Cluster Based Shortcut Routing in Zigbee Network

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Abstract
Many resource limited applications and devices uses the Zigbee tree routing, as it does not require any routing table and route discovery overhead to send a packet to the destination. The fundamental limitation of Zigbee tree routing is that the packet follows the tree topology, thus optimal routing path is not provided by this method. The limited tree links causes the traffic concentration problem in ZTR. To overcome these problems, a clustering scheme is introduced into Zigbee network. It uses clustering's structure to decrease average end-to-end delay and improve the average packet delivery ratio. Clustering divides the network into interconnected substructures. Each cluster heads within these substructures temporarily acts as base stations in its zone and communicates with other substructures or clusters. For the data packets to transfer, it also uses a neighbor table information to find the optimal short distance to the destination. In this method the routing is also done quickly and the error tolerance increased. This is because the address of the cluster determines the routing. The failure of any node in the route is detected by the cluster head and it uses an alternate node to forward the packet and thus error tolerance is enhanced.

Keywords
Clustering, Neighbor Table, Tree Routing, Zigbee

I. Introduction

Zigbee is an emerging worldwide standard for wireless devices and under the main goal to provide cost effective, low power, flexible, scalable and reliable wireless products. Zigbee network has been developing and standardizing by ZigBee Alliance. Zigbee defines ZigBee Coordinator, Router and ZigBee end device based on IEEE 802.15.4. The Zigbee network can be easily extended in size and coverage area since the network support star mesh and tree topologies and have more than 65000 address spaces. The star topology of Zigbee is mainly designed for the simple communication from one node to several nodes. The tree network uses a hierarchical tree routing mechanism. The mesh network uses the mixed routing method combined with Z-AODV and hierarchical tree routing.

Mobile Ad-hoc networks are used in battlefield and disaster relief scenarios, where the wireless hosts does not use a fixed infrastructure to communicate with each other. There exist several hops between the routes of two hosts in a network. Since host mobility causes frequent unpredictable topological changes, it is nontrivial task to find and maintain the routes in a mobile adhoc network. It is reliable to use the flooding scheme for sending packets in highly mobile cases. However, more efficient schemes must be introduced since power resources and link channel are very limited. This requires up to date information about the location of nodes. There occurs a lot of transmission overhead for updating the routing tables after each topological change. To reduce these overhead all nodes were divided into clusters. In cluster-based schemes for ad hoc networks, once clusters are formed, then for each cluster one cluster head (CH) is elected in fully distributed fashion. In this approach, the information about the cluster within which the destination is located must be known to the sender

Since all the information about the nodes in a cluster are contained in the cluster head, the data transmission starts by checking the neighbour table of the cluster head of the sender's cluster. If that cluster head does not contain any information about the destination, the cluster head send the destination information to its nearby cluster head. This process continues with the aid of neighbour table till the data reaches the destination cluster head.

II. Related Works

The ZigBee tree routing is widely used in many resource-limited devices and applications, since it does not require any routing table and route discovery overhead to send a packet to the destination. However, the ZigBee tree routing has the fundamental limitation that a packet follows the tree topology; thus, it cannot provide the optimal routing path. [1] proposes the shortcut tree routing protocol that provides the near optimal routing path as well as maintains the advantages of the ZigBee tree routing such as no route discovery overhead and low memory consumption is proposed. The main idea of the shortcut tree routing is to calculate remaining hops from an arbitrary source to the destination using the hierarchical addressing scheme in ZigBee, and each source or intermediate node forwards a packet to the neighbor node with the smallest remaining hops in its neighbor table. The shortcut tree routing is fully distributed and compatible with ZigBee standard in that it only utilizes addressing scheme and neighbor table without any changes of the specification. In this paper, the detour path problem and traffic concentration problem of the ZTR have been identified. These are the fundamental problems of the general tree routing protocols, which cause the overall network performance degradation. In order to overcome these problems, STR is proposed that uses the neighbor table, originally de-fined in the ZigBee standard. In STR, each node can find the optimal next hop node based on the remaining tree hops to the destination. The mathematical analyses prove that the 1-hop neighbor information in STR reduces the traffic load concentrated on the tree links as well as provides an efficient routing path

In mobile ad hoc network there are several routing algorithms, which utilize topology information to make routing decisions at each node. Aim of [4] is to utilize position information to provide more reliable as well as efficient routing for certain applications. Thus extensions to existing position based routing algorithm have been described to work more efficiently even in cases where they are not working at present. In [4] an algorithm is proposed, which removes some of the drawbacks of the existing GPSR (Greedy perimeter stateless routing) position based routing algorithm. In algorithm different algorithm has been used to planarize the graph so that it will not disconnect the route in case of location inaccuracy in perimeter mode whereas in GPSR in certain cases of location inaccuracy it will disconnect the graph and hence the packets will not be routed thereby decreasing packet delivery ratio. The problem was mainly due to the flaw in the planarization algorithm used in the existing GPSR algorithm. Since in case of location inaccuracy due to RNG the graph is disconnected and the packets are not delivered thereby decreasing the packet delivery ratio. Whereas in case of modified RNG it guarantees that the planar graph is always connected if, the topology is connected. This algorithm is working in scenarios where RNG gives error.

