A LITERATURE SURVEY ON POWER AWARE ROUTING PROTOCOLS IN MOBILE AD-HOC NETWORK

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Abstract: Mobile Ad-hoc Network (MANET) is an autonomous set of wireless devices usually called as mobile nodes communicate with other nodes over a wireless link without any pre- existing infrastructure. The mobile nodes act as a not only host but also as a router to forward data and control packets to other nodes in order to reach the destination. Each mobile node in the network is driven by a limited energy resource i.e. battery power. Due to dynamic behavior of nodes, topology changes frequently cause more power consumption and reduce node's lifetime. Effective energy utilization and finding an efficient path between source and destination node are the major challenges in a wireless mobile network. Many methodologies have been proposed in implementing an energy-efficient routing. Proposed paper presents some of the latest work carried out on minimizing energy consumption to enhance the lifetime of the network.

Keywords: *Energy efficient routing, Power aware routing, MANET, Mobile ad-hoc networks*

I INTRODUCTION

In wireless technology, one of the emerging types of network is a Mobile Ad Hoc Networks (MANETs), in which mobile nodes or hosts establish a connection with other devices on an ad-hoc basis. MANETs are a self-managing, self-configuring and self-administrating collection of devices connected with each other through a wireless link without any centralized management or fixed infrastructure. Some of the applications of mobile ad hoc networks are defense, disaster recovery, transportation, mining, heavy construction and event management.

Most of the today's available networks are based on fixed infrastructure, driven by the relationship between a network subscriber and a network operator. The subscriber needs to make a contract with the network operator to get mobile network access, and with ISP to access the Internet. To provide access to the corporate network, a predefined configuration of network devices is required. But now a day's these type of fixed infrastructure is replacing by wireless technology where the establishment of a network is happening on demand. One of an integral part of everyday life is mobile phones. Laptops, game consoles, pagers, PDAs and other similar devices have already adopted the wireless technology. Various sensors are enabled with wireless access, used in industries for easier accessibility and deployment. With all these increasing numbers of communication capable devices, a need of establishing a communication link between these devices has arisen. It is a very challenging task to establish a contract with every wireless device we want to communicate for a different purpose. Thousands of devices available in a market offering different services which cause difficulty when we want to know in advance which service we required and which device is capable of fulfilling this requirement. Each device will come up with its own configuration and manual configuration of each link is very difficult. Research has been initiated to target these reasons that should provide a new communication technology which is capable of supporting wireless ad-hoc network establishment and auto configuration of network communication devices.

II MANET ROUTING PROTOCOLS

MANET is the one where fixed infrastructure is not available which causes a number of challenges. One of the required and toughest challenges out of them is energy efficient routing. Routing is the process or way of finding and choosing paths in a network to send a packet from one node to another in order to reach the destination. Routing is a most complex task in MANET due to its dynamic changes in

topology and requires a special mechanism to search and maintain the paths.

Ad-hoc routing protocols define a standard set of rules, that controls how nodes in a network find a way to transmit data between computing devices in a mobile ad-hoc network. The main idea of routing in a wireless network is that each node has to announce its presence and also should continuously listen for other announcements send by its neighbors. So each node will have an idea its neighbor and path to reach them. Routing will happen on the basis of routing tables maintained by each node to forward a packet to appropriate destination. MANET categories routing protocols in two parts: Proactive Protocols or Table- Driven protocols and Reactive Protocols or On-Demand routing protocols.

A. Proactive routing protocols

In proactive routing protocols, each of the nodes in a network must and should have complete knowledge about all other nodes through the periodic updates. Each host or node maintains the route information about all destination in its routing table irrespective of route been needed or not. So when any data packet needs to transmit it can be forwarded easily and immediately as routes are already known in a table. Unfortunately, maintaining routing table is a big overhead in MANET environment due to its frequent topology changes. One of the common drawbacks of proactive routing protocol is a waste of bandwidth created by control packets in the absence of data packet for periodically updates the routes.

