is immediately available whenever a route is to be created from a source to destination. Cost of maintenance is very high if topology changes very frequently. For example Destination Sequenced Distance Vector Routing Protocol (DSDV), Wireless Routing Protocol (WRP) etc.
- *Reactive Routing Protocols:* The reactive routing protocols do not maintain routing table in advance. The routing information is collected only when it is required. Reactive protocols make their routes toward destination as the demand for that particular route appears. They do not periodically maintain information about topological change. The information about routing is exchanged through flooding. Ex: Dynamic Source Routing Protocol (DSR), Ad-hoc ON Demand Distance Vector Routing (AODV).
- *Hybrid Routing Protocols*: These protocols are developed for better trade off between Proactive & Reactive protocols. [5] An example of such a protocol is the Zone Routing Protocol (ZRP). ZRP divides the topology in to zones and then allows transmission between and within the zones based on strength and weakness of protocol.

D. ANALYSIS OF EXISTING ROUTING PROTOCOLS

An extensive literature survey highlighted that many routing protocols had been proposed for MANETs. To facilitate careful analysis, an effort is being made to classify these routing protocols on basis of their nature & parameter.

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1) ROUTING TABLE MAINTENANCE:

- Reactive Routing Protocols: Such protocols maintain route information only for active paths and reduces path maintenance overhead e.g. Ad hoc On-demand Distance Vector Routing (AODV), Dynamic Source Routing (DSR), Location Aided Routing (LAR), Temporally Ordered Routing Algorithm (TORA) [7].

- Proactive Routing Protocols: Network status is periodically maintained by such type of protocols by flooding network status information within the network. Every node keeps on maintaining their routing table e.g. Global State Routing (GSR), Hierarchical State Routing (HSR), Destination Sequenced Distance Vector Routing (DSDV) [7].

- Hybrid Routing Protocols: Such protocols have features from both proactive and reactive protocols. Thus adapting advantages of both types of protocols. Zone Based Routing Protocol (ZRP) [7]. This is an example of this type.

- Table driven: Such protocols provide update information about the network. Tables are created and updated as new routes are discovered e.g. Destination Sequenced Distance Vector Routing (DSDV) and Wireless Routing Protocol (WRP)[8]

2) POSITION OR LOCATION

Source Initiated: Such protocols are type of on demand protocols. They start discovering the route only when a node request for that. When a node demand for route discovery process it is initiated by transmitting a packet having destination address and that packet travels one hop to another till destination is discovered. Ad-Hoc On Demand Distance Vector Routing AODV, Dynamic Source Routing (DSR), Temporally Ordered Routing Algorithm (TORA)[8].

- Position Based: Such protocols always tend to discover position data of corresponding destinations. In this case there is no overhead of maintaining routing table or route discovery. The only overhead is of position discovery e.g. General Packet Radio Service (GPRS) & Location Aided routing (LAR) [8].

- Source Routing: In such type of protocols node forwards packet according to information contained in header. This information is added to header by the source node. Nodes forward packets on the route on basis of this information e.g. strict source and record route (SSRR)[8].

- Location Based multicast routing Protocols: These protocols determine location of each node by using positioning service or Global positioning system. Destination location can be searched by sender by the use of location services i.e. Scalable Position-Based Multicast (SPBM) [12].

- FGRP protocol using GLOMOSLM simulator: In this protocol [18] overheads related to geographic routing are considered. The problems that may occur when nodes connect are: absence of end to end connections, in additional to data bits to user transmitted data and most important is location information collection.

3) BROADCAST TECHNIQUE

- Full broadcast: In this, message needs to be retransmitted by intermediate nodes and is intended for every node in network e.g. Core Extraction Distributed Ad Hoc Routing (CEDAR), Destination Sequenced Distance Vector Routing Protocol (DSDV), Dynamic Source Routing (DSR), Flow Oriented Routing Protocol (FORP) and Witness Aided Routing Protocol (WAR) [8].

