A Packet Switching Routing in Node-Disjoint Multipaths for Energy Durability

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Abstract

A Mobile Ad hoc NETwork(MANET) is a system of wireless mobile nodes that dynamically self-organize in arbitrary and temporary network topologies. In the highly dynamic environment of MANET, energy efficiency is an important performance measure since it directly affects the network lifetime. The failure of energy severely impacts a communications system in crucial communications environments, such as disasters salvage. In this study, we propose a new packet switching routing that can increase the durability of the energy resource and therefore, the lifetime of the mobile nodes and MANET. The performance of the packet switching routing on the node-disjoint multipath and that of AODV are compared by NS2 simulation. The simulation results indicate that this new switching routing can extend the lifetime of a MANET.

1. Introduction

MANET(Mobile Ad hoc Network) is a dynamically self-organizing network without using any fixed infra such as base station or AP [1,2,3]. But since every node can move, changes in network topology are frequent, thereby MANET routing path can be easily broken. If the energy of nodes can not be balanced efficiently through the network, some nodes will be out of commission too early because of exhausting energy. Therefore, in MANETs, it's an important issue to establish and administrate the effective and steady routing between communication nodes. It is well known that there are three categories of routing protocols in MANETs. The first one is Table-driven(or Proactive) in which routes to destination are readily available at every node at all times. The second one is On-demand(or Reactive) which gathers the route information while a node require a route to destination. And the last one is Hybrid combining Table-driven and On-demand [4,5].

Nowadays, a lot of routing protocols have been researched and developed. MANET Working Group in IETF has already been doing much standardization of protocols [6-10]. However, most routing protocols including AODV and DSR just seek to establish the shortest unipath because of only considering the nodes mobility. Actually, nodes of MANET are not only influenced by the mobility but also restricted by remained energy, signal intensity, security and so on.

In order to prevent some nodes from being down because of exhausting the energy too early, we propose a packet switching routing based on the energy collection method of using average or minimum energy values on the Node-Disjoint Multipath Routing. The method are Hello Message Average and Hello Message Minimum respectively. The performance of the packet switching routing and that of AODV are compared by NS2 simulation.

2. Unipath and Multipath

This section introduces and compares the advantages and disadvantages of the representative routing protocols in MANET.

2.1. Unipath Routing

AODV and DSR are the representative protocols in MANET. And both protocols employ On-demand approach to establish a path between a source and a destination.

AODV(Ad hoc On-demand Distance Vector) [6] is the protocol registered in the RFC3750 document of IETF as the most widely used and researched protocol.

According to AODV, the source node initiates a path discovery process in order to establish a path to the destination. In the process, the source node broadcasts a Route REQuest (RREQ) packets to its neighbors.

Then the RREQ is forwarded to their neighbors, and so on, until either the destination or an intermediate node with a path to the destination. During the process of forwarding the RREQ, intermediate nodes record in their routing table the previous node addresses of neighbors from which the RREQ is received, for establishing a reverse path. If copies of the RREQ are later received, these packets are silently discarded.

Once the RREQ has reached the destination, the destination node responds by unicasting a Route REPly (RREP) packets to the source node by a reverse path established in the forwarding process. As the RREP

backs along the reverse path, nodes along this path set up routing table between the source and the destination. Finally, the path discovery process will be accomplished as the RREP returns to the source and then data packets will be transferred.

DSR(Dynamic Source Routing) [7] is another representative protocol in MANET. Similar with AODV, the source initiates route discovery by broadcasting a RREQ packet in DSR. However, when this RREQ pass through the intermediate nodes, it can collect the addresses and add these to RREQ. By the time the packet reaches the destination node, it contains the path information between the source and the destination. The destination node receiving RREQ generates RREP and places the path information contained in RREQ into RREP. When the RREP returns to the source, the source will receive the whole path information and add it into packet head for source routing. But the DSR also has disadvantage of the incrementing packet size by including the path information in the packet head

2.2. Multipath Routing

For providing a robust and steady communication, Multipath Routing establishes multipaths between a source and a destination. In MANET, every mobile node moves frequently but has limited energy, thereby the paths usually breaks because of the nodes exhausting energy. The common Unipath Routing employs only one path for communication. So when the path breaks, it has to require the new discovery process. To solve the defect, the research of establishing multipath to provide robust and steady path is studied [11,12,13].

The establishment method of multipath vary as many factors such as the number of node, density, mobility, remained energy, network security and so on.

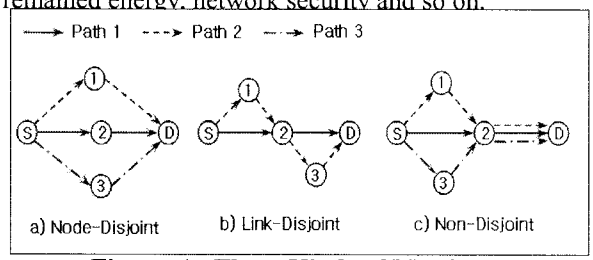

Figure 1. Three Kinds of Multipath

Three kinds of multipath are shown in Figure 1. Node-Disjoint is the complete separate multipath without any shared nodes and links(a); Link-Disjoint is a kind of multipath in which the nodes could be shared but all links are separate(b); Non-Disjoint is the multipath with shared nodes and links(c).