B. Reactive routing protocols

A wireless network is one where nodes are driven by limited energy i.e. battery, so the best approach is to keep the nodes silent when there is no data to be transmitted. Reactive routing protocols reduce the network overhead and save the bandwidth by avoiding unnecessary finding and maintaining of routes. As the name indicates on-demand protocol or reactive protocol do not maintain any routes in the network, but it will create it when requested. Routes selection will happen on-demand by transmitting route request packets through flooding in a network. Reactive protocols reduces the cost of maintaining the routes as well as control the network traffic by avoiding sending unnecessary control packets.

III MANET CHALLENGES

The below list shows some of the major challenges in mobile ad hoc network.

A. Dynamic Topology

Each node in MANET is free to move in any direction causes frequent changes in topology. This leads to frequent link failures and reestablishment of routes consumes extra energy.

B. Lack of Centralized Control

Lack of fixed infrastructure makes MANET more difficult to manage. Each node is responsible for managing and configuring the network.

C. Limited bandwidth

Wireless links are having very less data transmission capability compared to the physical link. Further, these links are affected by interference, external noise and signal attenuation effects which reduce throughput in a network.

D. Routing Overhead

Due to dynamic topology behavior, routing the data packets between nodes is one of the major tasks. Nodes can join and leave network any time causes route failure. Sometimes stable routes are used more frequently which creates extra network overhead.

E. Limited power supply

Nodes in MANET rely on limited energy which causes several problems. Nodes with the loss of energy will not further participate in the communication. Due to energy limitation frequent route failure occurs.

F. Lack of Security

In MANET all network activities are handled by a mobile node. This creates a challenge to provide security in mobile ad hoc network.

IV ENERGY CONSUMPTION SOURCES IN MANET

The important advantage of MANET is infrastructure less which can be easily deployed in emergency and rescue application. Each host or mobile node in such type of network is driven by limited battery power. So in such applications, it is a very challenging task to replace or charge these mobile nodes. These dead nodes are not further used for communication and make topology unstable. The figure shows energy depletion at different stages in MANET. In MANET, energy consumption occurs in below areas.

1. Transmission Stage

Whenever any node wants to communicate with another node in a network, it requires power to transmit the packet which called as transmission energy. The amount of energy required depends on the size of the data packet and other environmental conditions. So when the size of data packet increases, more transmission power is consumed by

radio.

2. Receiving Stage

Each intermediate node will act as a router to receive data from one node and send it to another node. Power required to receive a data packet from other nodes is called receiving energy. Reception Power required is a ratio of receiving energy and Time required to receive the packet.

3. Idle Stage

In MANET, by default each node is in the idle stage which continuously listen to the channel for packets and consumes unnecessary energy. When node finds any incoming packet from channel it will change its state into either transmit or receive mode.

4. Overhearing Stage

This stage is similar to the receive stage in which node will get packets from other nodes which are not targeted for it and causes depletion of energy.