- Limited Broadcast: There are limited broadcasts, in which the maximum hop count (time to live) is limited as

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Vol. 1, Issue 7, September 2013

desired Distributed Dynamic Routing (DDR) Global State Routing (GSR) , Optimized Link State Routing (OLSR), Source Tree Adaptive Routing (STAR), Topology Based Reserved Path Forwarding (TBRPF), Temporally Ordered Routing (TORA) and Wireless Routing Protocol (WRP) [8].

- Local Broadcast: This type of broadcasting is intended for any node within the senders reach, but merge is not retransmitted at all. AODV, Fuzzy Sighted Link State Routing (FSLS), Fisheye State Routing (FSR), High Availability Seamless Redundancy (HSR), landmark Routing Protocol (LANMAR), Location aided Routing (LAR), LMR, Scalable Source Routing (SSR) and Zone Routing Protocol (ZRP) [8].

4) RECOVERY MECHANISM

- Recovery Mechanism: Recovery mechanism [8] is very important for nodes to eliminate those routes that are not available or those having some errors. So there is need of some recovery mechanism or protocols. e.g. Associatively Based Routing (ABR), AODV, Cluster Based Routing Protocol (CBRP), DREAM3 ,
- Signal Strength: Route packets along the connection with the best signal strength. This is mainly used by ABR and SSR.
- Link Stability: Route packets along the connections that appear most stable over a period of time. It is used by Delay Sensitive Transport (DST) and FORP.
- Shortest Path/Link State: Select a shortest path according to some metric. This is used by many protocols: CEDAR, DDR, FSR, GSR, HSR, OLSR, STAR and Topology Broadcast Based on Reverse -Path Forwarding (TBRPF) , FORP, WAR and ZRP
- Reliable Route Recovery- AODV: RRR-AODV [16] is designed to improve the performance of AODV Protocol. This protocol improve network efficiency of network by reducing control messages with help of back up nodes. An implicit route recovery process is performed in this.

5) ROUTING STRUCTURE

A multicast group consists of senders and receivers. There exist a tree or mesh between these senders and receivers that act as connections between them. These Connections establish two types of routing structures: Tree Based and Mesh based.

- Tree Based: These tree structures have high cost, due to which senders are not able to maintain their own tree structures. Following are the categories of tree based protocols.

  a) Shared Tree Based: A multicast group [9] consists of senders and receiver's .Some protocols select a single sender to build a multicast tree that is shared with other sender. Such type of tree structure is called Shared Tree Based Structure e.g.: Multicast Operation of the Ad-hoc On-Demand Distance Vector Routing Protocol (MAODV).

  b) On Demand Shared Tree Based: These protocols dynamically assign every node in a multicast session an ID - number. These Sid numbers help to locate neighbouring nodes that are closer to a particular node's Sid. e.g.
  Ad Hoc Multicast Routing Protocol (AMRIS) Utilizing Increasing Id-numbers [9].

  c) Sender-Tree Based Protocol: Such protocols [9] are highly efficient multicast routing protocols. In this all members set their own branches where new forwarding nodes are added to tree. These are efficient because of a route optimization process that can detect and remove unnecessary nodes from the route. Bandwidth -Efficient Multicast Routing Protocol (BEMRP).

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Vol. 1, Issue 7, September 2013

d) On Demand Sender Tree Based Protocol: It adapts its behaviour based on application data sending pattern. In this application layer alone performs tasks of control packets, periodic neighbour sensing, or periodic routing table exchanges and can detect detection of link breaks and expiration of routing state e.g. Adaptive Demand -Driven Multicast Routing(ADMR) [9].

- Mesh Based Protocols

Forwarding Group Concept: On-Demand Multicast Routing Protocol (ODMRP) uses this concept to build a mesh and mobility prediction is used to refresh the mesh. ODMRP gives high data delivery ratio at high mobility and group members are strongly connected [9].

