Studty on Event and Energy Aware Node Disjoint Multipath Routing Algorithm in WMSNs

Yongqiang He[1,2]

[1]College of Computer, Henan University of Engineering, Zhengzhou,, China

[2]Henan IoT Engineering Research Center of Smart Building, Zhengzho, China

yqhe@haue.edu.cn

Keywords: event, energy aware, node disjoint multipath, WMSN

Abstract: Multipath routing in WMSNs has irreplaceable advantages, establishing multiple communication paths between nodes can improve network adaptability and load balance. This paper presents event and energy aware node disjoint multipath routing algorithm, and constructes a multi-path decision-making model, and detailedly describes the whole process of building algorithm through multipath routing establishment strategy, neighbor nodes discovering, intermediate node forwards RREQt message, intermediate node forwards RREPt message, multipath decision making, Routing maintenance. The effectiveness and superiority of the algorithm are verified by simulation.

1. Introduction

Many scholars have proposed and designed many schemes for establishing multipath routing in WMSNs. Ref[1] proposed a path-free multi-path algorithm based on location and energy perception. Although the scheme speeded up the transmission rate and reduced the transmission delay, although it speeded up the transmission rate and reduced the transmission delay, it failed to distinguish the quality of QoS provided by each path, so that the data processing of abnormal events couldn't achieve a faster response[1]. Ref[2] used the concept of similar pipelines to "isolate" the paths from each other in order to prevent interference[2]. Ref[3] proposed a multi-path decision-making algorithm based on energy perception. At the stage of routing establishment, the energy information of each node in each path was fully acquired [3]. When making multi-path decision, the path with rich residual energy was selected as the transmission path, which achieved the goal of balancing the energy of the sensor network and prolonging the life cycle of the network. Ref[4] proposed multiple completely disjoint multipath algorithms for links, by using location sensors to obtain location information, links were independent of each other and didn't interfere with each other[4].

Considering the urgency of current event data flow, the residual capacity of each node in multi-path network and the number of route hops in each path, providing an appropriate path for data flow transmission in different emergency situations[5-7]. We give an event and energy aware node disjoint multipath routing algorithm(EENDMA). Multiple paths from the source node to the target node are established by using the source routing method. The intermediate node establishes the reverse transmission path routing when forwarding RREQt message, which is prepared for forwarding RREPt message. When forwarding RREPt messages, the intermediate node takes full account of the remaining energy available in the path, and updates the minimum energy in the path in the RREPt message during the routing maintenance process, which provides reliable information and efficient transmission for path decision-making and data distribution of different event types[8-9].

2. Multipath Decision Model

Data type and residual energy of nodes are two very important factors in the decision-making process of multipath routing.

  DOI: 10.25236/mmmce.2019.106

$$SiE(i,t) \in SiE\text{mi(i,t)}=\{\text{SiE(i,t)}|\text{SiE(i,t)} \le E(i,j,t), i \le k, j \in S(i)\} \quad (1)$$

Among them, SiE represents the minimum remaining energy of a node on a transmission path. $SiE(i,t)$ represents the minimum residual energy of nodes on transmission path i at time t. $SiE\text{mi(i,t)}$ represents the set of energy values with the least residual energy of nodes in all transmission paths.

$$SiE\text{R}(i,t) = \frac{SiE\text{(i,t)}}{\sum_{i=1}^{m} SiE\text{(i,t)}} \quad (2)$$

SiER represents the probability that a path is selected as a transmission path on all transmission paths, $SiE\text{R}(i,t)$ represents the probability of selecting the transmission path i as the data transmission path at time t.

$$\text{LR}(i,e,t) = \begin{cases} 1, i \in MinH(i), SiES(i,t) > MinEn, e \in U(e) \\ Max(SiER(i,t)), (i \notin MinH(i), e \in C(e)) \,|\, (i \notin MaxH(i), e \in M(e)) \end{cases} \quad (3)$$

LR represents the probability of each routing path as a data transmission path for the energy state of nodes on all current transmission paths and the emergency degree of corresponding events in the current data flow. $\text{LR}(i,e,t)$ represents the probability of taking path i as the transmission path at the time t and the emergency degree e of the event corresponding to the data stream. MinEn represents the minimum residual capacity of nodes in all current paths. Considering the emergency degree of the source node data information in the current event, the minimum number of hops in each path and the energy state of the node in the available path, the final probability LR is used as the criterion to judge a path in the multi-path as the final data transmission path.