In [7], a cluster based routing protocol for mobile ad hoc network is proposed. It uses clustering's structure to decrease average end-to-end delay and improve the average packet delivery ratio. In this method, due to the weight group, the cluster creation speed increases, and causes the network services to be more accessible. Recreating of clusters is rarely executed, and when two clusters locate in the same range, one of them becomes the gateway of other node. This causes to prevent the creation of most constructions. In the proposed protocol the routing is also done quickly. The reason is that, routing is depended on the address of cluster heads. By failing any node in the route, its CH may use another node to forward packets (if available). This causes the error tolerance to be enhanced.

III. Preliminaries

Wireless networks provide mobile users with ubiquitous communicating capability and information access regardless of the location. Multihop networks does not require a fixed base station or wired backbone as compared to single hop network, which requires both. Multihop mobile wireless networks provide the only feasible means for communication and data access in scenarios like search and rescue operations and as in battlefield communication, where wireline network is not feasible. Dynamic reconfiguration and rapid deployment are the main motivation for mobile wireless multihopping.

Zigbee Tree Routing is designed for resource constrained ZigBee devices to choose multi-hop routing path. We can easily identify whether the destination is descendant of each source or intermediate node using hierarchical addressing scheme. In ZTR, each source or intermediate node sends the data to one of its children if the destination is descendant; otherwise, it sends to its parent, where a packet is routed through several hops towards the destination even though it is within the range of sender's 2-hop transmission range.

In ZTR, a packet is routed through several hops towards the destination even though it is within the range of sender's 2-hop transmission range and this causes detour path problem. Since the packet follows a tree topology the optimal path cannot be always possible. ZTR also causes traffic concentration problem in addition to detour path problem because all the packets passes through only the tree links. Severe congestion and collision occurs at the root node. This problem becomes worse as the number of packets increases. This finally causes the degradation of the packet delivery ratio, end-to-end latency, and other network performances.

IV. Proposed Method

Traditional routing algorithms in wireline network are not feasible for mobile wireless environment due to the dynamic change in link connectivity. To gain better performance for wireless network routing must take into account different possibilities of clustering along with some shortcut routing.

In the proposed method, the routing is done with the aid of a neighbour table. The neighbour nodes of each nodes are calculated on the basis of the mathematical formula

$$d = \sqrt{(x1 - x2)^2 + (y1 - y2)^2}$$

If the calculated distance between the nodes is below a defined area, that node is considered to be the neighbor. The neighbor table contains all the information about the neighboring nodes. Once the neighboring node is found, hello packets are send to the neighbor nodes.

A. Clustering

After the hello packets are send to the neighbor nodes, the nodes within a particular transmission range are grouped into a cluster. Thus a number of clusters are formed. Once the clusters are formed, then the next task is choosing a cluster head for each cluster. For this, transmission energy of all nodes in the cluster is compared. The node which possesses the highest transmission energy is chosen as the cluster head. Then onwards the task of routing is handled by cluster head.

In mobile wireless networks, the aggregation of nodes into clusters controlled by a cluster head provides a convenient framework for the development of important features such as code separation among clusters, routing, bandwidth allocation and channel access. A distributed algorithm is used within the cluster and a node is elected as the cluster head within a cluster. All the nodes within transmission range of the cluster head belong to this cluster. All nodes in a cluster can communicate with a cluster head and possibly with each other. A cluster head should get more chances to transmit because it is in charge of broadcasting within the cluster and of forwarding messages between mobile hosts which are not connected.

B. Routing

In order to get the optimal routing path the shortest distance route is to be found. The shortest distance between the source and destination is found by making use of the coordinates of source and the destination.

The cluster head will have the information about all the nodes in its clusters in the neighbor table. The cluster head of the source first checks if the destination node is within its cluster. If not, then it passes information to its neighboring cluster heads and checks if the destination node is present in its cluster. Once the destination is located, then the packet is delivered using the path found using the mathematical formula.

Cluster heads enable easy routing. It reduces the energy consumption and utilizes low memory. It didn't cause detour path problem and route discovery process overhead and also traffic concentration problem. It also avoids degradation caused when the number of mobile nodes increase.

C. Topology Formation

Constructing Project design in NS2 should takes place. Each node should send hello packets to its neighbor node which are in its communication range to update their topology.

