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RESEARCH ARTICLE

Improving Selfish Node Detection in ZigBee Wireless Network with Shortcut Tree Routing

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Abstract— The ZigBee tree routing and Bluetooth is used in many resources, limited devices and applications. ZigBee tree routing is not requiring any routing table and route discovery cost to send a packet to the destination. But, the ZigBee tree routing has the basic limitation that a packet follows the tree topology. So ZigBee tree routing is cannot provide the correct routing path. In this project work, a shortcut tree routing protocol is proposed that offering the near advantageous routing path and as well as maintains the advantages of the ZigBee tree routing such as no route discovery overhead and low memory consumption. The key 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. Each source or intermediate node forwards a packet to the neighbour node with the Slight remaining hops in its neighbour table. The shortcut tree routing is completely distributed and compatible with ZigBee standard in that it only using the addressing scheme and neighbour table without any changes of the specification. The mathematical analysis proves that the 1- hop neighbour information improves overall network performance by providing an efficient routing path and distributing the traffic load concentrated on the tree links. The efficient performance rating, it shows that the shortcut tree routing achieves better to performance compared to Ad Hoc On Demand Distance Vector with limited overhead of neighbour table maintenance as well as overwhelms the ZigBee tree routing in all the network conditions such as network density, network Structures, traffic type and the network traffic.

Keywords— ZigBee, STR, Neighbour Table, WSN, IEEE 802.15.4

I. Introduction

ZigBee is a specification for a suite of high level communication protocols used to create small, low-power digital radios from personal area networks. ZigBee is dependent on IEEE 802.15 standard. Deposit the low-energy; ZigBee devices usually receive and transmit data over longer distances by passing data through intermediate devices to reach more afar together, creating a mesh network; i.e., a network with no focused regulation or high-authority transmitter/receiver able to reach all of the networked devices. The match centre nature of such wireless ad hoc networks makes them suitable for applications where a central node cannot be relied upon.

ZigBee is used in applications that require a less data rate, long battery life and safety networking. ZigBee has a defined rate of 250 kbit/s, better the most appropriate for periodic or intermittent data or a single signal transmission from a sensor or input device. The technology limited by the ZigBee specification of the intended to be simpler and less expensive than like other WPANs, such as Bluetooth or Wi-Fi.

A WPAN (wireless personal area network) is a personal area network. A network for interconnecting devices centralized around an individual person's workspace in which the connections are wireless. Generally, a wireless personal area network uses some technology that permits communication within about 10 meters in other words, one of the shortest ranges. One such technology is Bluetooth, which was used as the basis for a new quality, IEEE802.15.

A WPAN could serve to interconnect all the ordinary computing and communicating devices that many people have on their desk or carry with them today. It could serve a more specialized purpose such as allowing the surgeon and other team members to communicate during an operation.

A key concept in WPAN technology is known like plugging in. In the ideal best case scenario, when any two WPAN-equipped devices come into close proximity (within several meters of each other) or within a few kilometres of a central server, they can communicate as if the connected by a cable. Another key feature is the ability of each device to lock out other devices selectively, preventing useless interference or unauthorized access to information.

The technology for WPANs is in its install stage and is undergoing rapid growth development. The proposed operating frequencies are surrounding 2.4 GHz in digital modes. The objective is to facilitate seamless operation among home or place of business devices and settings. Each device in a WPAN will be able to plug in to any other equipment in the only WPAN, provided they are within physical range of one another. In addition, WPANs around the worldwide will be interconnected.

II. RELATED WORKS

The Complexity of the Network Design Problem was Network design problem we are given a weighted undirected graph. To find a sub graph and shortest path problem [8]. We establish NP-completeness for the network design problem. Use of spanning trees. A minimum spanning tree (MST) or minimum weight spanning tree is then a spanning tree with weight less than or equal to the weight of every other spanning tree. Shortest path algorithms are applied to automatically find directions. Network design is an iterative process, is aimed at ensuring that a new telecommunications network or service meets the needs of the subscriber and operator Minimum spanning tree. Network design problem we are given a weighted undirected graph.

Highly dynamic Destination-Sequenced Distance-Vector routing [2] for mobile computers was Use of Ad-hoc Networks; DSDV is a table-driven routing scheme for ad hoc mobile networks based on the Bellman–Ford algorithm. The important contribution of the algorithm was to solve the routing loop problem and the each entry in the routing table contains a sequence number. The advantage of this work is Bellman–Ford algorithm is used in distance-vector routing protocols [4]. When a node receives distance tables from its neighbour's node and it's calculates the shortest routes to all other nodes and updates its own table to reflect any changes and the disadvantage of DSDV requires a regular update of its routing tables. Changes in network topology are not reflected quickly since updates are spread node-by-node. DSDV itself does not appear to be much used today other protocols have used similar techniques and the better known as sequenced distance vector protocol is AODV.