6) ARCHITECTURE BASED ROUTING PROTOCOLS

Such protocols [12] can create physical hierarchical architecture by different types of mobile nodes e.g. Hierarchical QoS Multicast Routing Protocol (HQMRP), Self Organizing Map (SQM) is typical Hierarchical architecture.

- Hierarchical Architecture: This architecture defines hierarchy of responsibly allocated for various tasks. Here Gateway node plays very important role among the clusters. It has to communicate with gateway of other clusters as well as to store the network topology information. Rest of the responsibilities like control message communication is on other nodes e.g. Zone-based Hierarchical Link State (ZHLS) [7].

7) ARTIFICIAL INTELLIGENCE

- Multicast Protocol for Ad Hoc Networks with Swarm Intelligence: MANSI [9] is a core based multicast protocol in which mesh is maintained and build by only one core node. In this protocol energy conservation and load balancing is controlled by the concept of swarm intelligence. This concept refers to complex behaviour that t arises from individual behaviors and interactions.

- Bee-Inspired Ad-Hoc Routing protocols for MANETs: Battery level of Bee Ad Hoc [36] is better as compare to other protocols because it tries to best utilize all routes instead of always sending packets on best path and keep on searching that only. All paths are efficiently utilized and thus energy level is also managed properly.

8) SIZE

Adaptive Cell Relay Routing protocol: Some routing protocols may work efficiently for small networks but they may not perform efficiently with change of network density. Adaptive Cell Relay Routing protocol (ACR) presented in this paper is efficient for sparse network but may not be suitable for dense networks. They perform better than Location aided protocols. Examples of ACR are: Cell Relay Routing Protocol for Dense Networks and Large Cell Routing Protocol for Sparse Networks [10].

9) QUALITY OF SERVICE

Quality-of-Service (QoS) in computer networks describes a predefined contract in which a service provider guarantees for good quality service to customer. This contract defines information regarding type of service required and its level.

Following are the type of QoS Routing Protocol presented in [11]

- Adaptive Proportional Routing (APR): In this routing protocol pair of node with source and destination have to maintain one or more explicit routing paths in advance. QoS protocols main task is to exchange QoS state information among routes and uses only locally gathered information

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(An ISO 3297: 2007 Certified Organization)

Vol. 1, Issue 7, September 2013

- QoS-aware Multicast Routing Protocol (QMPR): QMPR is designed to improve communication between multipath and single path routing. In this a unicast routing algorithm is used to add a node to already existing path. QoS protocols perform task of checking every intermediate node.
- Chen-Heinzelman protocol: This QoS protocol is better that any other hard QoS protocol as it tries to provide better service for bandwidth. It provides better service because of its two scheme structure that consist of feedback scheme and bandwidth scheme. In feedback scheme, if there is no residual bandwidth updated values are sent to application. In admission scheme, a route is searched that can a route that satisfies bandwidth.
- Multicast Core Extraction Distributed ad-hoc Routing: These protocols are designed to minimize data traffic. QoS metrics used are bandwidth, delay, packet loss rate and cost for multicast routing protocol.e.g. Multicast Core Extraction Distributed ad-hoc Routing (MCEDAR) [12].

10) SECURITY

Privacy Friendly Routing in Suspicious MANET: [15] presented PRISM – On demand location based anonymous MANET routing protocol for increasing privacy and security. Security and privacy are important in operations while establishing connections in hostile and suspicious settings. Location centric paradigm is best suited for privacy.

11) BASED ON POWER AWARENESS:

Energy Efficiency: Energy efficient protocols are introduced to enhance energy level of nodes. Some nodes may have limited battery power. With decrease in power they become incapable to forwa rd packets. These protocols are made to enhance this energy level among nodes. e.g. Minimum Weight Incremental Arborescence(MWIA) [13] is an example of this category. Detail of protocols focusing on this aspect is provided in the next section.
Above discussed protocols are being proposed over a span of ten years. Table 2 given below summarizes these protocols w.r.t. time so as to highlight the concerns behind these proposals.

