Literature Review on Energy Efficient Reliable Routing for Wireless Ad Hoc Networks

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Abstract— In wireless ad hoc network, the foremost drawback is to supply reliable energy efficient routes that maximize the network lifespan, i.e., the amount of winning transmissions. Energy management is an optimization technique, used to maximize the operational lifespan of networks through energy efficient routing. Numerous energy efficient routing algorithms are planned for ad hoc network to enhance the life time of network by considering numerous parameters like remaining battery energy, link quality, etc. this paper surveys numerous planned energy efficient routing algorithms.

Key words: Wireless Ad Hoc Network, Reliability, Optimization, Energy consumption

I. Introduction

Ad hoc network could be a network shaped without any central administration that consists of mobile nodes that use a wireless interface to send packet information. Wireless ad hoc network (WANET) could be a redistributed wireless network and no preceding infrastructure. Rather than every node during a network can serve as routers and hosts, they will forward packets for different nodes.

Energy consumption is additionally one among the foremost necessary performance metrics for wireless ad hoc networks, it directly relates to the operational lifespan of the networks. Within the Wireless Ad-hoc Networks, battery replacement might not be potential. Therefore as way as energy consumption involved, should try and preserve energy whereas maintaining high connectivity.

Each node depends on little low-capacity batteries as energy sources, and can't expect replacement once operative in hostile and remote regions. For Wireless ad hoc Networks, energy depletion and reduction is that the primary think about connectivity degradation and length of operational period of time. Overall performance becomes extremely addicted to the energy efficiency of the algorithm.

Effective mechanism for reducing the energy value of forwarding the packet in wireless ad hoc network is finished by energy efficient routing algorithms. In general, routes are discovered considering the energy consumed for end-to-end (E2E) packet traversal. This could not finding less reliable routes or overusing a group of specific nodes within the network. Energy-efficient routing in ad hoc networks is neither complete nor efficient while not the consideration of reliability of links and remaining energy of nodes.

Finding reliable routes will enhance quality of the service. Whereas, considering the residual energy of nodes in routing will avoid nodes from being overused and may eventually cause a rise within the operational lifespan of the network.

A. Retransmission Schemes:

Hop-by-hop retransmissions- lost packet in every hop is retransmitted by the sender once necessary, to make sure link level reliableness. Acknowledgements are generated once receiver receives packet correctly.

End-to-end retransmissions- here the retransmissions happen solely between finish nodes (source and destination), and acknowledgements are generated at destination node.

Various routing algorithms are planned aiming at increasing reliableness, energy-efficiency and therefore the lifespan of wireless ad hoc networks (e.g., [1], [2], [3], [4], [5], [6], [7], [8],[11]). These algorithms broadly speaking cluster into 3 classes.

The primary class includes algorithms that think about the dependability of links to search out additional reliable routes (e.g., planned rule in [1]). These algorithms found the reliable routes that comprise links requiring less variety of packet retransmissions throughout lost packet recovery. Since they need less variety of retransmissions such routes might consume less energy, however they are doing not essentially minimize the energy consumption for E2E packet traversal. What is more, giving a better priority for frequently of routes might end in overusing some nodes. Nodes together with these reliable links can fail quickly; as a result of they need to forward several packets on behalf of different nodes.

The second class includes algorithms that specialize in finding energy-efficient routes (e.g., the planned algorithms in [2], [3], [6], [7], [11]). Although a number of these algorithms (e.g., the projected algorithms in [6], [7]) address energy-efficiency and reliableness along, they are doing not avoid overuse of nodes since they are doing think about the remaining battery energy of nodes. And therefore the major downside of those algorithms is that they think about solely the transmission power of nodes and don't think about the particular energy consumption of nodes (that is that the energy consumed by process parts of transmitters and receivers) throughout energy-efficient route discovery. This may negatively affects reliability, energy-efficiency, and therefore the operational time period of the network altogether.

