www.s2is.org
International Journal on Smart Sensing and Intelligent Systems
ISSN 1178-5608

WIRELESS ZIGBEE NETWORK CLUSTER - CAPACITY CALCULATION AND SECURE DATA CONVEYANCE USING INDEGREE

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Submitted: May 27, 2017 Accepted: June 15, 2017 Published: Sep 1, 2017

Abstract- A tree topology is used to construct to construct a Zigbee networks practices by wireless sensor network for data delivery applications. There are 3 types of nodes in zigbee networks; coordinator, router and mobile end devices. Coordinator performs the initialization and maintenance functions in the network. A router is responsible for routing data between the coordinator and mobile end device. In-order to avoid the delivery failures occurs due to node movements and network topology changes, the existing system collect and analyze data about device movement and gives Zigbee node deployment and tree construction framework, which uses three algorithms ZND(zigbee node deployment), ZCD(zigbee coordinator decision) and ZTC(zigbee tree construction). In the proposed system we improve the data delivery by introducing the capacity calculation. If any two nodes have same number of indegree or out-degree, we select the node with maximum capacity.

Index terms: Mobility robustness, tree topologies, ZigBee wireless networks, Network Clusters.

I. INTRODUCTION

Wireless sensor networks have been an activeresearch topic for around a decade. The recentrelease of standards in the field, such as IEEE802.15.4 and ZigBee, brought the technology outof research labs and stimulated the development of numerous commercial products. Although many early sensor networks used proprietary routing algorithms and RF technology, most recent products use standards-based networking and RF solutions.ZigBee tree network with one *coordinator* (*sink*), some *routers*, and some *end devices*. Each router is responsible for collecting sensed data from its child routers or end devices and relaying incoming data to the sink. Each router can announce a beacon to start it's a superframe.

Which consists of an *active portion* (called an *active slot*) followed by an *inactive portion*. On receiving its parent router's beacon, a child router/end device has to wake up during the former's active portion and forward its data to the former.

There are many ZigBee applications, such as tour guiding and indoor/ building monitoring systems, require moving objects to be equipped with an end device that is connected to a backbone network for data collection and dissemination [7]– [10]. Another category of applications use ZigBee routers as roadside units and end devices as in-vehicle units. ZigBee networks provide low data rate and low power.

So this paper focus on the ZigBee cluster tree toplogy. ZigBee specification uses a small protocol stack and it is used in low power, low data rate and low cost applications. In zigbee specification, when a central server cannot locate a mobile end device, it will trigger a device discovery procedure. During the procedure, the centralserver simply floods the whole network with messages to locate the displaced end device. However, flooding the network is costly in terms of resources, and during the procedure, the network cannot accommodate multiple instances of rapid node mobility. Thus, we need a more efficient and automatic approach for locating mobile end devices. In many applications, there is a regularity in the mobile end device's movement pattern. Using this regularity, we exploit a routing toplogyand create a tree structure for sensing the node movements.

To improve the data delivey applications, we exploit the regularity in the node movemet and construct a mobility robust tree topology with the property that mobile nodes will move along the constructed data-forwarding path with high probability. Data will reach the target mobile nodes as long as they are within the transmission range of any router on the forwarding path. In other words, we choose the positions of the routers and design the tree topology so that most movements are directed toward the root of the tree. To achieve our objective, we gather information about node movements in the environment and construct a ZigBee tree topology framework.. The framework considers the regularity of the mobility patterns during the construction of the tree and deployment of the routing nodes, andit incorporates an overhearing mechanism for mobile nodes to further improve the data delivery ratio. We also design. heuristic and low-complexity algorithms for node deployment and tree construction and analyze their performance in ZigBee networks.

II. Related Work

In this paper, we focus on solving the mobility problem of data delivery in ZigBee networks while attempting to minimize the network overhead many schemes that deal with mobility issues in MANETs and DTNs cannot directly be applied to ZigBee networks; however, theyprovide hints about how we can exploit the regularity in the mobility of nodes to improve mobility support in the network.

In addition, to date, most research on ZigBee mobility support has focused on data collection applications. The network repair strategy demonstrates the importance of constructing or maintaining a connected network topology, but it increases the overhead when the network is operating; thus, it is not suitable for large networks. By exploiting the end device's historical movement data in our node deployment and tree construction algorithms at the design stage, the operating overhead such as route searching packets and network control messages in many conventional methods are substantially reduced.

