Energy Efficient Routing Approaches in Ad hoc Networks: A Survey

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Abstract Mobile Ad hoc Network (MANET) is a form of short term based network that contains multidimensional nodes having major concern such as battery power resources. Energy is playing as consequential undertakings in MANET. Limited power of network causes many effects on the performance of the networks. Lack of energy factor may break the connection which can mess the network or routing process. Routing process requires efficient utilization of battery power or energy to maintain the network condition so that packet can be transferred without any obstacle in the performance. As well as, network life or life of node is proportional to battery life which is powered by limited capacity. The meaning of energy-efficient is not about consuming less energy but to increase the time duration to maintain the network performance level. Routing performances can differ depending upon the network parameters. In order to reduce the usage of energy and to increase the life span of battery, several others Ad hoc routing protocols are reviewed with their novel conceptions and optimization techniques over the main routing protocols.

Keywords Mobile Ad hoc network · Energy efficiency · Network lifetime · Energy-efficient routing approaches

1 Introduction

Networking is the process of sharing the resources or communication between two or more parties {source, destination}. Infrastructure network (i.e. Cellular Network) and infrastructureless network (i.e. MANET, VANET and so on.) is the type of

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wireless network [1]. Infrastructure based network is not a "peer-to-peer" connection similar to Ad hoc network. It is roundabout connection between two or more network points which is able to get to be through fixed wireless access point called as central administrator. While in infrastructureless network, all nodes in network act as a router.

Meaning of Ad hoc is "for this" and "for this situation" comes from Latin. American uses word "Ad hoc" for immediate and special purpose. It means Ad hoc word use for temporary basis. Same thing, Mobile Ad hoc network (MANET) is temporary based network in which physical network layout will change frequently as network point is moving. Due to this dynamic topology, MANET has need of more system resources such as efficient power supply or energy, network throughput, network lifetime. MANET have a many key challenges [2, 3] such as limited power support, limited bandwidth, network lifetime, end-to-end delay, Quality of Service (QoS), network security.

The Major end, purpose of the MANET is to maximize the throughput, improve the life span of the network and minimize the delay time. Throughput can be measured through Packet Delivery Ratio (PDR). Routing is the process of selecting the best path through which it forwards the traffic over a network. All network points in MANET are dependent on battery power, in other words, network points are battery driven. Flooding the packet often may cause connection failure. Reason for connection failure is:

- Energy exhaustion by single dead node
- Node is moving out-of range of its close-by node

The rest of this paper is organized as follows. The energy-efficient issue is presented in Sect. 2. In Sect. 3, we provides summary of literature available on traditional routing protocols. Finally we conclude the paper in Sect. 4 with future research opportunities on energy-efficient.

2 Energy Efficiency Issues

The energy-efficient routing is voluminous concern in the MANET. All nodes are battery-driven, powered by constrained battery capacity. Due to the lack of energy, Node cannot communicate efficiently with another node. It is obligatory to take action to ameliorate the energy of node. This paper defines sundry efficiency routing protocol to solve the energy related problem. The parameters or process define as below in which node consuming more Energy.

- During transmit the packets
- On receiving the packets
- In a idle mode
- In a slumber mode

The various energy challenges are define as below:

1. **Limited Bandwidth**: Basically, Limited bandwidth in wireless network refers to packet connection's capacity and round-trip delay time (RTD) or round-trip time (RTT). It means Circumscribed bandwidth affects the network during the traversal of packets because of length of time taken for a request and reply.
2. **Battery Constraint**: Battery power is paramount concern into the Ad hoc network. Each node in wireless Ad hoc network is operates on battery potency. Less energy can affect the communication of the network.
3. **Packet losses due to transmission errors**: Certain connection may break due to the dynamic deportment of the node. The physical network topology often changes when node moves. In an astronomically immense network, a dead node exhausts all energy can cause the transmission error.
4. **Security threats**: Security is big challenge in terms of secure communication in Ad hoc network. The several security threats affect the network due to limited cryptographic measure, node traverse without adequate protection and static topology which is not adequate in dynamic comportment. As a result node grabs more battery power which affects the overall performance of the network.
5. **Mobility-induced route changes**: Ad hoc wireless network is dynamic topology. Certain connection may be break frequently due to the node movement during perpetual session of the network.
6. **Routing Overhead**: In wireless network, nodes are changing its location frequently. As a result, stale entry in obtained in routing table that increase the routing overhead.