These three kinds of multipath have their own advantages and disadvantages respectively. Node-Disjoint is outstanding in overhead distribution and security because of the complete separation. But it's tough finding the complete separate multipath and the number of multipaths is usually scarce. Compared with the Node-Disjoint, Link-Disjoint hold advantages on the number of the paths. However, as a result of intensive nodes overhead, shared nodes are easy to be down, thereby causing several paths to break simultaneously. Finally, in Non-Disjoint, it is easy to find out abundant multipaths, but many shared nodes and links could bring about the paths unstable and increase the administration overhead. In the three kinds of multipath routings, if the Node-Disjoint can effectively discover and establish the paths, it can bring a steady and excellent performance.

3. A Packet Switching Routing in Node-Disjoint Multipaths

A packet switching routing in Node-Disjoint Multipahts is proposed. The packet switching routing proposed can accomplish the packet switching in node-disjoint multipaths according to the energy information collected by HELLO message periodically.

3.1. Packet Switching Routing

Packet Switching Routing makes use of HELLO message to periodically gather the energy information in the path maintenance process. Then, according to the energy information collected, the packet switching can be achieved within node-disjoint multipaths.

Here, the packet switching routing is carried out based on two categories of energy information, average energy information and minimum energy information respectively

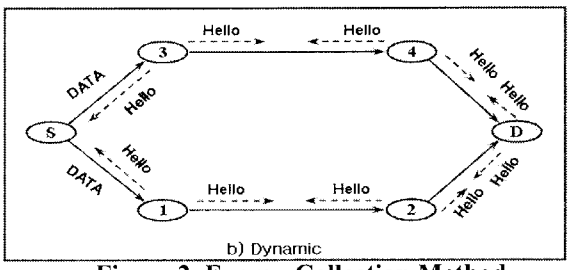

Figure 2. Energy Collection Method

Figure 2 shows the energy collection process. After the establishment of node-disjoint multipath, each active node broadcasts HELLO message to its neighbors. In the packet switching routing proposed, the energy information is added into HELLO message. And if the node receives HELLO message from its downstream node, it will obtain and update the energy information. And then, the energy information updated will be forwarded to the upstream node. The process will continue until the source receives the most recent energy information.

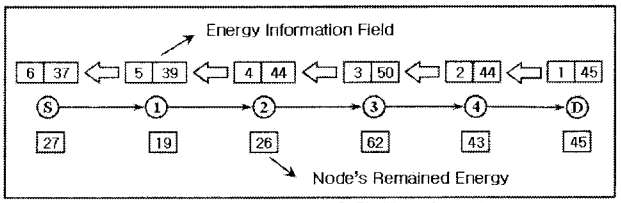

Figure 3. The Procedure of Collecting Average Energy Value

Figure 3 shows the collecting procedure of the nodes' average energy value from the destination D to the source S. In Figure 3, Energy Information Field of the packet is constituted by the number of node and average energy value. And the number of node and average energy value can be obtained by formula (1) and (2) respectively.

$$N_i = N_j + 1 \tag{1}$$

$$E_{i-ave} = \frac{(N_j \times E_{j\text{-}ave}) + E_i}{N_j + 1} \tag{2}$$

N_i is the number of node included in Energy Information Field to be forwarded to the upstream node. N_j is the number of node received from the downstream node j. E_{i-ave} is the average energy value to be forwarded to the upstream node. E_{j-ave} is the average energy value received from downstream node j. E_i shows remained energy of node i. On passing through nodes, the energy information can be calculated and updated. When the energy information reaches the source, the average energy information of all nodes on the path can be obtained. The mathematical proof of the average value is shown as follows:

$$\textit{Node } 1: \quad (E1,\ 1)$$

$$\textit{Node } 2: \quad (\frac{E1 \times 1 + E2}{2},\ 2) \quad => \quad (\frac{E1 + E2}{2},\ 2)$$

$$\textit{Node } 3: \quad (\frac{\frac{E1 + E2}{2} \times 2 + E3}{3},\ 3) \quad => \quad (\frac{E1 + E2 + E3}{3},\ 3)$$

...

$$\textit{Node } n: \quad (\frac{\sum_{i=1}^{n-1} Ei}{n-1} \times (n-1) + En}{n},\ n) \quad => \quad (\frac{\sum_{i=1}^{n} Ei}{n},\ n)$$

Packet Switching Routing based on minimum energy information is simpler than that according to the average energy information. It just needs to compare the current node's remained energy value with the minimum energy value forwarded from the destination node to the source. After comparing, the less value will be updated into the Energy Information Field and forwarded. Likewise, the same process continues until the Energy Information Field reaches to the source.

