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Improving Link Stability and Energy Saving in Mobile Adhoc Networks

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Abstract

A mobile ad hoc network (MANET) is a self-configuring infrastructure less network of mobile devices connected by wireless. In the mobile adhoc networks the mobile nodes are move randomly in the network so that design of stable and efficient routing protocols in mobile ad hoc networks is an important concern. So, in order to overcome this problem, we use a novel technique called a stability considered density adaptive routing protocol not only to support the stable routing, but to guarantee the efficiency of routing process[1] in order to reduce the overhead caused by control messages generated in the routing process.

SDR is also a stability-considered routing protocol that is suitable to the dynamicity

feature of MANETs According to different density values of vicinity; our proposal adopts the corresponding routing tactics to guarantee the stability and efficiency of routing process. Stability considered density adaptive routing protocol does not require routing table refresh or flooding in network, so the overhead caused by frequent broadcasts of advertisements can be reduced. But in this method high energy consumption. Energy saving mechanisms based only on metrics related to the remaining energy cannot be used to establish

the best route between source and destination nodes. So, in order to overcome this trouble, we introduce a technique to calculate energy metric for each node. Actually, in the mobile adhoc networks different nodes take different amount of energy for transmitting the same data packets. Based on this energy metric the path has to be chosen. Due to the energy drain rate, improve the energy saving. By using this energy aware metric we achieve high Data Packet Delivery Ratio, Normalized Control Overhead, Link duration, Nodes lifetime, and Average energy consumption.

INTRODUCTION

1. Introduction of the project

A mobile adhoc network (MANET) is a self-configuring infrastructure less network of mobile devices connected by wireless. Mobile ad hoc networks (MANETs) are sets of mobile devices that communicate with each other using wireless media without support of any existing network infrastructure. MANETs are suitable for applications, in which installing an infrastructure is not possible because the infrastructure is too expensive or too vulnerable, or the network is too transient, or the infrastructure was destroyed, such as in military, emergency rescue, and mining operations as well as in conference occasions. Compared to other types of wireless networks, MANETs are more difficult to guarantee the connectivity and communication between nodes due to the unique characteristics.

To improve the quality of routing, several improved routing protocols are used. The Optimized Link State Routing Protocol (OLSR) and Zone Routing Protocol (ZRP) are used for improve the routing. For the purpose of reducing overhead, OLSR reduces control packets by selecting only partial neighbor nodes for packet forwarding. For the same purpose, ZRP combines proactive routing and on-demand routing: in local zone, ZRP uses proactive routing; between remote nodes, ZRP uses on-demand routing. The Modified Greedy Perimeter Stateless Routing (Modified-GPSR) routing protocol for efficient communication among sensor nodes, which identifies optimal route based on energy utilization. The Modified-GPSR approach results in near optimal communication cost across the network. The algorithm provides energy efficient routing protocol with the ability to route data from source node to destination node and assures reliable delivery of packets.

In order to provide efficient routing, we use a novel technique called stability-considered density-adaptive routing (SDR) protocol. In the SDR protocol, each node evaluates the density of its vicinity. According to the density value, each node chooses different routing tactics: D-mode or S-mode. (1) If density value is larger than a predefined threshold of density value (p_{th}), D-mode is triggered as the routing tactics for the forwarding node. Forwarding nodes are those that participate into routing process according to their certain superiority, e.g., stability distance from the former forwarding node. Contrary to forwarding nodes, we name the other nodes that do not attend routing process as idle nodes. (2) If density value is smaller than p_{th}, S-mode is triggered as the routing tactics for the forwarding node. In addition to that the energy aware metric is calculated for each node to reduce the energy consumption. In the mobile adhoc networks different nodes take different amount of energy to transmit and receive the data packets. So, based on energy metric the path is to be chosen.

