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A Novel Routing Technique for Asymmetric Links: ProHet

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Abstract: ***To design efficient, reliable and scalable routing protocols in wireless heterogeneous sensor networks with asymmetric link is a challenging task. Usually most protocols in sensor networks work with high overhead. In this paper, we propose a novel routing technique for asymmetric links (ProHet) in Wirelesss Heterogeneous Sensor Network. It utilizes asymmetric links to attain assured delivery rate and it also provides low overhead. The protocol first produces bidirectional routing path for asymmetric link and uses a probabilistic strategy to choose the forwarding nodes then, sending messages and getting back acknowledgement. Extensive Simulation are conducted using MATLAB to verify its efficiency and performance.***

Keywords: (Asymmetric link, wireless, heterogeneous sensor network, one-hop receiver and two-hop receiver)

1. Introduction

Wireless sensor network consists of number of nodes and each sensor has the capability of sense data and forward it to other nodes or to the sink node for further processing. The advances in electronics and wireless communication paved the way for low cost wirelesss sensor network. WSNs have a wide range of military and civilian applications such as environmental monitoring, target tracking, disaster rescuing and for intelligent homes. The WSN formed by heterogeneous sensors is refered as wireless heterogeneous sensor network. since this heterogeneous sensors have different transmission ranges. The routing protocols for general WSNs are work with higher overhead so the routing protocols for WHSNs needs to be reschedule. A Novel routing technique for asymmetric link (ProHet) is proposed which can handle asymmetric links well and works in a distributed manner. It has two parts .The preparation part which includes identifying neighbor relationships and finding a reverse path for an asymmetric link, and the routing path which includes selecting nodes ,forwarding messages and sending acknowledgement. The focus is the usage of asymmetric communication links and assured delivery rate in WHSNs.

2. Preliminaries

2.1 Node's neighbor relationship

The neighbor relationships of sensors are categories in to In-Out neighbor , In-neighbor , Out-neighbor and Non neighbor. For two nodes *A* and *B* , sending messages and acknowledgement eachother, then termed as both are In-out neighbors each other If only $A \rightarrow B$(or $B \rightarrow A$),Then *A* (or *B*) is an In-neighbor of *B*(or *A*),and *B*(or. *A*) is an Out-neighbor of A. If neither $A \rightarrow B$ nor $B \rightarrow A$, they are non-neighbors of each other.

2.2 One-hop and Two-hop Receivers

A nodes's one-hop receiver is node's out-neighbor or In-out-neighbor .A node's two-hop receiver is the one-hop receiver of the node's one-hop receiver.

2.3 Delivery Probability

A node's delivery probability *Pdelivery* is defined as the ratio of the number of packets successfully delivered by the node denoted by *Nd* and the number packets forwarded by *Nf*. It can be expressed as

Pdelivery=Nd/Nf

3. Proposed Technique

The Proposed routing technique which has two parts. preparation part it includes identifying neighbor relationship and reverse routing path and routing part includes selecting node,forwarding message and sending acknowledgement.

3.1 Identifying neighbor relationship

First each node needs to identify its In-Out neighbors and In-neighbors (ifany) by sending eachother "Hello"messages.The identification of a node's Out-neighbors needs to wait until a reverse is found. Finding the reverse path which fully utilize the asymmetric links in network.If there are morethan one routing path to a node, it selects the shortest path.

3.2 Finding a reverse path

If node *A* is the source node and node *B* is the destination node. Node *A* to find the reverse routing path to each of its In-neighbors by broadcasting a"Find"message containing the source ID("*A*"),the destination ID("*B*") ,and expiration length. Each node rebroadcast the message by attaching its own ID to the message until its reaches the destination and send a identified reverse routing path to the source node by a"path"message containing the reverse route.