The third class includes algorithms that aim to prolong the time period of network by finding routes together with the nodes having higher level of battery energy (e.g., the projected algorithms in [4], [5]). However, these algorithms don't address reliableness and energy-efficiency. Since the routes discovered by these algorithms might neither be reliable nor be energy-efficient, this will increase the general energy consumption in wireless network.

II. LITERATURE REVIEW

A. Maximum Residual Packet Capacity (MRPC) Algorithm:

MRPC [5], power-aware routing formula for energy-efficient routing that will increase the operational period of time of multi-hop wireless networks. In distinction to conventional power-aware algorithms, MRPC identifies the capability of a node not simply by its residual battery energy, however additionally by the expected energy spent in reliably forwarding a packet over a selected link. Link transmission prices additionally rely upon physical distances between nodes and also the link error rates. Employing a max-min formulation, MRPC selects the path that has the biggest packet capability at the 'critical' node (the one with the littlest residual packet transmission capacity). Present CMRPC, a conditional variant of MRPC that switches from minimum energy routing to MRPC only the packet forwarding capability of nodes falls below a threshold.

MRPC works on choosing a path, given this battery power levels at the constituent nodes, that maximizes the entire range of packets that will be ideally transmitted over that path, presumptuous that every one alternative flows sharing that path don't transmit any longer traffic.

To formalize this idea, assume that the residual battery power at an explicit instance of your time at node i is B_i. Also, allow us to assume that the transmission energy needed by node i to transmit a packet over link (i, j) to node j is $E_{i,j}$. Let the supply and destination nodes for a selected session (route) be S and D severally.

If the route-selection formula then selects a path P from S to D that has the link (i, j), then the utmost range of packets that node i will forward over this link is clearly $\frac{B_i}{E_{i,j}}$. Consequently, they'll define a node-link metric, $C_{i,j}$ for the link (i, j) as :

$$C_{i,j} = \frac{B_i}{E_{i,j}}.$$

The key purpose during this formulation is that the value metric includes each a node-specific parameter (the battery power) and a link specific parameter (the packet transmission energy for reliable communication across the link).

The maximum "lifetime" of the chosen path P, outlined by the utmost range of packets that will be doubtless forwarded between S and D using path P, is decided by the weakest intermediate node– one with the littlest worth of $C_{i,j}$. consequently, the "maximal lifetime" related to route i is seen to be:

$$\mathrm{Life}_{e_p} = \min_{(i,j)\in p}\{C_{i,j}\}$$

The MRPC formula then selects the route $P_{canditate}$ that maximizes the "maximal lifetime" of communication between S and D. Formally, the chosen route is such that:

$$P_{candiate} = \arg\max\{\mathrm{Life}_{e_p} | P \in \text{all possible routes}\}$$

B. Minimum Battery Price Routing (MBCR):

While total transmission power is a crucial metric, it's a important disadvantage. Though this metric will cut back the full power consumption of the general network, it doesn't replicate the period of time of every host. If several minimum total transmission power routes have a, common host, the batteries of this host are going to be exhausted very quickly. Hence, the remaining battery capability of every host may be a lot of correct metric to explain the period of time of every mobile host [8], [12].

Let C_i' be the battery capability of a host n_i at time t go between 0 and 100. Define $f_i(C_i')$ as a battery price perform of a host n. suppose a node's temperament to forward/relay packets may be perform of its remaining battery capability, i.e., the lesser capability it's, the a lot of reluctant it's to forward packets. One potential alternative for f_i, is:

$$f_i(C_i') = \frac{1}{C_i'}$$

This higher than reflects that as battery capability decreases, the value perform for node n, increases. The battery price R_j for route j is then:

$$R_j = \sum_{i=0}^{D_i-1} f_i(C_i')$$

To find a route with the most total remaining battery capability, one ought to choose the route i that has the minimum battery cost:

