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Appraisal on Link Lifetime Prediction Using Geographical Information

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Abstract**—**Geographical routing protocol requires node physical location information to make forwarding decision. Geographical routing uses location service or position service to obtain the position of a node. The geographical information is a geographic coordinates or can be obtained through reference points on some fixed coordinate system. Link can be formed between two nodes. Link lifetime plays a crucial role in MANET. Link lifetime represent how long the link is stable without any failure between the nodes. Link failure may occur due to mobility and because of link failure energy of nodes can be drained. Thus this paper proposes survey about link lifetime prediction using geographical information.

Keywords**—**MANET, Geographical routing, Link lifetime, Link stability.

I. Introduction

MOBILE ad hoc network (MANET) is a type of ad-hoc network which does not require base station. MANET is a self-configuring and infrastructureless network. A MANET consists of many mobile nodes that can communicate with each other directly or through intermediate nodes. In MANET network topology change frequently and nodes are unpredictable. The features of MANET are

- Dynamic network topology
- Autonomous terminal
- Distributed operation
- Multihop routing

Routing is an important characteristic in MANET. Routing is the basic operation in ad-hoc networks. The responsibility of a routing protocol includes exchanging the route information, finding the feasible path to the destination based on criteria such as hop length, minimum power required and lifetime of a wireless link, gathering information about the path breaks, mending the broken paths expending minimum processing power and bandwidth and utilizing minimum bandwidth. Major challenges that a routing protocol faces are as follows [1]

- Dynamic change in topology
- Lack of mobility awareness
- Short battery lifetime
- Limited resources
- Location dependent contention

A routing protocol use software and routing algorithm to determine the optimal network data transfer and communication path between network nodes. There are different routing protocol i.e., protocol based on routing information, based on the use of temporal information, based on topology information, miscellaneous based on utilization of specific resources[1]. Network depends on node support for providing the packet routing. The routing algorithm should be robust, adaptive and in a self-organized way. Nodes cannot forward the data packets to the receiver node when the prediction error is less than a preconfigured threshold value.

The node mobility augments the convolution of routing because the greater the mobility of the nodes, the more chances of link breakage. The link breakage in turn leads to increased routing control overhead and will reduce the efficiency of the network due to the increased frequency of the route discovery process. The action of link breakages in MANET becomes an imperative aspect. This kind link breakage will lead to frequent path failures and may cause route.

A routing protocol which makes use of location information of a node to direct the packet is known as Geographical routing protocol. To detect the exact position of the mobile nodes a special device such as the Global Positioning System (GPS) can be used [11]. Protocol belongs to utilization of specific resources improve the performance of routing and reduce the control overhead by effectively utilizing the geographical information available [1]. The use of geographical information can prevent network wide searches for destinations, as either control packets or data packets can be sent in the general direction of the destination if the recent geographical coordinates for that destination are known [2].

Geographical routing approaches eliminate some of the difficulties of topology based routing. Using the location services such as GPS and other services a node obtains the location information of a node. The forwarding strategy is based on destination location, neighborhood location and node's hop. The pros of geographical routing protocol are

- No need for global view of network topology and its changes
- No need to keep routing table up-to-date

A major challenge in MANET is link failure. Apart from the link lifetime, the information regarding the lifetime of the node, prediction of location and prediction of link availability is an another issue [1]. Due to the mobility link failure or path break occur frequently in the network, energy constraint is another issue. A path selection should be based on minimum

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total transmission power when there exists some possible paths and all nodes through these paths have enough residual battery power [13]. The challenge is to provide energy efficiency by improving the lifetime of the nodes. The energy drain rate of a node is exaggerated not only by its own but also by its neighbouring data flows also. The network maintains its connectivity by choosing a route according to the remaining battery life of nodes [25]. The route may be assured with minimum total transmission power when there exist multiple paths. It is indispensable that all nodes through these paths must have adequate residual battery power.

In MANETs fatigue of energy will be more due to its infrastructure less nature and mobility. This leads to energy drain of nodes completely within a short period with general mobile network. Because of this lack of energy communication stuck between two nodes gets clogged-up and their topology may also vary as these nodes are intermittent from its own communication path. This may significantly affect the recital of routing protocol and also affect the network lifetime. This paper is a survey about link lifetime prediction using geographical location of the nodes.