3. EENDMA

3.1. Multipath Routing Establishment Strategy

EENDMA uses source routing mode. The intermediate node processes and forwards the received RREQt message. The target node replies RREPt message message message to the path of the received RREQt message. Thus, the routing Table from the source node to the target node is established. The main process is as follows:

Step 1: When the source node needs to transmit data to the target node, if there are routes to the target node in the routing Table item of the source node, then the EENDMA path decision algorithm model is used to select the best route to forward data from all effective paths; if not, step 2.

Step 2: The source node generates a RREQt request message and broadcasts it to the network through the neighbor node. RREQt message information includes packet type, source address information, target address information, message ID, timestamp and so on.

Step 3: When the intermediate node receives the RREQt message, if it is the target node itself, it will reply a RREPt message message message to the receiving path, which includes the data packet type, the time of RREPt sending, the RREPt message ID, the minimum energy in the path and so on; if it is not the target node, if it does not transfer itself. If the RREQt message has been sent and has not expired, the RREQt message will be forwarded to the neighbor node. In this process, the intermediate node is not allowed to send RREPt message to the source node.

Step 4: When the RREPt message is received by the source node, if there is no routing Table entry whose next hop address is the same as the destination address of the message in the routing Table, the next hop address and the destination address are added to the routing Table.

3.2. Neighbor Nodes Discovering

In order to find the effective neighbor nodes around a node in the recent period of time, For node i, $\text{N}(i)$ represents its set of neighbor nodes. So node i, neighbor node discovery process:

Step 1: Node I sends NHello broadcast message, which includes node address and timestamp of node i.

Step 2: After receiving the NHello message, the valid neighbor node of node i sends a ReplyNHello message to node i in a random time of 0.0-0.5 seconds to prevent collision.

Step 3: Node I receives the ReplyNHello message sent by the neighbor node. If the node does not exist in the local neighbor Table, it adds the neighbor node and deletes the invalid neighbor node.

3.3. Intermediate node forwards RREQt message

Intermediate node forwarding RREQt message is an important part of EENDMA algorithm. It provides the next hop address for RREQt message and RREPt message by establishing a forward path and a reverse path respectively.

Step 1: The effective content of RREQt message is processed and analyzed. When receiving the message of RREQt message sent by other neighbor nodes, the source node needs to discard the received message without any processing.

Step 2: If the intermediate node receiving the message has not forwarded the RREPt message to the same next hop address, the next hop address information of the RREPt message is set up, and the RREPt message is sent to the source node through the reverse path, which releases the received RREPQt message; if it is inconsistent, it enters the step 3.

Step 3: If a message with the same ID has been received, the message will be discarded; if it has not been received, it will be judged whether it reaches the corresponding destination address in its neighbor routing Table or not. If there is a route to the destination node in the neighbor routing Table, the node will be set as the last hop address of the transmission path and RREPt reply will be sent to the next hop. If the RREQt message does not exist in the neighbor routing Table, the RREQt message is broadcast to the neighbor node, and the node address information of the previous hop is added to the reverse path as the transmission path of the RREQt retaliation message.

3.4. Intermediate node forwards RREPt message

RREPt message is the connection information of the route from the target node to the source node. The minimum residual energy value of each node in the path from the target node to the source node is obtained. This minimum value is of great significance to the path decision-making process.

Step 1: Determine whether it is a source node or not, and if so, query whether there are routing Table entries with the same address to the target node and the next hop in its own routing Table, If it exists, and there are two routing paths with the same number of hops, the routing Table with fewer hops will be retained. If it does not exist, the routing is inserted into the routing Table entries as a new routing information.