D. Cluster Formation

Clustering is the process of dividing the network into different virtual groups based on rules in order to discriminate the nodes allocated to different sub networks. The nodes in a particular transmission range are grouped into a cluster and the node with highest transmission power in the cluster are chosen as the cluster head.

E. Shortcut Routing

The shortest distance between the source and destination is found by making use of the coordinates of source and the destination. The cluster head of the source first checks if the destination node is within its cluster. If not, then it pass information to its neighboring cluster heads and checks if the destination node is present in its cluster. Once the destination is located, then the packet is delivered using the path found using the mathematical formula.

V. Performance Evaluation

Network throughput is the rate of successful message delivery over a communication channel. As clearly seen from the graph, throughput increases exponentially as the time and after some period, the throughput remains constant.

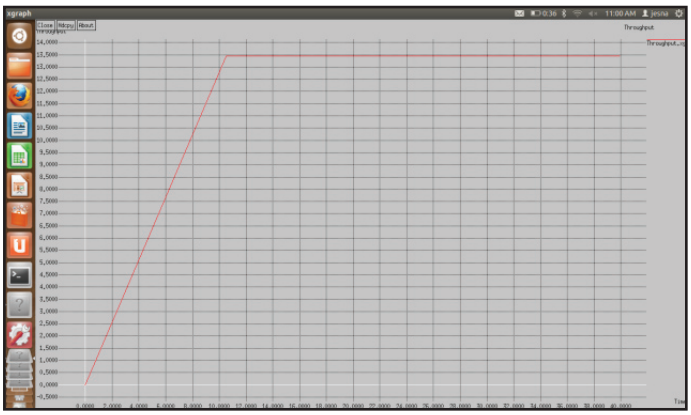

Fig. 1: Throughput

Packet delivery ratio gives the number of packets delivered to the destination. As seen in the graph, the proposed method gives a good delivery rate.

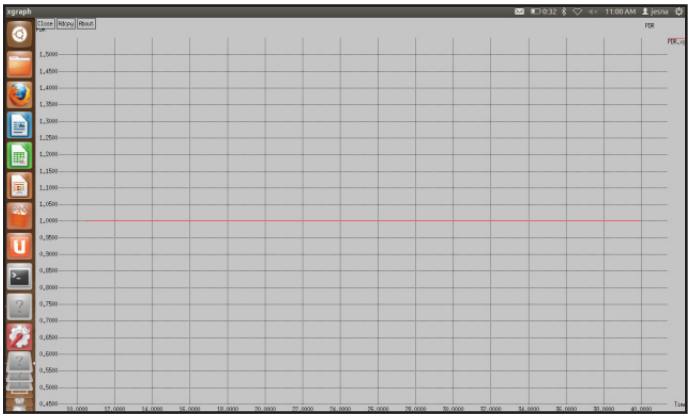

Fig. 2: Packet Delivery Ratio

From the graph it is clear that there is no packet drop occurring throughout the communication. Hence the packet delivery ratio is high.

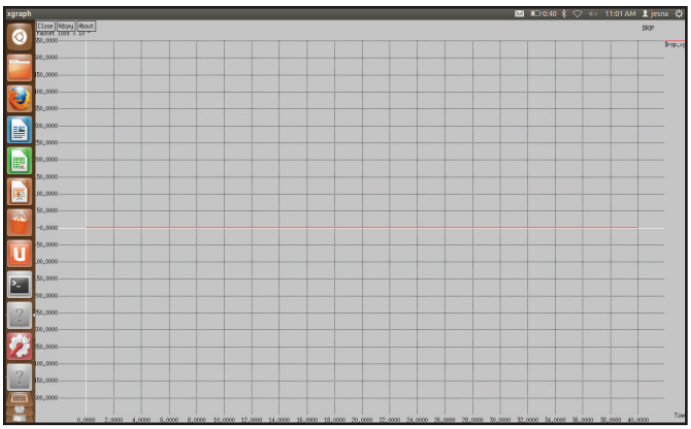

Fig. 3: Packet Drop

VI. Conclusion

Traditional routing algorithms in wire line network are not feasible for mobile wireless environment due to the dynamic change in link connectivity. To gain better performance for wireless network routing must take into account different possibilities of clustering along with some shortcut routing. To get the near optimal path, the nodes are grouped into clusters. The node with highest energy in the cluster is selected as the cluster head. The shortest distance between the source and destination is found by making use of the coordinates of source and the destination. The cluster head of the source first checks if the destination node is within its cluster. If not, then it passes information to its neighboring cluster heads and checks if the destination node is present in its cluster. Once the destination is located, then the packet is delivered using the path found using the mathematical formula of shortcut routing method. The experimental result shows that this method provides better throughput and packet delivery ratio.

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