3 Related Work

Energy saving is big concern in wireless Ad hoc network. In recent past years, many researchers have addressed energy-efficiency related issue and innovate incipient conceptions and novel techniques. Below shows few algorithm based on Energy efficiency mechanism.

Zhao and Tong [4] proposed EAGER protocol which includes proactive and reactive approaches based on traffic and mobility conditions. EAGER divides the network into equipollent size cell. It works based on two routing protocol: Intra-cell proactive routing and another Inter-cell reactive routing protocol. EAGER culls the optimal peripheral area that can be used to minimize the node in a traversal process.

Kim et al. [5], in this, LRCA is utilized to change the route if a node is dead or have a less-battery life by broadcasting the HELP and OK message.

Shin et al. [6], modified the conventional routing protocol with the avail of K-hop PRREQ message. K-hop PRREQ message used to reduce the number of broadcasting of route request (RREQ) message. K-hop PRREQ is use by sender to broadcast with hope with the use of Time To Live (TTL) field.

Loganathan and Ramamoorthy [7], describe comparison between the pristine DSDV and modified DSDV with the use of cost parameter assign for link and path of the Ad hoc network The cost parameter include parameters such as hop count (h), total inference (I), Node link delay (d), Residual energy of a node (R), node transmission power (T). The cost parameter is cummulate with different optimization function and for optimal path MAX/MIN Energy-Half-Interference Hop multicast algorithm in utilization.

Karuppanan and Mahalaksmi [8], in this, MANET is a subset of VANET. OLSR include data such as broken link information which leads the vagueness. Fuzzy Rough-OLSR (FR-OLSR) reduces the force of uncertainty in the dataset and produces the optimal path for packet traversal. FR-OLSR based on Fussy Rough set theory. FR based theory obviate the problem that is incapable to defense. FR defines the degree of kindred attribute between two objects which measured in 0–1 interval.

Kim et al. [9], proposed, TEES is based on DSR, use to reduce the control packet overhead and increase the amount of packet delivery ratio. TEES find the optimal path based on two levels LB (Lower Bound) and UB (Upper Bound). The energy value is compared with LB and UB to compute the case LC (Low Case), MC (Middle Case) and HC (High Case).

Shivashankar et al. [10], Described conventional the power aware algorithm. In DSR, the routing packet load increases the time for a multipath. DSR cull the path which have minimum number of hops. EPAR (Efficient Power Routing Protocol) select the path with the maximum lowest hop energy. DSR performance is inefficient in terms of medium and large size networks. For this, EPAR, MTPR is proved to be preponderant. EPAR in terms of throughput provide a preponderant result.

De Rango et al. [11], proposed EE-OLSR which is the modification of OLSR protocol to reduce the battery consumption. EE-OLSR is work on two methodologies, one is, EA-Willingness Setting and another one is Overhearing Exclusion. The willingness of node can be described by two steps or metrics: (1) Battery capacity and, (2) Predicted lifetime.

Sheng et al. [12], an energy-efficient protocol NCE-DSR (Number of times nodes send Constraint Energy DSR) based on DSR. NCE-DSR considers the two domain value MAX and AVE value that is added to datagram to record the mean value and the maximum value of the number of times node sending messages are protected or chosen for route selection.

Vazifehdan et al. [13], In this, two novel energy aware routing algorithm is proposed in which Reliable Minimum Energy Cost Routing (RMECR) is used to elongating the operational lifetime of the network while RMER reducing the consuming energy during end-to end packet traversal.

Fahrnv et al. [14], proposed, Predictive Energy Efficient Bee Routing (PEEBR) is a swarm based optimization algorithm that work on two phases: (a) node level and (b) network level.

Rekha et al. [15], GFSR is a grid based protocol used to exchange the control message and data packet by selecting the good candidate called the gateway. Grid includes the gateway and gateway is the node that used to forward the packet. GFSR chooses the best path by observing the node during transmission and checks whether it's gateway or not. Nearest node to the virtual grids is good candidate call gateway.

Ur Rahman Khan et al. [16], in this, the higher rate of mobility degrade the performance of network and maximize the packet delivery ratio. As a result, stale routes are updated into the routing table. DSDV uses stale route it signifies not a valid route to destination. Eff-DSDV utilizes the stale routes in case of broken link. In case of broken link, Eff-DSDV engenders the temporary link by sending one-hop packet to the destination.

Chettibi and Chikhi [17], the paper utilizes the Zero-order Sugeno Fuzzy Logic System adjust the willingness parameter into the OLSR protocol. FLS check the willingness of node by considering two parameters such as RE (Remaining Energy) and ERL (Expected Residual Lifetime).

