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Latency Reduction in Zigbee by the Hybrid Combination of STR and Steiner Tree

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Abstract -*Zigbee is a worldwide standard of wireless personal area network used to send packet from any node to any other node in which it doesn't have specific infrastructure and centralized access. It is a widely used technology since it connects nearly 64,000 devices at low cost, less power consumption and complexity. Instead of following proactive and reactive protocol to deliver packets it follows tree topology and it reduces route discovery overhead. However, it doesn't find shortest path to reach destination since fixed route is followed, even if the destination is nearer to source node. Shortest tree topology (STR) overcomes this problem and finds the shortest path by calculating the remaining hop to reach destination from the source node. Limitations of using STR is latency get increased since it finds shortest path among all the possible routes. So in this paper we present about steiner tree which finds shortest path among all the available paths with a reduction in latency and it also maintains advantages of zigbee such as low power consumption, low cost, less complexity, etc., It overcomes the problems like detour path problem and traffic concentration problem. In the performance evaluation, steiner tree achieves better performance to reach destination with reduced latency.*

Keywords : *MANET, shortest tree routing(STR), steiner tree, wireless sensor network, zigbee,*

1 Introduction

Wireless sensor network are highly distributed networks of small, lightweight wireless nodes, deployed in large numbers to monitor the environment or system by the physical parameter measurements such as temperature, pressure or relevant humidity. Wifi , Bluetooth , zigbee are personal area network standards used to share a packets whereas zigbee is mainly targeted to reduce cost ,power consumption , complexity and connects nearly 64,000 devices. Zigbee is a IEEE 802.15.4 based specification for a suite of high level communication intended to be simpler and less expensive than other wireless personal area networks (WPAN). Zigbee devices transmit data through mesh network over long distance. Zigbee network supports star , tree and mesh networking . It consists of four additional components such as network layer, application layer ,zigbee device objects (ZDOs) and manufacturer-defined application objects. ZDO which is responsible for tracking device roles , managing requests to include in a network , device discovery and security.

2 Related Works

Zigbee is an open standard technology targeted for simplicity and to reduce complexity. This application is also used in patients monitoring , home appliances , etc., zigbee provides adoptive parent based framework to increase bandwidth utilization without any extra message exchange[1]. It forms a network by joining device if it contains network address from parent device as well as it present solution for orphans problem[2] . Flooding scheme introduced to reduce the protocol overhead, message redundancy and minimize the number of forwarding nodes in each steps , less collision , high deliverability ratio, high scalable[3] . 1000's of tiny, low powered node works concurrently and meets the challenges like support complex, safe concurrency, flexible, fine grained components, low requirements[4]. Deluge technique is used for dissemination of data limits propagation performance[5]. Finds

shortest path with the avoidance of detour path problem and traffic congestion problem which doesn't follow tree topology to reach the destination [6].

3 Shortest Tree Routing

Zigbee tree routing follows tree topology for packet transmission. The example of the routing path of ZTR is detour path problem in which packet is routed to several hops even if the destination present in 2-hop distance. To avoid this complexity direct transmission rule is introduced. This rule enables coordinator or router to directly route the packet to destination without the routing protocol decision. But this rule can't be applied if the destination is located more than 2-hop distance from the source. Another problem is traffic concentration problem leads to performance degradation due to if packets increases to transfer in a limited tree link. To overcome this problem STR came in existence by using 1-hop neighbor information. STR choose one node as a neighbor node to reach a destination while the remaining nodes remains idle. The criteria for selecting the neighbor node as a next hop node is, every node calculates count of remaining tree hop node from next hop node to destination. Choose a node which consist of least hop count as a neighbor node to transmit a packet. The remaining tree hop is calculated using tree levels of source , destination and their ancestor nodes.