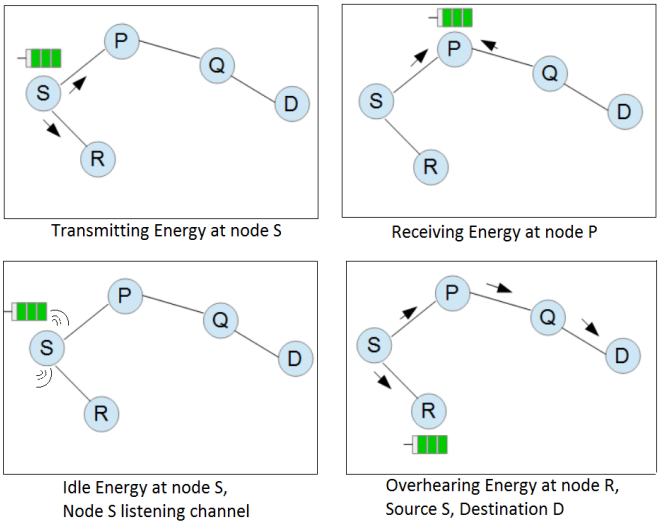

Figure 1 Energy consumption in MANET at different stages

V LITERATURE SURVEY

There are several types of research has been carried out by different authors to address the energy consumption issues in mobile ad hoc network. Saleh A. Alghamdi (2015), have proposed load balancing maximal minimal nodal residual energy ad-hoc on-demand multipath distance vector routing protocol[1]. This protocol generates link disjoint paths and evaluates these paths by considering maximal nodal residual energy. Path with higher nodal residual energy is considered first for packet transmission. Further, it calculates the maximum and an actual number of packets each path can transmit and distribute the packets based on the capacity of the path without depleting the energy of nodes. Distribution of packet among multiple paths reduces the energy consumption of a single path. Network with 200 nodes, existing AOMDV protocol consumes about 0.49 J of energy where proposed protocol consumes only 0.35 J. The main limitation of this protocol is a higher end to end delay as it focuses on a maximum number of packets transmission to the destination.

Ramanna Havinal(2016), proposed Minimal Energy Consumption with Optimized Routing protocol[2] which uses mathematical and signaling attributes of a node to handle energy and routing issues. The energy model is designed based on MAC techniques i.e. distributed coordination function in which network allocation vector is checked by the source node and if it is greater than zero node has to wait until it becomes to zero which saves unnecessary transmission energy of a node. Probability theory and energy model are used to calculate cumulative energy for data transmission and to find a route from source to a destination it uses shortest path technique and selects the path which has less energy dissipation. Author has also considered hidden node problem which may cause a collision by transmitting unnecessary data packets. To avoid this, the protocol uses two extra control messages CM_{RTS} and CM_{CTS} that takes lesser energy compare to data packets generated by hidden nodes. As per the analysis, proposed protocol saves 58.82% of energy in different mobility conditions. Due to additional control messages, network overhead is significantly increased in this protocol.

Senthilnathan Palaniappan(2015), have proposed Energy efficient stable routing using QoS monitoring agents[3]. Author has contributed on establishing stable and energy efficient paths using different link reliability metrics. These metrics are probabilistic link reliable time, link expiration time, link received signal strength, link packet error rate, and residual battery power. During route discovery, to select energy efficient stable path, the fuzzy logic technique is used which takes all metrics as input and based on fuzzy rules route selection is estimated. The residual battery power of the node is evaluated and used by the fuzzy system as major criteria in producing energy efficient path. Protocol conserves 8% of residual energy compared to Cross-Layer Metric-Based Location Aided Routing protocol. One of the drawback of this protocol is when number of nodes increases in network, frequent route disconnection occurs which decreases the packet delivery ratio.

Jipeng Zhou(2016), proposed Ant colony-based energy control routing protocol under different node mobility models[4]. It uses an ant colony optimization algorithm to select optimal path. Path selection is based on not only hop count and energy of node but also minimum and the average

energy of paths. To generate a path from source node to destination node, source node creates Fant(forward ant) packet and broadcast it to all its neighbor nodes. Upon receiving Fant packet each neighbor node checks if it has already received the same packet and if yes it will discard the packet. When the packet reaches to a destination it will send Bant(backward ant) packet in reverse path and each intermediate node calculate a number of hop count, minimum residual energy E_{min}, total residual energy E_{sum}, and average residual energy E_{avg}. Once the packet reaches to a source node, it will generate pheromone on the path. Based on path quality such as its number of hop count, nodes energy, and an amount of delay, a value of pheromone is decided. This value is used to select path while sending the data packet. Proposed protocol is evaluated in three different mobility models i.e. Random walk, Random waypoint, and Reference point group. The number of dead nodes is more in proposed protocol when nodes speed is higher, this is because node changes its position frequently and makes topology unstable which causes route rediscovery and consume more nodes energy.