TABLE 2
YEAR WISE ANALYSIS OF MANET ROUTING PROTOCOLS

YEAR	CATEGORY	PROTOCOL	Pros	Cons
[7]-2003	Hierarchical	ZHLS	Clear Distribution of task	Network breakdown with Gateway failure
	Proactive	GSR, HSR DSDV	It provides useful input to DTN Routing Algorithm by providing set of currently reachable node	Additional overhead cost due to maintaining up-to-date information and as a result; throughput of the network may be affected
	Reactive Routing Protocol	AODV,DSR, LAR,TORA	The communication overhead is reduced at the expense of delay to search the route.	it produces huge control packets due to route discovery during topology changes which occurs frequently in MANETs and it incurs higher latency
	Hybrid	ZRP	It reduces wastage of bandwidth and control overhead	There is large overlapping of routing Zones

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Vol. 1, Issue 7, September 2013

[8]-2003	Table Driven	DSDV, WRP	It maintain consistent, up-to-date routing information from each node to every other node in the network	There may be possible delays caused by buffering during route discovery latency, queuing at the interface queue
	Source Initiated	AODV,DSR, TORA	Removal of one node is quickly resolved without source intervention by switching to an alternate route	It introduces a single point of failure if the time source became unavailable
	Source Routing	CBRP,DSR	Link failure notifications at time required	Overhead incurred in long route maintenance
[10]-2006	ACR- Adaptive Cell Relay Routing Protocol	Cell Relay Routing Protocol for Dense Networks Large Cell Routing Protocol for Sparse Networks	ACR protocol can adapt the routing strategy for networks with different node density so high efficiency, low delay, and scalability can be achieved	may not be suitable for dense networks
[11]-2007	QoS Routing Protocols	APR	No QoS information is exchanged between the nodes, reducing protocol overhead	APR is not suitable for mobile networks, as paths have to be set up in advance
		QMPR	QMPR avoids flooding toreduce the communication overhead.	Because of its high-level design, it can be used on top of arbitrary unicast routing protocols, so it can be used in MANETs nevertheless
		Chen-Heinzelman	Better service for bandwidth constraints.	It is QoS-aware, but does not give any QoS guarantees, as no bandwidth is reserved for a route
[9]-2008	Multicasting Routing Protocol			
	TREE BASED			
	Shared Tree based	MAODV	With the unicast route information, the multicast tree can be constructed more quickly and efficiently.	The group leader continues flooding Group Hello messages even if no sender for the group exists.
	On Demand Shared Tree based	AMRIS	The concept of increasing id- numbers is useful for constructing and maintaining a multicast tree. 2. It may incur very low Overhead for a node to join or rejoin the session if it chooses a potential parent node which happens to be a tree node.	1. Joining and rejoining of a node may take long time and waste much bandwidth since each node tries potential parent nodes arbitrarily. 2. The usage of periodic beacons consumes bandwidth.
	Sender Tree Based	BEMRP , DDM	1. It achieves higher multicast efficiency. 2. The path optimization process eliminates redundant paths gradually that leads to	1. Joining and rejoining of a node take long time and consume high bandwidth. 2. The failure of a shared link affects receivers.

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(An ISO 3297: 2007 Certified Organization)