Roy et al. [18], SEEC (Signal and Energy Efficient Clustering) play consequential role while cluster dies. It considers the second node as a cluster head while cluster head's power level goes below to the certain threshold value.

Mangai and Tamilarasi [19], the ILCRP (Improved Location aided Cluster based Routing Protocol) used to maintain the nodes location by utilizing the GPS. Due to the advantages of system, ILCRP used to reduce the control overhead. ILCRP works on three phases: cluster formation, route maintenance, route discovery.

Sharma et al. [20], proposed, new algorithm MCGCR (Modified Cluster Head Gateway Switch Routing Protocol) combining the two approaches: proactive and reactive approach. MCGCR ameliorate the routing performance by utilizing the cluster heads and gateways.

Verma [21], the main three areas that consume more power, namely, radio frequency, nodes processing unit and energy consume by nodes. To calculate the energy consumption by node, ZRP with anycast is use. Anycast is use while node is consuming more energy in receiving and sending the packet. The total energy calculated by sum of receiving and sending packet process.

SreeRangaRaju and Mungara [22], ZRP utilizes the query methodology targeting the peripheral nodes which is more efficient than the flooding process. It is possible that the neighbour receive the packet multiple times. It is obligatory to reduce the control overhead. The query control mechanism used to reduce the delay in which detection mechanism include source node's id and query id pair. In this, node sends the packet to the peripheral node. It may transpire that packet may receive multiple times through peripheral node. At this time, query bordercasting approach is use.

Table 1 describes the survey on various traditional routing protocols with their novel conception and optimization techniques.

Table 1 A survey on traditional routing protocol

Topic name	Protocol	Description	Mechanism/ algorithm	Methodology	Performance/QoS
Energy-efficient adaptive routing for Ad hoc networks with time-varying heterogeneous traffic [4]	EAGER	Eager protocol works based on two routing protocol: Intra-cell proactive routing and Inter-cell reactive protocol	Energy aware geo-location aided routing	Partitioning the network into equal sized cells	Large-scale energy, Overhead, difficult to maintain the location of nodes
LRCA: enhanced energy-aware routing protocol in MANET [5]	LRCA	LRCA is utilized to transmute the route if a node is dead or have a less battery life	Local route change algorithm	Route change with the help of HELP, OK, RCRQ message	Packet loss rate, route recovery, power consumption
Energy efficient route discovery for mobile HCI in Ad hoc networks [6]	DSR, AODV	K-hop PRREQ message use to reduce the number of broadcasting of route request message	K-hop pre-route request message	Message broadcast with the use of Time To Live (TTL) value	Energy consumption, route discovery
Performance analysis of enhanced DSDV protocol for efficient routing in wireless Ad hoc networks [7]	MPB-DSDV	Newly protocol assign the cost parameter like hop count, total inference, node link delay, residual energy, transmission power	MAX/MIN energy-half-inference-half hop multicost algorithm	By assigning the cost parameter for link and path	Network energy, network lifetime
Enhanced optimized link state routing protocol for VANET using fuzzy rough set [8]	FR-OLSR	FR-OLSR based on fuzzy rough set theory which is obviate the problem that is incapable to defense	Fuzzy rough set theory	FR is used to define the similarity between objects to remove the uncertainty	Uncertainty in routing information, vagueness due to broken link in OLSR
A routing protocol for throughput enhancement and energy saving in MANETs [9]	TEES based on DSR	TEES find the optimal path based on two levels Lower Bound and Upper Bound	Throughput enhancement and energy saving	Choose path by comparing three cases (LC, MC, HC) with two energy level UB and LB	Throughput, control packet overhead
Designing energy routing protocol with power consumption optimization in MANET [10]	EPAR, MTPR, DSR	EPAR calculate the lowest hop energy which is given battery power for each path	Conventional power aware algorithm	Path selection based on energy	Network lifetime, energy consumption, PDR, throughput

(continued)