2 SYSTEM ANALYSIS

2.1 Existing System

In the existing system, we introduce an innovative technique called a stability-considered density-adaptive routing (SDR) protocol that has the following features making it suitable for the environment of MANETs:

(1) SDR is a density-adaptive routing protocol that can perform different routing tactics according to the corresponding density of vicinity. The routing tactics are termed as dense mode (D-mode) and sparse-mode (S-mode), respectively. In consideration of density value of vicinity, SDR can not only reduce the overhead in dense network, which is mainly caused by broadcast of control messages, but also guarantee the routing quality in sparse network.

(2) SDR is a distributed routing protocol that is suitable to the infrastructure of MANETs. The determination of whether to be a forwarding node or not (i.e., whether to participate into the routing process), is made by each node itself independently and autonomously. Moreover, each node in MANETs switches the routing mode (i.e., D-mode or S-mode) for different routing tactic autonomously, which is termed as routing mode self-selection.

(3) SDR is also a stability-considered routing protocol that is suitable to the dynamicity feature of MANETs[1]. In SDR, relatively stable nodes are elected to form the relatively stable routing path. By considering stability value of each node, SDR can not only guarantee the stable routing process, but also reduce the overhead caused by re-routing while link break occurs.

(4) SDR does not require routing table refresh or flooding in network, so the overhead caused by frequent broadcasts of advertisements can be reduced. SDR only

requires the knowledge of local neighborhood instead of the global view of the whole network.

In the SDR [2], each node evaluates the density of its vicinity. According to the density value, each node chooses different routing tactics: D-mode or S-mode. (1) If density value is larger than a predefined threshold of density value (p_{th}), D-mode is triggered as the routing tactics for the forwarding node. We define forwarding node as follows: Forwarding nodes are those that participate into routing process according to their certain superiority, e.g., stability, distance from the former forwarding node. Contrary to forwarding nodes, we name the other nodes that do not attend routing process as idle nodes. (2) If density value is smaller than p_{th}, S-mode is triggered as the routing tactics for the forwarding node.

2.2 Proposed System

In the proposed system, in order to save energy we calculate energy drain rate. Because in the mobile adhoc networks[3] to transmit the same data packets the nodes take different amount of energy. Energy saving mechanisms based only on metrics related to the remaining energy cannot be used to establish the best route between source and destination nodes. If a node is willing to accept all route requests only because it currently has enough residual battery capacity, much traffic load will be injected through that node. In this sense, the actual drain rate of energy consumption of the node will tend to be high, resulting in a sharp reduction of battery energy. As a consequence, it could exhaust the node energy supply very quickly, causing the node soon to halt. To mitigate this problem, other metrics, based on the traffic load characteristics, could be employed. To this end, techniques to measure accurately traffic load at nodes should be devised. In

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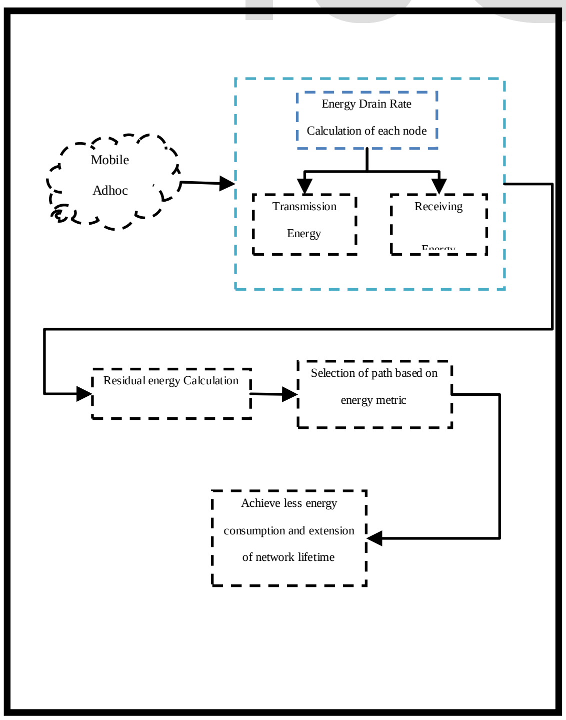
particular, the Minimum Drain Rate will be considered. If the energy consumption decreases, then the lifetime of the nodes is increased. So, by using this energy metric the path has to be chosen. Energy drain rate is calculated by subtracting energy saved in sleep mode from the energy consumption. After that the energy drain rate is calculated for all paths. We select the minimum drain rate path for that we achieve minimum energy consumption.