Vol. 1, Issue 7, September 2013

			higher efficiency and lower packet transfer delay. 3.It incurs low control overhead at low mobility.	
	On Demand Sender Tree Based	ADMR	1. It utilizes the application data sending pattern to avoid periodic control messages. 2.It can adapt to the change of mobility.	1. The joining and rejoining processes waste bandwidth and take time. 2. The occasional flooding of multicast packets is an overhead.
	Mesh and Tree Structure	MCEDAR	1. The underlying mesh structure is robust to high mobility. 2. When multiple groups coexist, the core graph can work as a backbone and hence reduces the total control overhead for these groups	1. High control overhead is incurred on the partitioning procedure. 2. Since the data forwarding tree is built among core nodes
	Mesh Based Multicast Routing Protocols			
	Forwarding Group Concept	ODMRP	1. It proposes an effective "forwarding group" concept. 2. The offering of shortest paths reduces data delivery latency. 3. The mobility prediction scheme lowers control overhead at mobility.	1. It suffers from excessive flooding when there is a large number of senders. 2. The duplicate transmissions waste bandwidth at low mobility.
	Core based	MANSI	1.The swarm intelligence makes MANSI applicable to different performance metrics. 2. It utilizes a mobility-adaptive mechanism to adapt to the degree of mobility.	1. Implementation complexity is high. 2. Swarm intelligence may be not useful at high mobility.
[12]-2008	Proactive Multicast Routing Protocols	CAMP, LGT and AMRIS	Up-to date information about network routes is always available	High overhead due to table maintenance
	Reactive Multicast Routing Protocols	ACMP and CQMP	Better Scalability	Long delays for route searching
	Architecture-based multicast routing protocol	HQMRP	HQMRP allows an ad-hoc group member to join/leave the multicast group dynamically, and supports multiple QoS constraints.	Unreliable channel and lack of centralized control
	Location based multicast routing prot	SPBM	SPBM uses the geographic position of nodes to provide a highly scalable group membership scheme	Because of aggregation, the overhead for group membership management is bounded by a small constant
	Quality of Service	MCEDAR	Satisfy end-to-end QoS requirement in terms of	Excessive computation overhead, lack of knowledge about global network

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(An ISO 3297: 2007 Certified Organization)

Vol. 1, Issue 7, September 2013

			Bandwidth and delay	state.
	Energy efficiency	MWIA	MWIA is the optimal solution for broadcast routing with the minimum largest edge-weight	
	Reliable multicast rou Protocols	EraMobile,(BEMA ReMHoc	Geared to support prioritization of data transmissions, Has little overall control overhead and provides impressive good-put	Reliable broadcast Problem
	Overlay multicast	OMHF	Enhances packet Delivery	Collision avoided up to some extent , as network become more dense it tends to increase
[13]-2009	Energy Efficient Location Aided Routing Protocol Approach	EELAR	Control packet overhead is reduc	There may be loss of routes due to power shortage that resu loss of data packets
[14]-2010	Energy Constraint Nc Cache Based routing protocol	ECNC_AODV	Reduces energy Consumption and routing overhead	
[15]-2011	Privacy-friendly Routing in Suspicious MANETs protocol	PRISM	Topology leakage is less .Hence increased security and privacy	It would require each node to store a complete network membership table which is expensive to store and maintain.
[16]-2012	RELIABLE ROUTE RECOVERY-AODV	RRR-AODV	Reduces the number of control messages with the help of backup nodes to improve the efficiency of the network.	Extra overhead due to back up nodes information gathering
[17]-2012	Opportunistic Routing Protocols	OMNeT++	Effective for Collision Overhead	Not efficient for all type of MANET environments
[18]-2013	Geographical Routing in MANET using Flexible Combination of Push Pull Algorithm	FCPP	Reduces network Overhead by reducing flooding problem	For sparse system Information dissemination will be low

Next section focuses on energy consumption aspect in MANETs and elaborates its causes and protocols focusing on minimal use of energy while packet transmission.

II. ENERGY CONSUMPTION IN MANET

Whenever packets are transmitted via intermediate node, its energy is consumed every time. Asymmetric power configuration of adjacent nodes is affected. There are many ways to efficiently utilize energy in MANETs. By utilizing techniques for energy preservation selfish behaviour may be detained to some extent.

- Firstly, by adopting optimum path, power consumed to transmit a packet may be minimized. There are algorithms used to find out the optimum path between the source and destination, node.
- Secondly, the routing protocols must be energy efficient to maximize network throughput, network lifetime,

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Vol. 1, Issue 7, September 2013

and to minimize delay.