III. System Model

A ZigBee network comprises the following three types of devices: 1) a coordinator; 2) multiple routers; and 3) multiple end devices. The coordinator performs the initialization, maintenance, and control functions in the network. A router is responsible for routing data between the end devices and thecoordinator. An end device is not equipped with forwarding capability, and its hardware requirements are minimized to control costs. With the three types of devices, the ZigBee standard supports the following three network topologies:1) star networks; 2) cluster-tree networks; and 3) mesh networks.In a star network, multiple end devices directly connect to the coordinator, and in a cluster-tree network, routers form clusters with their surrounding devices. Moreover, in clustertree and mesh networks, the devices communicate with each other in a multihop fashion.

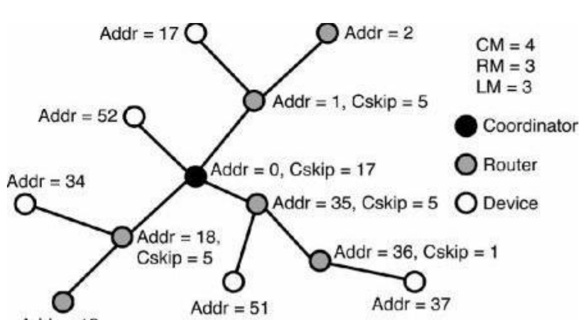

Fig1 ZigBee Cluster Tree

Before a topology is constructed, the following three system configuration parameters must be set: 1) the maximum number of children of a router or the coordinator (*Cm*); 2) the maximum number of child routers of a router or the coordinator (*Rm*); and 3) the depth of the network (*Lm*). Fig. 1 shows a ZigBee cluster- tree topology with the parameters *Cm* = 4, *Rm* = 3, and *Lm* = 4.

The proposed scheme does not impose any associations between the mobile end devices and routers. Instead, a mobile end device simply sends a packet, which is then forwarded to the coordinator through the routers. Upon the reception of a packet from a mobile end device, the router forwards the packet to its parent, as indicated by the tree structure. The location of the mobile end device is recognized by the network and maintained by the coordinator, which identifies the last router that was used to forward the end devices uplink data packets. When a downlink packet is sent to a mobile end device, the coordinator delivers the packet to the last recorded location, i.e., the last router that received the uplink packet from the mobile end device. Upon the reception of the downlink packet, the router simply forwards it to the mobile end device and waits for an acknowledgement message from the end device. If the mobile end device has moved from the last known location, the data delivery fails, and the coordinator starts a search by broadcasting a message that asks for information about the mobile end device's current location. Broadcast operations are expensive in terms of bandwidth and power consumption, particularly when mobile end devices frequently move between different router's region.

The movement patterns of mobile end devices exhibit certain regularity, because there are explicit paths that visitors with mobile end devices follow. We collect and utilize the data about device movements to construct a topology, we form a tree topology that is composed of the coordinator and routers to efficiently deliver downlink packets without frequent location tracking overheads. We call the tree topology a *mobility-robust tree*. The objective is to increase the number of successful data deliveries and thereby reduce the number of broadcasts triggered by the coordinator due to the location changes of the mobile end devices.

A heuristic algorithm is proposed to implement the mobility robust ZigBee tree topology. Algorithm is implemented in three phases: 1) ZigBee node deployment (ZND); 2) ZigBee coordinator decision (ZCD); and 3) ZigBee tree construction (ZTC). ZND determines the number and locations of router nodes. ZCD selects one of the routers as the coordinator. ZTC constructs MRZT based on the deployment in the previous two phases.

IV. Mobility-Robust Zigbee Treetopology Deployment

In this section we describe the details of the heuristic algorithm. The algorithm is implemented in the following three phases: 1) ZigBee node deployment (ZND); 2) ZigBee coordinator decision (ZCD); and 3) ZigBee tree construction (ZTC). The ZND phase determines the number and locations of router nodes, the ZCD phase selects one of the routers as the coordinator, and the ZTC phase constructs an MRZT based on the deployment in the previous two phases

ZND Phase

This phase implements an algorithm which determines the number and locations of router nodes.

Algorithm1

Input*:* A grid graph $G = (V,E)$, a mobility profile M, and the antenna gain profile $ANTg$.