II. Related Work

A. Lifetime Prediction Routing (LPR)

Lifetime Prediction Routing (LPR) [3] is an on demand source routing protocol which uses battery lifetime prediction. The intention is to extend the lifetime of MANET with dynamic topology. This protocol chooses the path with maximum lifetime. Lifetime Prediction can be achieved by *Simple Moving Average* (SMA) predictor which keeps track of last *N* values of residual energy and the corresponding time instances for the last N packets received/transmitted by each mobile node and this information is recorded and stored in each node. Lifetime of a node is a function of residual energy in the node and energy to transmit a bit from the node to its neighbors. This metric works well for static networks and is not suitable for dynamic [4]. Hence, dynamic distributed load balancing approach is proposed which avoid power blocked nodes and chooses path that is casually loaded. This helps LPR to achieve minimum variance in energy levels in the network. In LPR every nodes except the destination node calculate the predicted lifetime. If the predicted lifetime is lower than the existing min lifetime value then the min lifetime in the header with predicted lifetime is replaced.

In LPR, the destination waits for a threshold number of seconds Route Request (RREQ) after the first RREQ packet arrives. During that time the destination examines the route cost of every arrived RREQ packet. After the timer expires the destination node selects the route with the minimum cost. LPR has a route invalidation timer that eliminates the old routes. In case of low mobility it avoids the over usage of particular paths.

Route maintenance is required for two reasons such as Mobility and Change in predicted lifetime. If a new RREQ is sent out and the entry to the route cache consistent to the node moved out of series is eradicated. This policy is adopted to tackle the change in predicted lifetime. Once the route is established the pathetic node in the path screens the decrease in its battery lifetime. When the remaining lifetime goes beyond a particular threshold level, the node sends a route error back to the destination and the destination sends this route error message to the source. This route error message forces the source to initiate route discovery again. This decision depends on the lasting battery capacity of the current node and its discharge rate. It is known as local decision. LPR adopts this local decision approach because it minimizes the control traffic. Thus, LPR increase the network lifetime and through increasing the lifetime energy can be saved.

B. Link Stability and Energy Aware Routing Protocol (LAER)

A novel routing protocol called Link-stability and Energy aware Routing protocol (LAER) [5] is used for link stability and for minimum drain rate energy consumption. LAER is based on local topology knowledge and it would make use of greedy method based on a joint metric and a modified perimeter forwarding strategy for the recovery from local maximum. Link stability and energy consumption are the two metrics which are used for path selection. It uses Power Efficient Reliable Routing protocol which applies the following three metrics for path selection

1. The estimated total energy to transmit and process a data packet
2. The residual energy
3. The path stability

The LAER algorithm requires each node to advertise its location, rate of energy consumption by each node and its link stability index. Each node broadcast a HELLO packet to the entire neighboring node.

The data forwarding method of LAER is based on greedy technique but the hop selection tries to minimize the joint energy stability in LAER. For greedy technique neighborhood and destination knowledge alone is necessary hence high scalability can be achieved. The flexibility can be offered through the capability to weight the stability and the energy consumption. It is possible to meet a void or local maximum in the GPSR during the greedy technique. Local maximum means a point in the network where it is not possible to find any neighbor node that leads to the minimization of the distance towards the destination in comparison with the current node. In this case, the protocol uses a technique of recovery mode called Perimeter Forwarding.

In LAER Perimeter Forwarding can happen due to greedy routing approach based on the minimization of the joint metric associated with each link. If a node met a local maximum, LAER uses an approach similar to GPSR but the joint metric is used to select the set of neighbor candidates for the perimeter mode. Path stability metric is considered rather than link stability [6].

C. Lifetime-Prediction Protocol in an Exploring Dynamic Nature Routing for Large Scale Network (LEDNR)

In LEDNR [7] protocol every node saves the received signal strength and the received time of the RREQ packet in its local memory and this information is added to the Route Reply (RREP) packet header in a piggyback manner. The node agents update their predicted node lifetime during every period and then the node-lifetime information in the RREP packet is updated when the RREP packet is returned from a destination node to the source node. LEDNR protocol has two algorithms

- Node life time predication algorithm
- Connection lifetime prediction algorithm

1. Node Lifetime Prediction

An active node used in data-forwarding paths consumes more energy than the remaining inactive node and the active node has a shorter lifetime. An exponentially weighted moving average method is used to estimate the energy drain rate. *Ei* represent the current residual energy of node *i*, and *evi* is the rate of energy depletion. *Ei* can be obtained from a battery management instrument, and *evi* is the statistical value obtained from recent history.