2.3 Architecture Diagram



3. SYSTEM IMPLEMENTATION

3.1 Network model

An undirected graph G (V, E) where the set of vertices V represent the mobile nodes in the network and E represents set of edges in the graph which represents the physical or logical links between the mobile nodes. Sensor nodes are placed at a same level. Two nodes that can communicate directly with each other are connected by an edge in the graph. Let N denote a network of m mobile nodes, N1, N2...Nm and let D denote a collection of n data items d1; d2; . . . ; dn distributed in the network. For each pair of mobile nodes Ni and Nj, let tij denote the delay of transmitting a data item of unit-size between these two nodes.

3.2 Calculation of density of the node

In the SDR protocol is a density adaptive routing protocol that employs different routing mode according to the density value. To calculate the density, the destination facing and stability-considered density (p_{ds}),[5] to measure the density in each node's vicinity.

3.3 Destination facing area (DFA)

Consider that the nodes in the destination facing area of each node's transmission area are more useful and valuable than the nodes in the opposite direction area [4] in terms of packet forwarding, since the nodes in the destination facing area are closer to destination node than the nodes in the opposite direction area. By considering the DFA, the calculation of density value[5] can be more precise and reasonable in respect to packets forwarding. The DFA and reference line can be obtained with the aforementioned assumptions:

(1) A node can determine its own position.

(2) A node is aware of its neighbors' position.

(3) The position of the destination node is known by the source node.

Besides DFA, each node's stability is taken into consideration for calculating the density value of each node. The motivation of introducing stability is as follows: (1) First, since the network environment is MANETs, each node can move around with certain velocity. The nodes with large velocity may cause frequent topology changes[6], which can lead to frequent link breaks. (2) In addition, frequent re-routing processes caused by link breaks can increase the overhead greatly in the network.

3.4 Stability Evaluation

In the stability evaluation, nodes know the picture of their corresponding vicinity by beacon message. The network formed by nodes and links can be represented by a directed graph G(t) =

(V(E(t)) called neighbor relation graph, wherein V={1,2..N} denotes set of participating nodes, and E(t)= $\{e_1, e_2, \ldots e_m\}$ denotes the set of wireless links. If node i can receive information which is sent from j, there is a directed edge e(i,j) between node i and node j, i.e., node j is the neighbor of node i. $E_i(t_j)$ and $E_i(t_{j+1})$ denote the wireless links situation of node i at two adjacent time points t_j and t_{j+1}. The stability value can be represented by the mean similarity value between $E_i(t_j)$ and $E_i(t_{j+1})$ are as,

$$S_i = \frac{1}{n-1}\sum_{j=1}^{n-1} cos\theta_j = \frac{1}{n-1}\sum_{j=1}^{n-1} \frac{E_i(t_{j+1})}{|E_i(t_j)||E(t_{j+1})_i|}$$

where θ_j is the included angle between the vectors $E_i(t_j)$ and $E_i(t_{j+1})$. n is number of time points at which E(t) is observed. S_i denotes the similarity between node i's vicinity situation status at different time points, e.g $E_i(t_j)$ and $E_i(t_{j+1})$. If S_i is larger the angle between $E_i(t_j)$ and $E_i(t_{j+1})$ namely θ_j will be smaller which implies more similarity between $E_i(t_j)$ and $E_i(t_{j+1})$ i.e., the neighbors of node i do not change dynamically at t_j and t_{j+1} namely node i is relatively stable. On the contrary, if S_i is smaller, θ ill be larger, which expresses less similarity between $E_i(t_j)$ and $E_i(t_{j+1})$ i.e., the neighbors of node i change dynamically at t_j and t_{j+1} namely node i moves fast.