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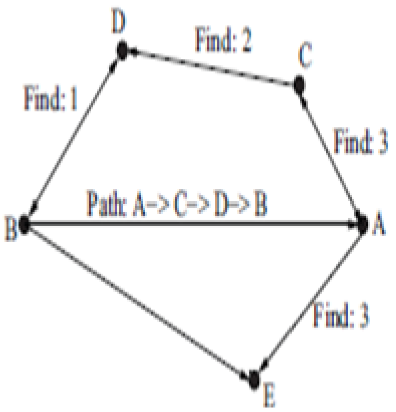

Figure 1: An Example of finding a reverse routing path

Let's consider the WHSN in fig.1 to explain the preparation part. In this network *A, B, C, D, E* are sensors with different transmission range. Node *A* has to find reverse routing path to *B* this is because of *A* is In-neighbor of *B*. Node *A* broadcast a "Find" message(*A, B, 3*) to its neighbors ,where 3 is the expiration number.. The message is received on sensors *C* and *E*. Sensor *E* doesn't broadcast the message, its transmission range is so small. Sensor *C* rebroadcast the message to sensor *D* as (*A, C, B, 2*). *D* receives the message and is not the destination node so it again rebroadcast the message by attaching its ID as (*A, C, D, B, 1*).When *B* receives the message ,it sees that it is the destination.Then node *B* builts a "Path" message (*A, C, D, B*) and sends its to *A* and it gets the reverse routing path to *B*.

3.3 Selecting Nodes

The selecting nodes algorithm source *v* calculates the probability threshold *Pth* .The threshold is set to a value and *v* chooses the subset of two-hop receivers whose delivery probability *Pdelivery* ≥ *Pth* and the *v*'s one-hop receiver and two-hop receiver is denoted as notation *N1(v)* and *N2(v)* and also selected one-hop receiver and two-hop receiver is denoted by *SN1(v)* and *SN2(v).*

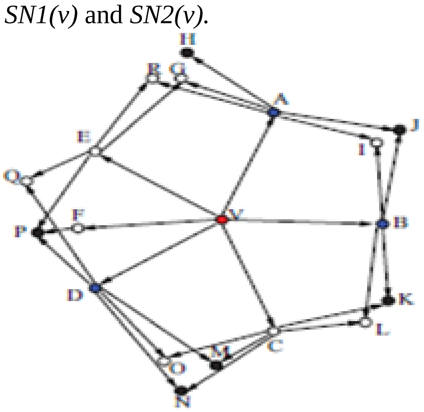

Figure 2: An example of selecting node algorithm

Let's use an example to explain the selecting node algorithm in fig 2. Suppose *V* has a packet to send. It uses the algorithm to select *v*'s two-hop and one- hop receivers. If there is a directional link *A* to *B* or a bidirectional link,It means *A* covers *B.* First,suppose six of *V*'s two-hop receives *H ,J ,K ,M, N, P* are selected into *SN2(v)* because their delivery probabilities are no less than *Pth* given *P*. Next,we select the minimal set of *V*'s one-hop receivers to cover all of the nodes as follows:Node *H* is only covered by one one-hop receiver *A*. So, *A* is selected into *SN1(v).*Node *A* also covers *J*. Next,the one-hop receiver covers most of the remaining node is *D*.So,also it put as *SN1(v).*Then,the only node left in *SN2(v)* is *K* and it is covered by node *B* and *C*. Neither *B* Nor *C* covers any other node.Choose either one of them to cover *K* . So we choose *B* ,so finally *SN1(v)={A, B, D}*.Then, it selects the forwarding nodes.

3.4 Forwarding messages

Any forwarder will run the Forwarding Messages algorithm, where the forwarding Number *Nf* is recorded. The current forwarding node *v* broadcast the packet contains *SN1(v), SN2(v)* and the message to be delivered to the sink.The forwarding number of *v* is increased by one.If a receiver *u* is a subset of *N1(v)* is in *SN1(v*), it will rebroadcast *P*, by increasing its forwarding number by one and also attach *u*'s ID in *P* as a forwarding node in the routing path.

3.5 Sending Acknowledgement

After the forwarded message reaches the sink, the sink will send back an acknowledgement to all the forwarding nodes on the path by the sending acknowledgement algorithm. On the way to send back the acknowledgement the delivery number *Nd* is recorded and the nodes delivery probability is obtained.