3.2. Packet Switching Method for Energy Balancing

In the simulation, we propose to apply the packet switching routing to the node-disjoint multipaths. In the establishment of node-disjoint multipath, the source broadcasts the route request packet traversing the network. And each intermediate records the address from which the first copy of route request packet and discards the additional copies of the same route request packet, thereby establishing a reverse path. The destination node receiving every route request packet from different paths responds by forwarding the route reply packets to the source along with the each reverse path, thus, establishing the node-disjoint multipath.

For energy balancing, packet switching routing based on average energy information switch the packet transmission in different paths according to each path's energy proportion in the node-disjoint multipaths. And the routing based on minimum energy information makes use of path with maximum minimum energy information to send packet in order to achieving the same objective.

4. Performance Evaluation

By the computer simulation, we compare and evaluate the performance of packet switching routing based on two categories energy information and that of AODV. Simulation tool in the research is NS2 [14,15], the version of ns-allinone-2.28.

The simulation deploys 45 nodes randomly within the testing area of 1000m × 1000m. The three source-destination links are provided. The transmission range is 250 meters. Free space propagation channel and data transfer ratio is 2Mbps. Energy model initials the energy value as 100 for analyzing. The energy consumption for sending and receiving one packet is 0.6 and 0.3 respectively. The simulation time is 500 seconds. Finally, after the communication finishes, the remained energy value, the packet delivery ratio and routing overhead which are widely used in MANET are evaluated.

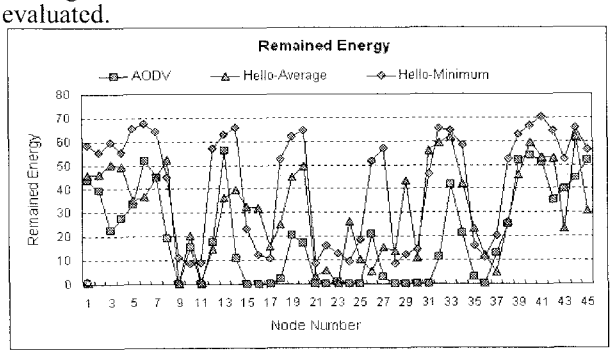

Figure 4. Remained Energy

Figure.4 shows remained energy after the communication finishes. In this case, many nodes are down before finishing the communications, which induces breaking the paths. AODV has to re-initiate a new path request process when the path breaks. As the increasing number of nodes exhausting energy, flooding RREP has to be repeated constantly. In contrast, because of applying the packet switching routing, the energy consumption can be balanced to the entire network on the Node-Disjoint Multipath. Thereby, the proposed packet switching routing based on the energy information, not only can preserve energy but also reduce the number of nodes exhausting use of the energy. Especially, the packet switching routing based on minimum energy information shows

that each node's minimum energy can be controlled and down of nodes are efficiently prevented.

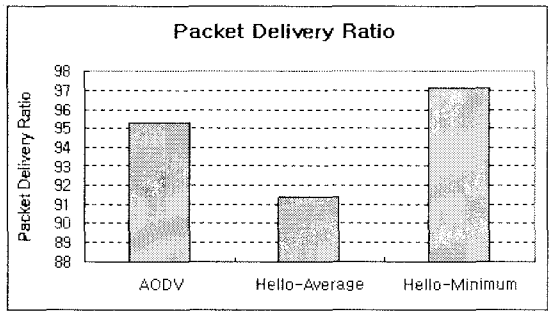

Figure 5. Packet Delivery Ratio

Figure 5 shows the packet delivery. Initial energy 100 means all nodes have unsufficient energy. In this case, the routing based on minimum energy information shows the best performance because it maintains the path better and reduces the probability of the path breaks on account of nodes exhausting energy.

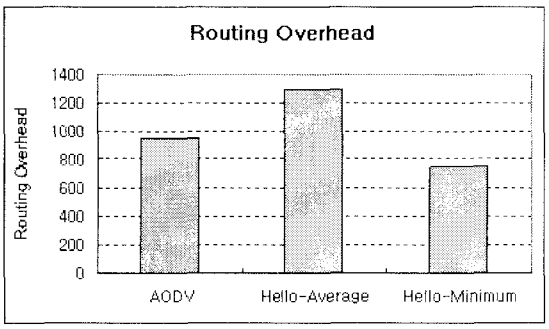

Figure 6. Routing Overhead

Figure 6 shows the routing overhead of proposed packet switching routing and that of AODV. In the case of initial value 100, the more frequent paths break in AODV than those of the packet switching routing based on minimum energy information cause worse performance.

5. Conclusions

The packet switching routing based on the energy information is proposed upon Node-Disjoint Multipath Routing. The performance of the proposed packet switching routing is compared with that of AODV.

The computer simulation verifies that the packet switching routing based on minimum energy information has better performance in remained energy, packet delivery ratio and overhead, especially on low energy situations.

A future research issues are to apply the packet switching routing to several kinds of multipath routing protocols on considering the various initial energy values and mobility of nodes

6. References

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