$$R_i = min\{R_j | j \in A\},$$

Where A is that the set containing all attainable routes

C. Min-Max Battery Cost Routing (MMBCR):

MMBCR [4] could be a power-aware routing algorithmic rule that self-addressed the matter of increasing the operational life time. MMBCR used Min-Max route choice theme (it is associate algorithmic rule that selects the path that has the best value for its most important node). Like Min-Max route choice theme, MMBCR selects the route whose important node has the very best residual battery energy. In MMBCR, a value metric Cp associates with a particular path P is given by

$$Cp = \min\{B_i\}$$

Where b_i is that the residual battery capability of node i lies on route P. the path elect by PMMBCR is given by

$$PMMBCR = \max\{Cp\}$$

The battery value R_j for route j is outlined in MMBCR [4] as:

$$R_j = \max_{i \in route-j} f_i(C_i')$$

Similarly, the specified route i will be obtained from:

$$R_i = min\{R_j | j \in A\},$$

Since this metric tries to avoid routes with nodes having the smallest amount battery capability among all nodes altogether possible routes, the battery of every host are used additional fairly as compared to previous schemes. Initially, it should appear that the lifespan of all nodes are elongated. However, since there's no guarantee that minimum total transmission power paths are electing beneath all circumstances, it will still consume additional power to transmit user traffic from a source to the destination. This truly reduces the lifespan of all nodes that once more is unattractive.

MMBCR safeguards nodes with low energy because it selects the route during which the node with minimum energy has additional energy, compared to the nodes with minimum energies of the opposite routes. Yet, it doesn't take into consideration explicitly the transmission power consumption, thus leading to a possible reduction of the network life time. Therefore, it will cause overall higher energy consumption and consequently, a reduction of the common node lifespan.

D. Conditional Max-Min Battery Capacity Routing (CMMBCR):

In CMMBCR [10], once all nodes in some potential routes between a source and a destination have comfortable remaining battery capability (i.e., on top of a threshold γ), then a route with minimum total transmission power among these routes is chosen. Since less total power is needed to forward packets for every route, the relaying load for many nodes are going to be reduced, and their period of time are going to be extended. However, if all routes have nodes with low battery capability (i.e., below a threshold), then routes as well as nodes with the bottom battery capability should be avoided so as to increase the period of time of those nodes. Define the battery capability R_j^c for route j at time t as:

$$R_j^c = \max_{i \in route-j} C_i'$$

Let A be a group containing all potential routes between any two nodes at time t and satisfying the subsequent equation:

$$R_j^c \geq \gamma, \text{for any route j} \in \text{A}$$

γ is a threshold and ranges between zero and one hundred. This scheme suffers from an unfair increment of the forwarding traffic towards nodes with additional energy. However, this low energy path computation doesn't take under consideration energy prices because of packet retransmissions.

E. Basic Algorithm for Minimum Energy Routing (BAMER):

BAMER [6] finds minimum energy paths from s to all or any different nodes within the end-to-end retransmission model. Basically, BAMER could be a generalized extension of Dijkstra's shortest path algorithmic rule. In Dijkstra's algorithmic rule, solely edge weights are considered. Assume that node u precedes v within the path from s to v, denoted by P(s, v). Let P(s, u) denote the part of P(s, v) between s and u. For any path P(i, j), let C(P(i, j)) denote the energy consumption of with success delivering a packet on that path from i to j. In Dijkstra's algorithmic rule, it's clear that

$$C(P(s, v)) = C(P(s, u)) + W(u, v).$$

BAMER algorithms take into consideration each link weights and link error rates. The key observation is that

$$C(P(s, v)) = N(u, v).[C(P(s, u))+W(u,v)].$$

F. General Algorithm for Minimum Energy Routing (GAMER):

Solve the minimum energy path drawback during this mixed retransmission model with the overall algorithmic rule for Minimum Energy Path (GAMER). GAMER [6] may be a more generalization of BAMER, wherever every individual link could or might not give per hop reliableness. Again, assume that node u precedes v within the path from s to v, denoted by P(s, v), and let P(s, u) denote the a part of P(s, v) between s and u. The extra observation is that if link (u, v) doesn't support hop-by-hop reliableness,

$$C (P(s, v)) = C (P(s, u)) + N(u, v) W(u, v).$$

Where C(P (s, v)) is that the energy consumption of with success delivering a packet on that path from s to v and P(s, u) denote the a part of P (s, v).