3.5 D-mode mechanism

If the forwarding node's destination facing vicinity is dense[7], i.e., the density value in the DFA of the node is larger thanp_{th}, D-mode is selected by the forwarding node. D-mode has route request process and route reply process.

3.6 Route Request process

The route request process works as follows.

Step 1: The source node starts route request by broadcasting RREQ (Route Request)

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which could be received by each one-hop neighbors.

Step 2: After receiving RREQ, each one-hop neighbor node checks whether it is the destination node or not, or whether it has a valid route to the destination or not. If it is, the process goes to step 5; otherwise, the process goes to step 3.

Step 3: Each one-hop intermediate neighbor node (e.g., node i) initializes backoff time (B_i) and waits for the corresponding B_i.

Step 4: The first node that runs out the backoff time rebroadcasts the RREQ. The node that hears the same RREQ more than once ignores it and stops the backoff waiting. Then, the process goes to step 2 to continue the relaying of the RREQ until the RREQ reaches the destination.

Step 5: When the destination node receives the RREQ,[8] the route request process ends and the route reply process starts; otherwise, the process goes to step 2 to continue the relaying of the RREQ until the RREQ reaches the destination.

$$B_i = b_i.CW_{min} \qquad (0<b<1) \qquad (2)$$

Where CW_{min} is the minimum contention window. The Distributed Coordinating Function (DCF) of 802.11 specifies the use of CSMA/CA with the purpose of decreasing collisions. A node which intends to transmit packets picks a random back off value from [0, CW] (CW is the contention window size), and performs transmission after waiting for back off value delay. If a transmission is unsuccessful, the CW value is doubled. If the transmission is successful, the node resets its CW to a minimum value.

The back off time B_i is the dependent variable depends in the coefficient b_i. If b_i is large B_i is also large. i.e., the node which is assigned a large B_i has to wait for longer time before rebroadcast the RREQ received from the former forwarding node. It means the RREQ message may probably be swallowed instead of being rebroadcasted, since any node acts on only the first RREQ with the same RREQ ID and ignores any subsequent RREQs. If b_i is small, B_i will be small. The node which is assigned a large B_i waits for shorter time before rebroadcast the RREQ received from the former forwarding node. The calculate on of coefficient b_i of node i:

$$b_i = \left(\ln\frac{1}{d_i^{norm}}\right)\left(\ln\frac{1}{S_i^{norm}}\right)\left(\ln\frac{1}{C_i^{norm}}\right) \quad (3)$$

The coefficient b_i is the function of three parameters, i.e., normalized distance value (d_i^{norm}) , normalized stability value (S_i^{norm}) and normalized connectivity value (C_i^{norm}).

The first parameter ''normalized distance value d_i^{norm} can be calculated as,

$$d_i^{norm} = \frac{d_i - \mu_d}{\partial_d} \quad (4)$$

$$\mu_i^d = E[d_i] = \frac{1}{n}\sum_{i=1}^{n} d_i \quad (5)$$

$$= \sqrt{E[(d_i - \mu_i^d)^2]} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(d_i - \mu_i^d)^2} \quad \partial_i^d \quad (6)$$

Where μ_i^d is the mean of distance in the vicinity of node i; ∂_i^d is the standard deviation of distance of node i. d_i is the distance between current forwarding node and the former forwarding node projected along the direction of reference line S–D between the source node and the destination node.

$$d_i = \left[\sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}\right] . |\cos\delta_i$$

$$\delta_i = argtan\frac{y_i - y_j}{x_i - x_j} - argtan\frac{y_i - y_d}{x_i - x_d}$$

Where (x_i, y_i) is the coordinate of the former forwarding node, (x_j, y_j) is the current coordinate of the candidate forwarding node, and (x_d, y_d) is the coordinate of the destination node.

The second parameter ''normalized stability value S_i^{norm} can be calculated as,

$$S_i^{norm} = \frac{S_i - \mu_i^s}{\partial_i^s} \quad (7)$$

$$\partial_i^s = \sqrt{E[(S_i - \mu_i^s)^2]} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(S_i - \mu_i^s)^2} \quad (8)$$

Where S_i is the stability value of the candidate forwarding node i. μ_i^s is the mean of stability in the vicinity of node i; ∂_i^s is the standard deviation of stability of node i.