4. Simulation Result

The Proposed technique (ProHet) is implemented and simulation is done by using MATLAB and evaluate the performance by comparing it with other methods using a simulator in Java. They are Flooding, Random-K , TopRatio-K are used to compare it with. It use some metrices to evaluate the performance .

- Delivery Ratio: It is the ratio of the number of packets successfully delivered to the total number of packets generated.
- Average control message overhead: The average number of Control messages which contains all of the communication messages to identify neighbors, find reverse paths.
- Average packet replication overhead: The packet replication is average which results successful delivery of packets.

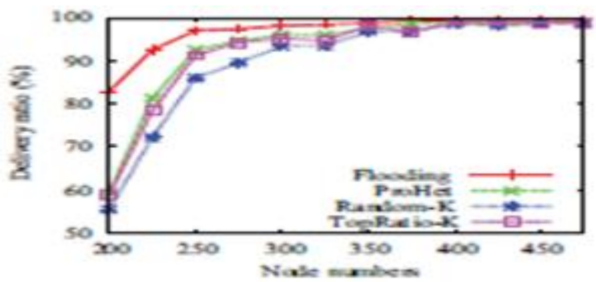

Figure 3: Comparison of delivery ratio

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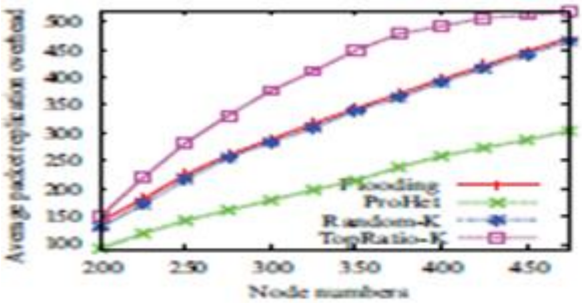

Figure 4: Comparison of Average packet replication overhead

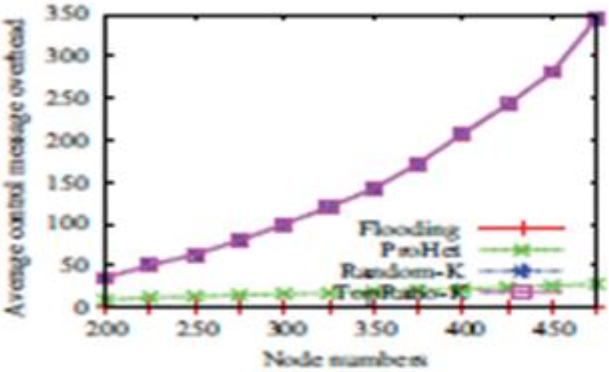

Figure 5: Comparison of Average control message overhead

4.1 Performance Analysis

When compared the Proposed routing technique(ProHet) with other routing methods like Flooding, TopRatio-K, Random-K . It verifies that Flooding has the highest delivery ratio.ProHet has higher delivey ratio than those of TopRatio-K and Random-K . When increasing the delivery ratios with the increase of nodes numbers implies more connection between nodes result in more successful deliveries. In Fig 4 shows that ProHet has the least average packet replication overhead and which proves that the probabilities method to choose forwarding nodes in the two-hop neighborhood is effective to removing many redundant packets in the delivery process. In Fig 5 it reveals that due to unbuffering of neighbor information in routing . ProHet's control overhead is much lower than those of Random-K and TopRatio-K .

5. Conclusion

A novel routing technique: ProHet to deal with asymmetric links is proposed, which reduces the delay of routing and it also deals with the reliability, scalability issues in WHSNs. It considers asymmetric link by finding reverse paths and it provides assured delivery rate. It improves the scalability and reliability of routing by choosing forwarding nodes.The efficiency of the novel routing technique(ProHet) was evaluated by MATLAB simulation and In future, we will design more efficient routing techniques in WHSNs.

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