G. Expanding Ring Search (ERS):

ERS [9] is applied to AODV for route discovery method to scale back overhead and to use energy with efficiency by using the Time to Live (TTL) mechanism. The ERS belongs to the reactive protocols. The goal of ERS is to search out the destination or the knowledge concerning the destination by controlled flooding of the RREQ across the network to forward the packets from source to destination. The TTL value determines the most number of hops that the RREQ will undergo. To use the ERS, the source node sets the TTL values of the RREQ to an initial TTL_START value and initiates the route discovery. If no reply is received among the discovery period, the supply then will increase the RREQs broadcast id so re-initialize the RREQ with TTL value increased by TTL_INCREMENT value. This method of increasing TTL value continues till the TTL_THRESHOLD price is reached, beyond that the RREQ is broadcasted across the whole network until it reaches RREQ_RETRIES.

The ERS methodology has the subsequent restrictions. If the destination node is much from the source node, then the source node needs to broadcast multiple RREQ messages. Consequently, intermediate nodes have to receive and process this message repeatedly. This results in a lot of consumption of energy and routing overhead.

H. PAMAS:

Energy-aware routing protocols for variable-power situations aim to directly minimize the full power consumed over the whole transmission path. PAMAS [2], is one such minimum total transmission energy protocol, wherever the link value was set to the transmission power and Dijkstra's shortest path algorithmic rule was used to work out the path that uses the tiniest additive energy. Within the case wherever nodes will dynamically regulate their power supported the link distance, such a formulation usually ends up in the formation of a path with a large range of hops. By employing a changed kind of the Bellman-Ford algorithmic rule, this approach resulted within the choice of ways with smaller range of hops than PAMAS. The algorithmic rule doesn't take into account the remaining battery energy of nodes to avoid overuse of nodes.

It doesn't take into account the particular energy consumption of nodes to find energy efficient routes. It solely considers the transmission power of nodes neglecting the energy consumed by process elements of transmitters and receivers. What's considered as energy value of a path by these algorithms is just a fraction of the particular energy value of nodes for transmission on a path. This negatively affects energy efficiency, reliability, and therefore the operational time period of the network altogether.

I. Reliable Minimum Energy Price Routing (RMECR):

RMECR [12] addressed three vital needs of ad hoc networks that are reliability, energy-efficiency, and prolonging network lifespan. This scheme considered the subsequent ideas whereas pioneering studies [1], [2], [3], [4], [5], [6], [12] neglected those ideas

- Considered the impact of restricted number of retransmission allowed per packet and packet size
- Considered the impact of acknowledgment packets
- Considered energy utilization of process components of transmitter and receiver.

RMECR theme considered the energy utilization, the remaining battery energy of nodes and quality of links to find energy-efficient and reliable routes that increase the operational span of the circumstantial network.

J. Reliable Minimum Energy Routing (RMER):

RMER [12] algorithm finds path which minimizes the total energy required for end-to-end packet traversal. RMER does not take into account the remaining battery energy of nodes, and which is used as a point of reference to study the energy-efficiency of the RMECR algorithm. RMER saves more energy compared to existing energy efficient routing algorithms (e.g., [2], [3], [4], [5], [6], [7]) and also increases the reliability of wireless ad hoc networks.

III. CONCLUSION

In this survey we have targeted energy efficient and reliable routing protocols for extending operational life time of ad hoc networks. Some planned schemes associated with energy aware routing are summarized and a few common drawbacks are detected. The concept of energy-aware routing should be additional enriched with the energy overheads related to signaling and mobility management in ad hoc wireless environments.

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