The third parameter ''normalized connectivity value (C_i^{norm}) can be calculated as,

$$\mu_i^c = E[C_i] = \frac{1}{n}\sum_{i-1}^{n} C_i \quad (9)$$

$$\partial_i^c = \sqrt{E[(C_i - \mu_i^c)^2]} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(C_i - \mu_i^c)^2} \quad (10)$$

Where C_i is the distance-considered connectivity value of the candidate forwarding node i. μ_i^c is the mean of connectivity in the vicinity; ∂_i^c is the standard deviation of connectivity[8] . A node i is considered to be a neighbor of another node j if node i lies within the transmission range of node j. The node with larger number of neighbors and smaller distance from neighbors has higher opportunity to be chosen as a forwarding node. It's better to elect a forwarding node with the nearest members. This might minimize node detachments and enhances link's stability. If a forwarding node has distant neighbors, more power is required to communicate with larger distance node. Therefore, signal strength decreases with distance. Thus, less distance summative nodes[9] are more preferred than with higher distance summative values.

$$C_i = \frac{Deg_i}{Dist_i} \quad (11)$$

Where Deg_i is the number of node i's neighbors in the vicinity evaluated. $Dist_i$ is the distance summative value between the node and its neighbors in the vicinity evaluated,

$$Deg_i = \sum_{i=1, j\neq i}^{N} \begin{Bmatrix} 1, dist(i,j) \leq T_{range} \\ 0, others \end{Bmatrix}$$

$$Dist_i = \sum_{i=1, j\neq i}^{N} \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}$$

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Where (x_i, y_i) and (x_j, y_j) are the coordinates of node i and node j, respectively.

3.6 Route reply process

The route reply process works as follows.

Step 1: When the RREQ reaches the destination node D or an intermediate node that knows a valid route to node D, RREP (Route Reply) is sent to the source node S along the inverse accumulated path. The RREP includes inversed full path that the RREQ traversed along.

Step 2: Nodes on the path relay the RREP to the next-hop node toward the source node S, until the RREP reaches the source node S. The unique characteristic of the proposed route reply process is re-routing before link break. The motivation of re-routing before link break is that: in conventional routing protocols in MANETs, conventional route maintenance process is required to maintain the routing path. When link break occurs, Route Error message (RRER) is generated by the intermediate node which senses the link break, and then sent to the source node. When receiving the RRER, the source node re-initializes routing request process by re-broadcasting RREQ message again. Apparently, the conventional re-routing after link break causes non-ignorable delay. To solve this issue, we introduce a self-denounce mechanism to achieve re-routing before link break. As we mentioned, in SDR, RREP message piggybacks stability value of each node along the reply route. The intermediate nodes, whose stability value is smaller than a predefined threshold of stability value (S_{th}), is required to piggyback its stability value and velocity in the RREP to denounce itself as the relatively not stable node. The routing path life time is the minimum value of link life time is calculated as,

$$T_{path} = \min(T_{link}) \qquad (12)$$

Where T_{link} is the life time of a link. T_{path} is the life time of a path. A path is comprised by several one-hop long links.

After receiving the RREP, the source node extracts the stability values and velocity values, and evaluates the potential routing path life time,

$$T_{path} = \min(T_{link}) \tag{13}$$

$$= \min \left[\frac{-(ab+cd)+\sqrt{(a^2+c^2).r^2-(ad-bc)^2}}{a^2+c^2}\right]$$

$$T_{path} = \min(T_{link})$$

Where a, b, c, d can be calculated,

a = $v_i.cos\eta_i - v_j.cos\eta_j$

b = $x_i - x_j$

c = $v_i.\sin\eta_i - v_j.\sin\eta_j$

d = $y_i - y_j$

where (x_i, y_i) and (x_j, y_j) are coordinates of two one-hop adjacent intermediate nodes i and j. v_i and v_j are the speed of the two nodes. η_i and η_j represent the orientation of the two nodes.