X. Wang(2015), presented Improving the Network Lifetime of MANETs through Cooperative MAC Protocol[5]. Author has proposed distributed energy efficient location-based protocol(DEL-CMAC) to improve network lifetime. Proposed energy model considers the energy consumption at transceiver and amplifier level and selects best relay for data transmission based on residual energy and location information. After establishing the route, hop by hop cooperative relay terminals are selected. To manage dynamic transmitting power and relaying operations, it uses two new control messages i.e. Eager to Help(ETH) and Interference indicator(II). ETH packet selects the best relay based on minimum transmitting power and maximum residual energy. II used to inform source terminal that amount of interference available in the path. Control packets Request To Send, Clear To Send, Acknowledgement, and Eager To Help are transmitted with fixed transmission power whereas transmitting power for Data packets and Interference Indicator packets are dynamically assigned. Network with low node density increases power consumption as sometimes same node needs to act as both source and cooperative relay which consumes more power.

Gu, Chao(2014), proposed Energy-Aware Routing Protocol for Mobile Ad Hoc Networks Based on Route energy Comprehensive Index[6]. This protocol presents new routing metric i.e. Route Energy Comprehensive Index(RECI) and selects the path with maximum RECI value and minimum hop count. Protocol generates utility function(UF) for nodes energy consumption based on residual energy and energy drain rate at time t. For each node value of RECI is calculated which is a ratio of UF value and sum of all nodes UF value. Before sending RREQ to an intermediate node, source calculates energy consumption utility function and adds it as part of RREQ. Intermediate node checks if the packet is already received then calculates RECI value and forward duplicate RREQ to next node. Destination node gets multiple RREQ packets, selects the best route which has larger RECI value and sends RREP packet to the source node in reverse path. This protocol will not discard duplicate packets coming from the same source because it may possible that packet could come from the path which is more energy efficient. Main drawback of proposed method is that single route gets flooded and causes decreasing packet delivery ratio.

Li(2015), have proposed An Energy Level Based Routing Protocol[7]. Proposed protocol is based on residual energy and delay characteristics. Packet forward decision is taken based on the energy level of each node. When the packet reaches to an intermediate node and if it does not have the route to the destination in its routing table, it will hold the packet for certain amount of time which is inversely proportional to its current available energy. This makes less delay for nodes with higher energy level. After time expires node sends a packet to its neighbor nodes. Each intermediate node will accept the only packet received earlier and discard other packets came from nodes with low energy. Hence destination node will get a request from the path which has nodes with higher level energy. Author has proposed delay function which divides nodes energy into four different categories: safety, sub safety, danger and very danger. Delay function is applied for nodes which are in danger and very danger state and put that node in sleep mode. A node with safety, sub safety state will follow same request delay forwarding technique to reach the destination node. As each node will hold packet for time inversely proportional to its energy level causes a longer delay for nodes with less energy. Because of this delay, some RREQ needs to retransmit which makes heavier congestion and bigger routing load.

Shadi S(2014), proposed Energy efficient zone based routing protocol[8]. It considers the amount of energy and bandwidth wasted in route rediscovery process. To reduce redundant broadcasting, this protocol presents zone based parallel collision guided(ZCG) system. It uses clustering algorithm which divides a network into zones and selects one node as zone leader according to low and high battery power. By default all nodes are idle and