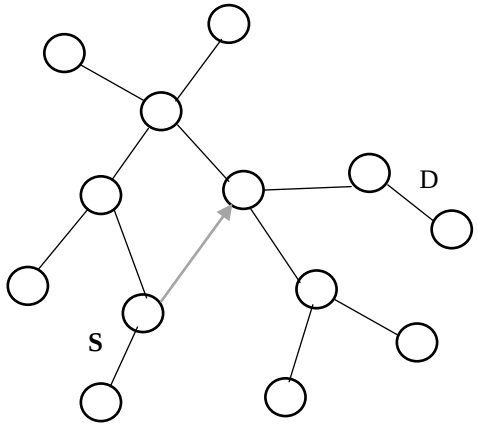

Fig 1.1 STR

Table 1. Shortest Tree Routing Algorithm

Find_NextHopAddr(dstAddr)
Input: dstAddr-network address of the destination
Output: nextHopAddr-next hop address for the destination
1. Initialize minRouteCost with inf
2. Level((dstAddr),A(dstAddr)←Find_Ancestors(dstAddr)
3. **for each**(neighbor's address n_k in neighbors table)
4. level(n_k),A(n_k) ←Find_Ancestors(n_k)
5. level(LCA)=0
6. **while**(level(LCA)<=min(level(dstAddr),level(n_k)) and A(dstAddr,level(LCA))=A(n_k,level(LCA)))
7. ++level
8. **end while**
9. nbrRouteCost←level(dstAddr)+level(n_k) – 2.level(LCA)
10. if(nbrRouteCost<minRouteCost)
11. nextHopAddr←n_k
12. minRouteCost←nbrRouteCost
13. **end if**
14. **end for each**
15. transmit packet to nextHopAddr.

STR is designed to compute remaining tree hop using Zigbee address hierarchy and tree address from source to destination. Table1 describes the algorithm to find shortest tree routing in Zigbee.

Find_Ancestor()- ancestor network address is found at each tree level together with the tree level of the given devAddr which is found starts from root node contains address 0, until the given devAddr is identical with the network address of ancestor. To find tree routing cost, common ancestor is computed. The tree routing cost is calculated from the equation " level(S) + level (D) – 2level(LCA(S,D))". First, level(dstAddr) and A(dstAddr) for given dstAddr is computed. Then for each neighbor node from the source or intermediate n_k to destination dstAddr, the remaining tree hop node is calculated. Finally, source or intermediate node select neighbor node as next node which contains minimum remaining tree hop. If there is no neighbor node , then it selects parent or one of the children as a next node and transfer the packet. Fig 1.2 explains zigbee tree routing cost calculation.

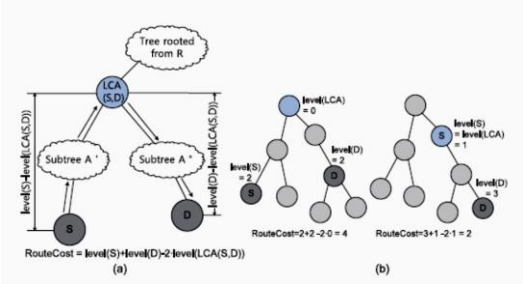

Fig 1.2 Zigbee tree routing cost

4 Steiner Tree

By using STR technology it increases the latency since it finds the least neighbor hop node as next hope node to reach the destination. Each and every time it wants to check all the available neighbor hop to select next hop node, hence it increases the latency time and reduces the performance during the first transaction. to reduce the latency time we propose steiner tree along with STR technology which finds shortest path as well as overcomes the disadvantages of zigbee and STR.A Steiner tree is a tree which spans all the given vertices with minimal edges, point which connects vertices with edges is said to be Steiner point. Steiner tree problem can be used to model the routing of nets with more than two indirect terminals. Steiner tree is superficiary similar to the minimum spanning tree problem. A set of V points, interconnected as a networks with shortest length where the length is the sum of the lengths of all edges. The main difference between steiner and spanning tree is, in steiner new can be introduced in order to reduce the length of the computation cycle(spanning tree). Using this advantages, vehicular zigbee along with STR protocol, the computation time for the shortest data nodes will be reduced.

5 Result and Conclusion

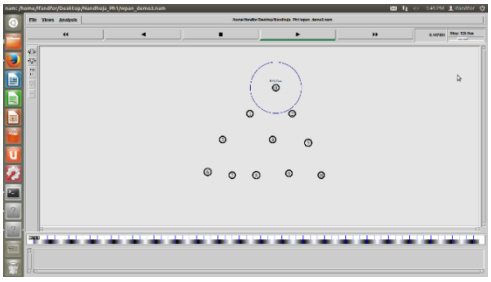

Fig 1.3 Node discovery

Fig 1.4 packet flow between two nodes

Fig 1.3 shows node discovery starts from root node or coordinator node. After the node discovery, node starts to find neighbor node which contains minimum hop count to reach destination. Finally it transmit packet to the node which contains less count. Fig 1.4 shows packet flow between two nodes. A network model consist of 20 MANET nodes which follows the Zigbee protocol is designed. The inbuilt functional elements of Network Simulator is utilized to simplify the MAC layer properly. The routing table of the Zigbee protocol is modified in the c++ header file of the NS2 all in one 2.31package. Shortest Tree Routing Protocol ensures the Quick Searching of destination nodes by skipping the regular protocol. Steiner tree searching algorithm will be utilized along with STR protocol to develop a hybrid design. The performance analysis of STR and Steiner protocols will be compared by means of throughput and latency.

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