3.7 S-mode mechanism

When the density value is smaller than the predefined threshold of density value (p_{th}) S-mode[10] is triggered as the routing tactics. In S-mode, a stability-based face routing mechanism is proposed for the routing. Firstly, we present an improved graph algorithm, i.e., Stability-considered Gabriel Graph Algorithm (SGG). The contribution is that we propose a stability-considered graph algorithm named Stability-considered Gabriel Graph Algorithm (SGG). In SGG, the node whose stability value is smaller than a predefined threshold of stability value (S_{th}) cannot be included in the formation of the graph. When the density of the forwarding node's neighborhood is smaller than the threshold, the S-mode is selected as the routing mode. In S-mode, stability-considered face routing is selected by the forwarding node. It is based on the idea that the network links form a communication graph, and a message can be routed along a sequence of faces in this graph. Routing along a face means that the nodes of a face pass the message along the incident edges by locally applying the left-hand or right-hand rule.

3.8 Energy efficient routing method

When a source node has information to send, it sends a Route Request packet. We change Route Request packet in the way that include some additional variables. We use such additional variables to collect necessary information throughout network and make decision about routing. One of these variables is reqSize. Source node puts size of data that wants to send at this variable and sends route request packet. Other additional variables consist of: unstable Nodes Count, sum Of Neighbors, and sum Of Buffered Packets, which apply in turn for holding unstable nodes count during path, founding sum of neighbors of all nodes in the path, and founding sum of buffered packets of all nodes in the path. When a node receives Route Request packet from others, a receiving node calculates own remaining lifetime by following equation:

$$RLT_i = \frac{E_i}{DR_i} \quad (14)$$

RLT_i is the remaining lifetime, E_i is the residual energy, and DR_i is the drain rate of node i and indicates how much the average energy is consumed by a node n_i per second during the interval. The node battery power drain rate[10] actual value is calculated, using the well-known exponential weighted moving average method applied to the drain rate values DR_{old} and DR_{sample} representing the previous and the newly calculated values, as follows:

$$DR_i = \alpha \times DR_{old} + (1 - \alpha) \times DR_{sample}$$

If the node remaining lifetime is more than the needed time to send data packets, which are supposed to send from source to destination, it broadcasts Route Request packet, otherwise it will drop it.

3.9 Performance evaluation

In this section the performance of the existing and proposed method is compared. In the existing method, a stability considered density adaptive routing protocol is used. In the proposed method, the energy efficient routing method is proposed. Compared to the existing method in the proposed method to achieve energy efficiency.

4.RESULTS AND DISCUSSION

5.CONCLUSION AND FUTURE WORK

5.1 Conclusion

A routing protocol, named as SDR, is proposed in MANETs considering both stability metric and density metric. According to different density value, different routing tactics is selected for each node autonomously: when the density of a node's neighborhood is large, the dense mode is selected by the node for routing; conversely, when the density of the node's neighborhood is small, the sparse mode is selected for the routing. By this density-adaptive routing tactics switch mechanism, not only the efficiency in routing process can be guaranteed, but also the recovery process can be prevented. As to stability metric, considering re-routing, which is mainly caused by link break or topology change lead by node's movement, can cause serious overhead, we choose the node with high stability value to attend the routing process. By doing this, the path between source node and destination node could be relatively stable. In order to improve energy efficiency, we introduce a technique to calculate energy metric for each node. Actually, in the mobile adhoc networks different nodes take different amount of energy for transmitting the same data packets. Based on this energy metric the path has to be chosen. Due to the energy drain rate, improve the energy saving.

5.2 Future work

For future work, security in mobile adhoc network is to be considered. A MANET-based application depends on a multitude of factors, with trustworthiness being one of the primary challenges to be met. Despite the existence of well-known security mechanisms, additional vulnerabilities and features pertinent to this new networking paradigm might render such traditional solutions inapplicable. In particular, the absence of a central authorization facility in an open and distributed communication environment is a major challenge, especially due to the need for cooperative network operation.

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