Step 2: If it is not the source node and its residual energy is less than the minimum energy in RREPt message, the residual energy in RREPt message is replaced by its own residual energy. Then query the address information of the next hop arriving at the source node in the reverse path, modify the address information of the next hop in the RREPt retaliation text and forward it to the neighbor node.

3.5. Multipath Decision Making

Under the condition of guaranteeing the success rate, in order to make the emergency part of the event data stream send to the destination address with relatively short transmission delay and extend the effective lifetime of the whole sensor network as far as possible, when the source node transmits different event type data to the target node, it must be based on the current network. For the specific size of the residual energy of the middle node, the path of data transmission must be relatively optimal. The model based on the perception of events, energy and hops of multi-path routing is used as the basis of multi-path decision-making, and the path with the largest LR value is used as the path of data transmission.

3.6. Routing maintenance

3.6.1. Neighbor Table Updates

When the network is relatively idle, in order to obtain the latest neighbor node information and update the content of the neighbor routing Table, each node will send NHello messages to the network at a fixed time point.

3.6.2. Available Path Confirmation and Energy Information Updating

The source node sends EHello message to the target node periodically through all paths in the routing Table. When the target node receives the EHello message, the target node will send a ReplyEHello reply message along the reverse path to the source node, and set the energy value of the message to infinity. When the intermediate node forwards eplyEHello message, if the residual energy of the node itself is less than that of the ReplyEHello message, the residual energy of the node itself is used to update the energy value of the ReplyEHello message. If the source node does not receive a reply from a path within a specified time, the EHello message is sent repeatedly, and if the ReplyEHello message on the path is not received, the path is deleted in the routing Table. If the number of available paths to the destination node is less than the allowable minimum number of paths, RREQt messages need to be sent to re-establish multipath routing.

4. Simulation and Analysis

In order to verify the reliability and efficiency of EEDMA algorithm, using NS2 network simulation tool to test and analysis, a number of WMSNs nodes are randomly distributed in 300m*300m area. The density of nodes is 4096 km^2, the radius of nodes is 25m, the initial energy of nodes is 50J, the transmitting power is 0.3w, the receiving power is 0.2w, and the idle time power is 0.3w. The rate is 0.03w, and the topology is shown in Figure 1, from which three non-intersecting transmission paths are selected.

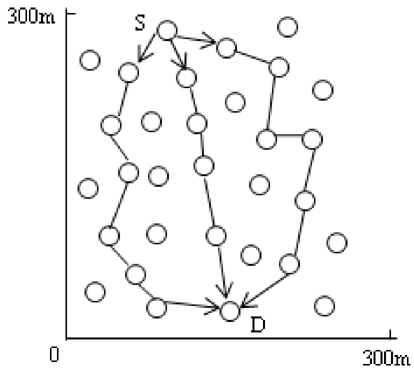

Figure 1 Topology.

We mainly compares and analyses GEAM algorithm of Ref[1] and EENDMA algorithm from the aspects of node energy balance, transmission delay of special data streams in WMSNs.

In order to evaluate the balance degree of node energy in the network, the variance of residual energy of each path node is used as the evaluation criterion. The smaller the variance represents the more balanced the energy consumption of each path node; conversely, the larger the variance represents the worse the energy consumption balance of each path node. Analysis and comparison of Figure 2 shows that the EENDMA algorithm significantly reduces the variance of residual energy of nodes. Especially with the increase of network lifetime, the advantages of EENDMA in balancing node energy and prolonging network lifetime are obvious. This is the result of the perception of residual energy of nodes in the path and multi-path decision-making.

Analysis and comparison of Figure 3 shows that the superiority of EENDMA algorithm in shortening emergency delay. By perceiving the degree of time emergency and the hops of each route, the response speed of network to emergency is accelerated. Based on the perception of event type, when emergency data flow is generated in the source node, in order to enable emergency data information to be transmitted through the network to the destination node in the shortest possible time, the shortest route hops are used as the data transmission path in all available paths. The transmission delay is reduced to a large extent.