2. Connection Life Time Prediction

The connection lifetime is a stable connection within the communication range of each other node and the connection lifetime may last long. If the senders transmit the packets with the same power level, a receiver can measure the received signal strength when receiving a packet and then calculates the distance by directly applying the radio propagation model. If the received signal power strength is lower than a threshold value, this link said to be unstable and the connection time is calculated. The proposed method requires two sample packets, and piggyback information on route-request (RREQ) and route reply (RREP) packets is implemented with no other control overhead message and it does not increase the time complexity.

3. Trust Computation

Trust computation is performed for establishing and determining theme assuring behavior of each node. Trust computations and controlling are highly demanding issues due to the computational complication constraints, and the independent movement of nodes. This would prevent the direct application of techniques appropriate for other networks. The trust level of a node must be positive. In MANETs, a deceitful node can be feeble considerable damage and adversely affect the quality and reliability of data, so trust level of a node should be analyzed. The following functional blocks are proposed

1. Trust computations based on metrics and definitions
2. Trust propagation
3. Trust aggregation
4. Trust prediction
5. Trust applications

D. Power Boosting Geographic Routing with Link Lifetime Estimation (PBGR)

Traditional geographic routing have been developed based on the combinations of greedy forwarding and face routing. Abundant researches can be classified into two categories: greedy forwarding and face routing improvements. Similarly in PBGR [9] two metrics are used to decide a forwarding node in the greedy forwarding algorithm. In this approach, a forwarding node should satisfy following two conditions [9]: (1) The estimated location of it is the closest to a destination node; (2) The expected distance from a forwarding node is less than the transmission range of the forwarding node. PBGR [8] has three metrics such as greedy forwarding, temporal power boosting and link lifetime estimation. PBGR protocol predicts the link lifetime using the model from [14] which adopts a free space propagation model [15] where the received signal asset is only determined by the distance to the transmitter. Therefore, as long as the distance between two nodes is less than the transmission range or equivalently the signal strength is higher than some threshold the link between them can be maintained. Using greedy forwarding technique the neighbor node, which is geographically closer to the destination, forwards a packet. A metric called expected link lifetime is used to select a forwarding node. In case of link failure the performance of network can be degraded, to overcome this situation a protocol called PBGR check the expected link lifetime between the selected forwarding node and a node. If the expected lifetime of a link is lesser than particular threshold then the forwarding node is discarded. The perimeter forwarding in PBGR starts if there is no neighbor node closer to destination.

E. Stability-Based Adaptive Routing Schemes (SSA)

In this SSA routing link is classified based on received signal strength [16]. It is classified into strong one and weak one. The mobile node will process the RouteRequest (RREQ) based on its signal strength. The mobile node process the RREQ that is received from strongest link.

SSA protocol has two protocols

- Forwarding Protocol(FP)
- Dynamic Routing Protocol(DRP)

SSA protocol should consider unpredictable mobility nature and location instability of nodes.

F. Link Stability Prediction-Based Routing (LSPR)

In LSPR, to evaluate the mean link duration to predict link stability it uses relative motion and distance between two neighbour nodes [17]. After the delay is decided by the mean link duration predicted the mid nodes forwarded RREQ to other nodes. A forwarding rule is used to reduce the number of RREQ.

III. Conclusion

Among number of network architectures, the design of mobile ad hoc network (MANET) has attracted a lot of attention [18]-[24]. A MANET composed of a set of mobile hosts that can communicate with other. Routing is challenging in MANET because mobility may cause radio links to break frequently. When any link of a path breaks, that path needs to be either repaired by finding another link or replaced with a newly found path [10]. In MANETs, a link is formed by two adjacent mobile nodes which have limited battery energy and can roam freely and the link is said to be broken if any of the nodes died because they run out of energy or they move out of each other's communication range [1]. There are two types of lifetimes related to the lifetime of the network: node battery lifetime and link lifetime. A host in a MANET operates with batteries and can roam freely and a host may exhaust its power or move away, giving no notice to its neighboring nodes causing changes in network topology. The energy drain rate of a node is affected not only by its own but also by its neighboring data flows [12]. One of the important and challenging problem in the design of ad hoc networks is the development of an efficient routing protocol that can provide high-quality communications among mobile hosts. This survey paper considered both the node lifetime and Link Life Time (LLT) to predict the route lifetime and the dynamic nature of mobile nodes such as the energy drain rate and their relative motion estimation rate of nodes to evaluate the node lifetime and the LLT. Link Expiration Time (LET) is used to judge the stability of the link.

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