Output*:* A network graph $Gr = (Vr,Er)$

($Q,Rg,R,Rtmp, rant$) , , , 0) and define

1. ← (E, an empty graph Gr = (Vr,Er)
2. Sort(Q) ∅∅∅ Dequeue the maximum-weight edge $e(a,b)$
3. from Q and add it to R
4. **for all** $e(u,v) \in Q$ **do**

5. **if** DiskCover(*e*(*u*,*v*),*R*,*ANTg*) = *TRUE* **then**

6. Remove *e*(*u*,*v*) from *Q* and add it to *Rtmp*

7. **end if**

8. **end for**

9. (*R*, *rant*) ←FindMaxAngle(*Rtmp*,*ANTg*)

10. Add (*R*, *rant*) to *Rg* and add (*Rtmp* −*R*) back to *Q*

11. **repeat**

12. (*R*,*rant*)←FindMaxPolygonCover(∊*Rg Q*,*ANTg*)

13. Add (*R*, *rant*) to *Rg*

14. Remove all *e*(*u*,*v*∊) *R* from *Q*

15. **until** *Q* is empty

16. **for all** (*R*, *rant*) *Rg* **do**

17. *p* ← MakePolygon(*R*)

18. Add *p* to *Vr* with a node weight *rant*

19. AddNewRouter(*p*,*Gr*,*ANTg*)

20. **end for**

21. *E*←MakeConnection(*Vr*,*r*) *p*
Vr such that its degree
= 0
AddNewRouter(*p*,*Gr*,*ANTg*

22. **end for**

23. **return** *Gr*

The first step of this algorithm (lines 1–10) attempts to find an appropriate location for the first router. At the beginning of this step, the edge with the largest weight is added to *R*. Here, *Q* is the set of weights on all the edges in *E*. We sort *Q* in non-increasing order such that the first element in *Q* is the maximum weight in *Q* in line 2 (function **Sort**). We denote *e* as the edge with the maximum weight in *Q*, dequeue the edge *e*(*a*,*b*) from *Q*, and add it into an empty set *R*. We choose the angle with the maximum sum of edge weights to be *rant* (the angle of the antenna for this router) based on the design rationale where most of the node movement will be covered by a single router (function FindMaxAngle). Finally, we add the couple (*R*, *rant*) to a group set *Rg* in line 10.

At the second step of the ZND algorithm (lines 11–15), we keep locating more routers until *Q* is empty. This step ensures that the map is fully covered by the routers' communication range. Here, every router's communication range is at least partially overlapped with another deployed router's communication range such that at most two forwarding routers need to be added for each pair of two routers whose communication ranges are partially overlapped to ensure the communications of these two routers.

After the loop has been completed, the loop between lines 16 and 20 marks the position of each router based on the group *Rg*.We model the center of each disk formed by edge sets in group *Rg* as a vertex (function **MakePolygon**) and then add the vertex to *Vr*. In line 21, we form bidirectional edges between each pair of two vertices in *Vr* (function **MakeConnection**). There will exist an edge *e*(*u*,*v*) in *Er* if and only if the two routers represented by vertices *u* and *v* are within each other's communication range based on the antenna gain profile. In other words, the edges in *Er* represent the transmission links between routers.

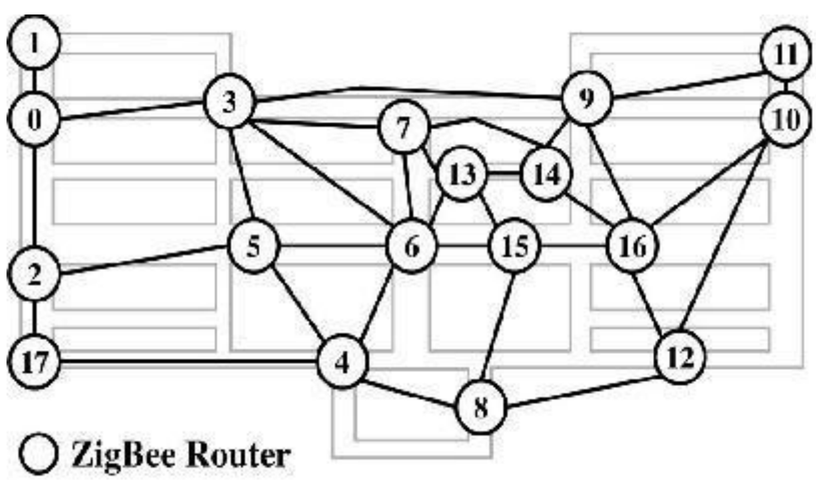

Fig2 Router Deployment

ZCD Phase

This section explains the implementation of the ZCD phase using Algorithm 2. Based on the deployment completed in thefirst phase, the ZCD phase selects one vertex in the region as the root (coordinator) of the routing tree. This phase also builds an edge-weight function based on the mobility profile for the graph *Gr*. The function will be used to construct the routing tree in the ZTC phase.