Table 1 Analysis of Energy Aware Routing Protocols

Protocol Name	Extension Of	Category	Energy Efficiency	Advantages	Limitations
Load balancing maximal minimal nodal residual energy AOMDV	AOMDV	Multipath	High	Uses multiple energy efficient link disjoint paths Network load is distributed through multiple available paths	Higher end-to-end packet delay
Minimal Energy Consumption with Optimized Routing Protocol	AODV	Single Path	High	Energy consumption per request is linear in dynamic mobility conditions Packet error rate is less	Extra control messages increases network overhead
Energy-efficient stable routing using QoS	AOMDV	Multipath	Medium	Stable routes are selected Reduce number of route reconstruction	Packet delivery ratio is less when number of nodes increases
Ant colony-based routing protocol	AOMDV	Multipath	Low	Energy efficient route selection based on pheromone value Network throughput is higher	Communication overhead reduces the overall performance
Improving the Network Life-time through Cooperative MAC protocol	IEEE 802.11 DCF	Multipath	High	Finds energy efficient paths Suitable for smaller network	Number of dead node increases with higher node speed Routing overhead is high
Energy-Aware Routing Protocol based on RECI	AODV	Single Path	Low	Network lifetime is longer than AODV in varying data rates	Choosing of threshold value is major issue Single route gets flooded with packets Decrease packet delivery ratio
Energy Level Based Routing	AODV	Single Path	Medium	Request delay mechanism is used to find energy efficient routes Lower energy consumption	Lower the node energy longer the delay
Energy efficient Zone Based Protocol	ZRP	Single Path	Medium	Route discovery happen in parallel Zone leader takes all routing decisions	Packet collision at intermediate node consumes highest energy
Enhancement of accuracy metrics for energy levels in OLSR	OLSR	Single Path	Medium	Performs better in high mobility speeds Saves more residual energy compared to original OLSR protocol	Overall throughput is less compared to OLSR protocol Overall inaccuracy increases when traffic rate increase
Protocol for energy efficient mobile applications	AFECA / SPAN	Single Path	Low	Produce better throughput	EAZRP increases overhead when network size grows To wake up sleeping node, it uses additional hardware circuit.

when forming network they will exchange Hello message with each other to create a zone and decides zone leader among the list of idle nodes. Path discovery is initiated by zone leader. The energy model is designed based on the energy cost of each packet and computed as an incremental cost. Each node wants to communicate with a node of another zone, it sends a request to its zone leader. Zone leader calculates time and sends path discovery message to both nodes to start route discovery in parallel. When any intermediate node receives two packets from both nodes with same broadcast id, it will save it into its routing table and sends an RREP packet to both nodes to form the bi-directional route. Unnecessary rebroadcasting is avoided by member nodes based on the value of Zone to Live(ZTL). Due to dynamic behavior of mobile nodes, each member node within zone changes its position frequently which causes a number of packet flows between zone leader and sometimes creates unnecessary traffic.

Muthusamy(2015), have proposed Enhancement of accuracy metrics for energy levels[9]. This protocol modifies hello interval and TC interval metrics of existing OLSR protocol to improve network lifetime. Hello interval is used for generation of hello message to inform neighbor about nodes presence and TC interval is for generation of TC message to inform about topology changes. This protocol modifies MPR selection and route discovery algorithm. As most of the routing in OLSR is performed through MPR node, protocol selects a number of MPR nodes based on higher residual energy and number of two hop neighbor covered by the node. Route selection is performed via MPR node which will ignore the node which has low residual energy. One of the limitation of this protocol is that the overall inaccuracy increases when traffic rate increases.

G Ravi(2015), proposed protocol for energy efficient mobile applications[10] in ad hoc network. This protocol combines two energy saving mechanisms: Adaptive Fidelity Energy Conservation Algorithm(AFECA) and SPAN. AFECA is combined with ZRP to form EAZRP(Energy Aware Zone Routing Protocol). AFECA provides a way to select nodes which are idle and can rotate node state to active, sleep or listen state. By periodically changing nodes state energy saving is achieved. Energy-aware span routing protocol(EASRP) periodically selects coordinator node from the list of nodes to balance energy savings. All route request will go through the coordinator node and span put this node sleep mode when it is idle. Hardware circuit is used to wake up sleeping mode to achieve further optimized energy consumption. Packet delivery ratio of EAZRP protocol decrease when network size increases.

VI CONCLUSION

In this paper, we have studied and analyzed some of the energy efficient routing protocols. Mobile nodes or host in mobile ad hoc network are driven by limited battery power. Each node depends on the battery power to perform packet transmission and receiving functionality. It is very difficult to replace or change these batteries in mobile ad hoc network for continuous network operation. So reducing energy consumption is a key problem in mobile ad hoc network. Hence designing energy efficient routing protocol is major demand in mobile ad hoc network to improve network lifetime.

Energy efficiency, robustness, security, reliability, and scalability are the further attention in this area of research. Hence new routing protocols can be implemented to address these issues in mobile ad hoc network.

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