- Lastly energy is consumed when a packet is transmitted. Nodes tend to become selfish if their energy level starts diminishing which is an important issue in MANET. It incurs routing overhead [6].

A. *ENERGY IS CONSUMED IN THREE DIFFERENT WAYS [19]*

- While sending a packet/ Active State
- While receiving a packet/ Active State
- While in idle mode/ Sleep Sate

The energy consumed while sending a packet is the largest source of energy consumption in all the modes. This is followed by the energy consumption during receiving a packet. The energy is also consumed when the node is idle state i.e not participating in any communication but in that case there is wastage of energy because it is not actually consumed and any other node could have used that energy which is the part of communication channel at that particular instance.
Transmission power control and *load distribution* approaches are used to minimize the energy consumption in the active communication energy, and *sleep/power-down mode* is used to minimize energy consumed during Sleep State. Given below is the description of these approaches.

- Transmission Power approach

  It is very necessary to find optimal path and routing algorithm for efficient routing and it can be achieved by plotting a graph and by considering vertex as mobile node and edge representing a wireless link between the two nodes. These transmission nodes are within each other's transmission range. Number of immediate nodes neighbour to a particular node can be adjusted if node's transmission power is controllable. Transmission power plays a very important role if it is weaker it can cause a problem of network partitioning that may arise due to topological sparse, on the other hand if transmission power is strong transmission range is increased and it can also reduce hop count to the destination [20]. e.g, FAR, OMN, PLR, MER.

- Load Distribution Approach

  Goal of this approach [25], [26], [27] is to detect those nodes over the route that underutilizes the energy and to find the optimum path not on the basis of shortest route but selecting a route where energy consumption by nodes is less. A route with least load among possible routes from source to destination is chosen. In this, packets are only routed through energy rich intermediate nodes. The routes may be longer but the nodes chosen are rich in energy. Such protocols considers the energy efficiency of nodes and overloading of nodes is prevented to make them efficient thus ensures longer network lifetime e.g. MPR, LEAR.

- Sleep / Power-Down Mode Approach

  The sleep/power-down mode approach focuses on inactive time of communication. There are many radio hardware that support low power states. This approach also considers the fact that system must not turn off when it goes to sleep state to save the resources, most importantly energy. This approach is based on Master selection in MANET. Whenever nodes are in sleeping state in MANET, they are actually not listening or forwarding packets at that time. One of the ways to save the energy is by selecting a node as Master node and rest of the nodes are slave nodes. Master node should coordinate and manage the neighbouring slave nodes. Slave nodes can save the battery by periodical sleeps. They can wake up periodically and ask for any data transmission from the Master node. If any data is to be transmitted it is communicated by the Master node to the slave nodes. But node sleeps again if it is not addressed to it. e.g. GAF, PEN.

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International Journal of Innovative Research in Computer and Communication Engineering

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Vol. 1, Issue 7, September 2013

B. *EFFECT OF ENERGY CONSUMPTION ON NODES*

Cooperation is the Core of MANETs. A Mobile Ad-hoc network is only successful if there is cooperation between nodes. High cooperation is expected between the nodes while packet transmission. But as far the commercial MANET is concerned it is difficult to encourage the cooperative behaviour between the nodes. In Commercial MANET Power consumption and power saving is a concern with every individual node. In order to save power for its own usage some nodes stops forwarding packets. Intermediate nodes want to conserve their limited resources like energy and bandwidth. This leads to selfish behaviour of nodes in MANETs. These non -cooperative nodes don't cooperate or participate in forwarding packets for other nodes or finding routing path for them. This is a serious concern & devising ways to detain or minimize selfish behaviour is an open research challenge in this domain.

C. *ENERGY CENTRIC ROUTING PROTOCOLS*

With fast increase in popularity and applicability of MANETs, retaining energy of mobile nodes became an utmost concern for the researchers. Literature highlights that many energy centric protocols have already been proposed which try to minimize energy usage while data transmission.