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Topic name	Protocol	Description	Mechanism/ algorithm	Methodology	Performance/QoS
EE-OLSR: energy efficient OLSR routing protocol for mobile Ad hoc networks [11]	EE-OLSR	Modified OLSR works on two method such as Willingness setting and Overhearing exclusion	EA-willingness setting mechanism	Node willingness can quantified by battery capacity and predicted life time	Battery consumption, network lifetime, network performance
A novel energy-efficient approach to DSR based routing protocol for Ad hoc network [12]	NCE-DSR	NCE-DSR calculate the cost function by considering two values Mean and Max for elongate the duration of network lifetime	Number of times send constraint energy DSR	Route selection using cost function	Energy consumption, hardware overhead, network lifetime
Energy-efficient reliable routing considering residual energy in wireless Ad hoc networks [13]	RMECR, RMER	New routing protocol use genetic routing algorithm which calculate the MECP between every two nodes of the network	Genetic routing algorithm	Energy reduction using Minimum Energy Cost Path (MECP)	Energy efficiency, reliability, network lifetime, end-to-end delivery
PEEBR: predictive energy efficient bee routing algorithm for Ad hoc wireless mobile networks [14]	PEEBR	PEEBR is a swarm based optimization algorithm that work on two phases, Node level and Network-level	Swarm intelligent routing algorithm	Potential path selection based on integrity ratio	Optimal path, energy consumption, battery power saving
Efficient routing algorithm for MANET using grid FSR [15]	Grid FSR	GFSR partitioning the network in two dimensional virtual grid and select the best gateway through minimum distance between virtual grid and node	Fisheye state routing algorithm	Path selection by choosing alternative gateway in grid	Bandwidth
An efficient DSDV routing protocol for MANET and its usefulness for providing internet access to Ad hoc hosts [16]	Eff-DSDV	Eff-DSDV utilizes the temporary routes in case of broken link	Efficient DSDV	Route establish by creating the temporary link.	End-to-end delay, PDR, Mobile-IP overhead
FEA-OLSR: adaptive energy aware routing protocol for MANETs using zero-order sugeno fuzzy system [17]	FEA-OLSR	The paper utilizes the FLS to adjust the willingness parameter to check the willingness of node	Zero-order Sugeno fuzzy logic system	Node willingness computes by the use of FLS	Energy-efficient routing

(continued)

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Topic name	Protocol	Description	Mechanism/ algorithm	Methodology	Performance/QoS
Energy efficient cluster based routing in MANET [18]	CBRP	SEEC consider the alternative node as a cluster head (CH) while previous CH's power level fall down to the certain threshold value	Signal and Energy Efficient Clustering (SEEC)	Minimize the energy cost by selecting the other node as a cluster head (CH)	Energy level, signal strength, battery power level
A new approach to geographic routing for location aided cluster based MANETs [19]	ILCRP	ILCRP (Improved Location aided Cluster based Routing Protocol) used to maintain the nodes location using GPS. Due to advantages of GPS, it reduce the control overhead	Cluster based routing algorithm	Providing location information of nodes by utilizing the GPS	Performance metrics (end-to-end delay, control overhead, PDR)
An efficient cluster based routing protocol for MANET [20]	MCGSR	MCGSR amalgamate the two approaches, proactive and reactive, to improve the routing performance by utilizing the cluster head and good candidate	Modified cluster head gateway switch routing protocol	By utilizing the cluster heads and gateways	Performance metrics
Energy efficient routing in MANET with ZRP and anycast [21]	ZRP	ZRP with anycast is utilized to calculate the total energy consuming by node, as well as, check the total active nodes of network	ZRP with anycast addressing	By applying anycast in ZRP	Energy-efficient
Tuning ZRP framework for CR networks and MANETs [22]	ZRP	Bordercasting use IERP to broadcast the packet to node in zone boundary to control the overhead packet	Query control mechanism, selective bordercasting procedure	By utilizing IERP mechanism which is differ from IERP in ZRP	Delay in route acquisition, congestion, throughput

4 Conclusion and Future Scope

To evaluate the energy consumption, this paper surveys various routing protocols with their novel conceptions and optimization techniques over the pristine routing protocols. Paper also describes the erudition of conventional routing protocol briefly. Maintaining the energy level and network life is voluminous concern in Ad hoc network. For that, efficient routing protocols are required to discover the routes which facilitate the secure and reliable communication.

It is infeasible to compare the routing protocols with one another because protocols are dependent on network parameters or each protocol has a different goal with different postulation. The network parameters affect the overall performance of the protocol in the network. As well as, each modified routing protocols perform independently in case of energy cognate issue. Due to this reasons, Results cannot be compared with one another.

We surveys several routing protocols utilizing a single-hop and multi-hop routing process. But there are many open questions in case of maintaining the energy level such as QoS guarantees, adaptability, and security. QoS and adaptability is most crucial during communication process in Ad hoc network which are found missing in most of the routing protocol being proposed. Therefore, new optimization techniques or energy-efficient routing protocol that address QoS and adaptability need to be developed.

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