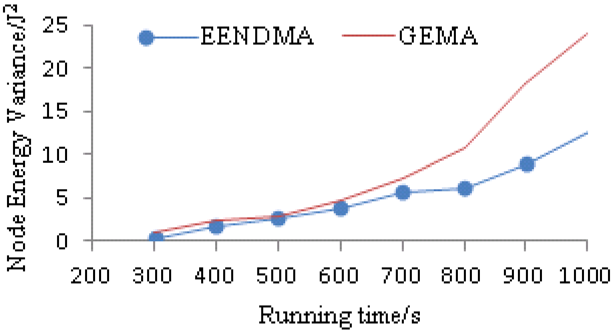

Figure 2 Variance of all nodes lay in node-disjoint multipath.

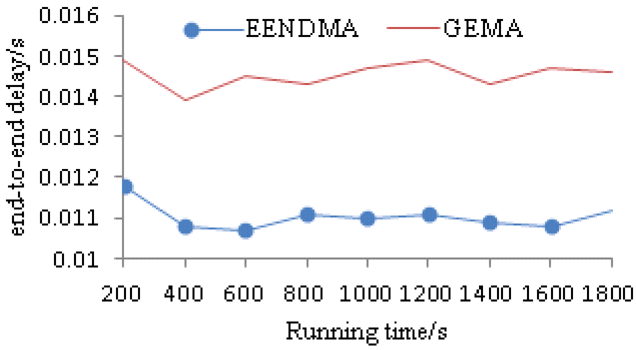

Figure 3 The end-to-end delay in urgency event.

5. Conclusion

Based on the emergency degree of the current event type and the remaining energy state of the nodes on the current paths, the choice of the best path selection scheme, this paper presents event and energy aware node disjoint multipath routing algorithm, and constructes a multi-path decision-making model, and detailedly describes the whole process of building EENDMA. The simulation results show the effectiveness and superiority of the algorithm. It provides a reliable and efficient path selection scheme for the information flow with strict network delay requirements, balances the energy consumption of nodes in WMSNs, and plays an important role in prolonging the effective lifetime of the whole network.

References

[1] Li BY, Chuang PJ. (2013) Geographic energy-aware non-interfering multipath routing for multimedia transmission in wireless sensor networks. Information Science, 249, 24-37.

[2] Lee J, Park H, Oh S, et al. (2012) Radio-disjoint Geographic Multipath Routing for Reliable Data Transfer in Lossy WSNs. IEEE International Conference on Advanced Information Networking and Applications, 1-5.

[3] Xie M, Gu Y. (2012) MultiPath Routing Algorithm for Wireless Multimedia Sensor Networks within Expected Network Lifetime. International Conference on Communications and Mobile Computing, 284-287.

[4] Waharte S, Boutaba R. (2012) Totally Disjoint Multipath Routing in Multihop Wireless Networks. IEEE International Conference on communications, 12: 5576-5581.

[5] Ali T, Arslan Q, Adil Mehmood K, et al. (2013) WEAMR-a weighted energy aware multipath reliable routing mechanism for hotline-based WSNs. Sensors, 5, 6295-6318.

[6] Caleffi M, Paura L. (2011) M-DART: multi-path dynamic address routing. Wireless Communications and Mobile Computing. 3, 392-409.

[7] Cherian M, Gopalakrishnan N. (2011) Multipath routing with novel packet scheduling approach in wireless sensor networks[J]. International Journal of Computer Theory and Engineering, 5, 666-670.

[8] ZHANG Peng, CUI Yong. C.N. (2010) Survey on Routing Algorithms of Mobile Ad Hoc Networks. Computer Science, 1, 10-22.

[9] LIU Guang-cong, ZHANG Hua, WEI Dong-li, C.N. (2011) Node-disjoint multi-path routing algorithm based on AODV in Ad hoc networks. Application Research of Computers, 2, 692-695.