- Energy Constraint Node Cache-AODV: [14] describes ECNC_AODV routing algorithm which is based on energy status of each node and cached node. This protocol is better with respect to energy consumption due to rou ting packets, routing overhead and delivery ratio.

- Flow Augmentation Routing: FAR [21] protocol aims at minimizing the sum of link cost along the path and chooses the path with minimum cost. It basically assumes that network is static.
- Online Max-Min Routing: OMM power-aware routing protocol [22] for wireless ad-hoc is applicable over geographic area and support application where sequence of message is not known. It is very helpful in prevention of occurrence of overloaded nodes. The performance of individual node and whole network is affected by these overloaded nodes. This protocol optimizes the lifetime of the network as well as the lifetime of individual nodes .
- Power-aware Localized Routing: (PLR) protocol [22] is a localized, fully distributed energy-aware routing algorithm. It works with the assumption that a source node has the location information of its neighbors and the destination. PLR is equivalent to knowing the link costs from the source node to its neighbors, all the way to the destination. Based on this information, the source cannot find the optimal path but selects the next hop through which the overall transmission power to the destination is minimized.

- Minimum Energy Routing: MER protocol [23], [24] adjust the transmission power of individual node so that it's enough to reach the next neighbouring hop node. So aim of this protocol is to adjust the nodes power and not to make paths energy efficient.
- Multi-Path Routing*:* This protocol [28] is suitable when the number of paths in use is more and data usually flow over these distinct paths simultaneously from the source to the destination. During single path load balance technique it is decided that whether a specific path is efficient for sending packets for message sending or not and when that path is found, it is considered as the optimum path. This path remains optimum till a new path is found. The problem with this technique is to decide when a good path turns into not good.
- Geographic Adaptive Fidelity: GAF protocol [29] works on master slave architecture. It aims at saving the battery power of the network by keeping the slave nodes with low energy.
- Prototype embedded Network: PEN protocol [30] practices the sleep period operation in an asynchronous way without involving master nodes.
- Progressive Energy Efficiency Routing Protocol: This protocol [31] performs better during path discovery and in other mobility scenarios. It can achieve its goal in following steps:

a) Route discovery process: It starts with searching all shortest paths, then path having minimum energy level is chosen and to perform this task route request is generated that consist of two piece of information hop

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(An ISO 3297: 2007 Certified Organization)

Vol. 1, Issue 7, September 2013

count and energy consumption. Hop count is updated at every intermediate node level. For route discovery a problem regarding choice of best energy efficient route may arise if there are several routes having same energy efficiency.

b) Route maintenance: In this protocol nodes can passively watch data exchange within its neighbourhood nodes and looks for more efficient path. Control messages are sent by monitoring nodes to update paths in Replace and insert operations. Maintenance overhead is low because these messages are only send when better path is detected.

- SPAN and BECA/AFECA combination: BECA/AFECA is the two power-save approaches: the Basic Energy-Conserving Algorithm (BECA) and an extended version called the Adaptive Fidelity Energy Conserving Algorithm (AFECA). In this approaches after fixed intervals nodes can dynamically switch between different states. These states are sleeping, listening and active state. These states have important relevance because active nodes by transmitting or retransmitting message between nodes ensure active or listening states. Communicating nodes stay awake. This paper [32] presents a comparison of a combination of Span with AFECA running on top of AODV compared with the same combination modified for nomadic networks. It consists of span coordinator selection mechanism requires BECA/AFECA chain to be modified to take super nodes into consideration. By forcing super nodes to become coordinators, regardless of how well they fare in the coordinator selection algorithms, these nodes will do as much of the routing as possible. Coordinators are in Span chosen based on a number of criteria, such as the remaining energy. It could therefore be expected that Span automatically would favour super nodes as coordinators.
- Energy Efficient Routing using OLSR. In this protocol EEOLSR [33] Residual energy level of nodes and inaccuracy of state information is focused and residual energy collected by control messages in OLSR is also considered. Inaccurate information effect the efficiency of OLSR protocol. In this all those parameters are studied that contains inaccuracies in energy level information of neighbouring nodes. Future work regarding proposal of some techniques to reduce inaccuracies with improves residual energy information of nodes is also suggested.
- Cluster Based routing protocol: CBRP [34] is robust and scalable. In this paper energy efficient Cluster based routing protocol is presented and evaluated. Nodes are divided into cluster in CBRP and clusters are connected via cluster heads .In tis paper idea is to place all the member nodes expect gateway node should go to sleep mode when they are in idle mode.. In this method only Cluster Heads (CHs) and gateway nodes are active for any communication in other words the backbone of the network every time is active to any communication.
- Energy Efficient, Secure and Stable Routing Protocol: EESSRP [35] was introduced with combining factors like security, power and stable routing. MANET is still a very critical task due to highly dynamic environment. An effort has been made to perform analysis using random way point mobility model. The results have been derived using self created network scenarios for varying number of mobile nodes.