Algorithm 2

***Input**:* A network graph *Gr* = (*Vr*,*Er*), a grid graph *G* = (*V*,*E*), and a mobility profile *M*

***Output**:* A vertex *pr* and an edge-weight function *Wr* for

1. $pr \leftarrow \emptyset^{Gr}$
2. Define a weight function *Wr* for graph$_{\emptyset}$ *Gr* such that *Wr* ← CombineState(*M*,*G*,*Gr*)
3. **if** (*pr* ← UserAssignRoot(*Gr*)) ≠ **then**$^{\text{graph}}$
4. **return** (*Wr, pr*)
6. Define a $_{\epsilon}$weight$_{\epsilon}$ function *WIV* such that
7. **for all** *d* *Vr* **do**
8. *WIV* (*d*) ← *s* *Vr* *Wr*(*e*(*s*,*d*))$^{5.\textbf{endif}}$
9. **end for**
10. *pr* ← FindMax(*Vr*,*WIV*)
11. **return** (*Wr*, *pr*)

The input of the algorithm in this phase comprises the graph *Gr* constructed in the previous phase, the original graph *G* with a virtual grid, and the mobility profile *M*. The algorithm outputs the root vertex *pr* and the edge-weight function *Wr*. First, we define the edge-weight function*Wr* by merging states in the mobile profile *M* (function **CombineState**). Each state in *M* has a corresponding vertex in *G*. Some states are merged into one state if the positions of their corresponding vertices in *G* are covered by one disk centered at a vertex in *Gr*. Then, the new mobility profile will comprise the edge-weight function of *Gr*. In line 3, we check if the root has been selected (function **UserAssignRoot**). If a vertex has been designated as the root, the algorithm is completed and outputs the root vertex *pr* and the edge-weight function *Wr*.

ZTC Phase

This section explains the implementation of the ZTC phase.

Algorithm 3

***Input**:* A network graph *Gr* = (*Vr*,*Er*) with *Wr* and *pr*, *Rm*, and *Lm*

Output: A ZigBee routing tree *T*

1. Define∅a tree *T* = (*VT*,*ET*) whose root node is *pr*
2. **repeat**∈∈ ∈
3. *Q* ←
4. **for all** *e*(*u*,*v*)   *Er*, *u* /   *T*, *v*   *T* **do**
5. Add *e*(*u*,*v*) to *Q*
6. **end for**
7. Sort(*Q*)
8. **for all** *e*(*a*,*b*)∈*Q* **do**
9. **if** CheckLegal(*e*(*a*,*b*), *T*,*Rm*, *Lm*) = *TRUE* **then**
10. Remove *e*(*a*,*b*) from *Q*

The algorithm defines a tree and initially takes *pr* as the root node. The main loop is in lines 2–16, and the tree is constructed in this loop until the number of vertices in *Gr* is equal to that in *T*. First, we put into an empty set *Q* each directed edge whose source vertex is not in *T* and destination vertex is in *T*. Then, in line 7 (function **Sort**), the algorithm sorts *Q* in non-increasing order such that the first element in *Q* is the edge with the largest weight.

If *T* is legal, we add the edge *e*(*a*,*b*) to the tree. Finally, the algorithm outputs the tree *T*. Recall that, for the tree construction, our design rationale is to prefer that the paths of downlink data delivery and end device movement patterns are as close as possible and in reverse direction. To achieve this goal for the simple example, the ZTC algorithm constructs the ZigBee routing tree that includes only the coordinator at first. The edge with the maximum weight among all edges directed at the coordinator will then be selected to be included as part of the tree. Then, the edge with the maximum weight among all remaining edges directed at the tree will be chosen to be included, and so on.

V. CONCLUSION

Finally this paper proposes a scheme that exploits the regularity in node movements in wireless ZigBee networks. It proposes three algorithms to construct mobility based ZigBee cluster tree topology. The primary objective of the proposed approach is to deploy the routers and construct a tree topology that enables mobile end devices to move with high probability in the direction of the routing paths.

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