Following table provides analysis of existing energy centric protocols based on routing overhead, energy consumed/packet transmission and packet delivery ratio as parameters of interest.

TABLE 3
ANALYSIS OF EXISTING POWER AWARE ROUTING PROTOCOLS

Parameters		**Routing Overhead**	**Energy Consumption**	**Packet Delivery Ratio**
Progressive Energy Efficiency Routing	PEER	Less Routing Overhead	PEER can effectively reduce energy consumption of nodes up to some level.	Packet Delivery ratio is good as compare to other existing protocols.
SPAN/AFECA		Less Routing overhead as compare to BECA/AFECA	Idle time energy consumption	The unmodified SPAN/AFECA has delivery ratio of 83% and 66.5% in the low and high density simulations and nomadic version has a delivery ratio of 86% and 66.5% in same

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				simulation
Energy Efficient Location Aided Routing Protocol Approach	EELAR	Less Overhead than DSR & LAR	Energy consumption overhead less than AODV, DSR, LAR.	EELAR has higher delivery ratio than DSR, LAR and AODV
Energy Constraint Node Cache-AODV	ECNC_AODV	Overhead reduction of 10% to 30% is observed by varying speed , number of nodes, sources and grid area as compare to AODV.	Reduction of energy is observed under mobility & traffic pattern, network size, and area shape.	Delivery ratio is not affected with increased energy efficiency.

III. CONLUSION

This work explored various routing protocols existing in MANETs. The energy consumption behaviour of various routing protocols is being analysed. With energy optimization proper delivery of packets with optimum cost is also concerned. Thus, Energy that is to be consumed by the nodes in transmitting a message can be estimated and packets may be distributed both in case of On-Demand and table driven transmission. In table driven transmission the energy can be estimated while prior load distribution and in case of on demand a packet can be send as acknowledgement after examining the energy consumption at a particular node while sending a long information.

In addition, ad hoc routing requires that nodes cooperate in forwarding each other's packets through the network. This means the throughput available to each single node's applications is limited not only by the raw channel capacity, but also by the forwarding load imposed by distant nodes. This effect could seriously limit the usefulness of ad hoc rou ting. One serious question is that why the nodes should cooperate in forwarding traffic to other nodes when there is no benefit.

MANETS are not seen as networks in their own right any more than local area networks are networks in their own right. Instead, MANETS are seen as localities within networks, much as LANs operate as the local access to a wider area Internet. The operation of MANETS in isolation is a special case of their operation as part of a larger network. Therefore the unwillingness of nodes inspired by energy saving theory in commercial MANET could seriously hamper the application of ad hoc network. Reputation schemes that are already existing are able to detect the selfish nodes but there are some drawbacks with these schemes such as when to declare a node selfish. Is it necessary that a node which is non cooperative is Selfish there may be some another reasons for that. Ad Hoc Networks is an area that is being widely researched these days and is a very fast growing area. Much work is still left in this field for make it commercially viable.

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