Dynamic Source Routing in Ad Hoc Wireless Networks [3] was a protocol for routing in ad hoc networks that uses dynamic source routing. Route Discovery and Route maintained. Reflecting Shorter Routes and Piggybacking on Route Discoveries

The routing problem is to find a route from S to D when some or all of the nodes are mobile. DSDV Protocol was considering a collection of mobile computers, (nodes) which may be to from which base station. The computers (nodes) exchange control messages to establish multi-hop paths in the same way as the Distributed Bellman-Ford algorithm. These multi-hop paths are used for exchanging messages among the computers (nodes). Packets are transmitted between the nodes using routing tables stored at each node. Each routing table lists all available destinations and the number of hops to each destination. For each destination, a node knows which of its neighbours leads to the shortest path to the destination. Consider a source node S and a destination node D. Each route table entry in S is tagged with a sequence number that is originated by the destination node. For example, the entry for D is tagged with a sequence number that S received from D (may be through other nodes). And need to maintain the consistency of the routing tables in a dynamically varying topology [1]. Each node periodically transmits renewals. When significant new information is available that time done by each node. It does do not assume any clock synchronization among the mobile nodes.

The route-update messages indicate which nodes are accessible from each node and the number of hops to reach them. To consider the hop-count such as the distance between the both two ends points of the two nodes.

However, the DSDV protocol can be conversion for other measurement as well. A neighbour in turn checks the best route from its own table and forwards the message to its relevant appropriate neighbours and the routing progresses this way of forwards process. There are two issues in this protocol one is How to maintain the local routing tables and another one is How to collect enough information for maintaining the local routing tables. Ad-hoc On-Demand Distance Vector Routing (AODV)[6] is a packet routing protocol designed for use in mobile ad hoc networks (MANET). Intended for networks that may contain thousands of nodes. Each node maintains a routing table that contains information about reaching destination nodes. The basic message set consists of:

RREQ – Route request, RREP – Route reply, RERR – Route error and HELLO – For link status monitoring

Shortcut Tree Routing in ZigBee Networks was a Shortcut tree routing protocol to reduce the routing cost of ZigBee tree routing. Using the neighbour table. Simulation of ZigBee networks[5] was Network simulators is like NS2, OPNET, and NetSim, can be used to simulate IEEE 802.15.4 ZigBee networks. The IEEE 802.15.4 covers the follow the two layer one for physical layer and another one for the MAC layer of less-ratio WPAN. The ZigBee is “an emerging standard that is based on the IEEE 802.15.4 and adds network construction (The construction network is follow that star networks, mesh networks, peer-to-peer networks, and cluster-tree networks), usage services, and more”.

III. ZIGBEE AND IEEE 802.15.4

IEEE 802.15.4 MAC uses the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) mechanism for accessing the channel. Moreover, it provides the GTS (Guaranteed Time Slots) allocation method in order to provide real time data communication. Based on IEEE 802.15.4 PHY/MAC, the ZigBee network layer activities offered such as dynamic network development, addressing, routing, and finding 1 hop neighbours.

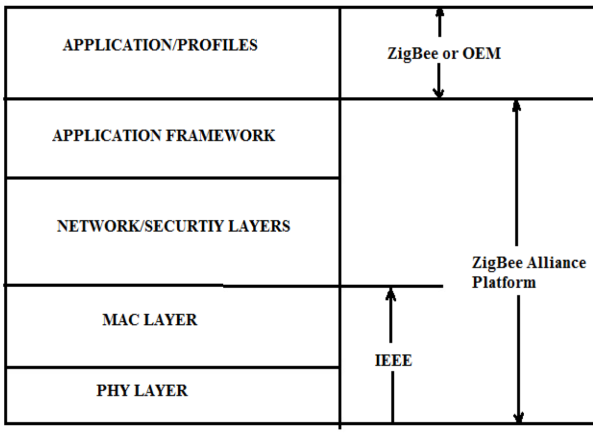

Figure 2: ZigBee Network layer information

Network address size is calculated with bits and the size of the network address is 16 bits, so ZigBee is capable to receptive about 65535 devices in a network, and the network address is appointed of a hierarchical tree structure’s this document as a template by simply typing your text into it.

IV. SHORTCUT TREE ROUTING (STR)

The main idea of STR is that we can compute the remaining tree hops from an arbitrary source to a destination using ZigBee address hierarchy and tree structure as discussed in previous section. In other words, the remaining tree hops can be calculated using tree levels of source node, destination, and their common ancestor node, because the packet from the source node goes up to the common ancestor, which contains an address of the destination, and goes down to the destination in ZTR.

This project work proposed algorithm basically follows ZigBee tree routing algorithm, but chooses neighbour nodes as next hop nodes if the routing cost to the destination can be reduced.

1. *Algorithm of find Minimum cost Routing*

Find_NextHopAddr(dstAddr)
Input: dstAddr
Output: NHDstAddr
begin
1. depth_dstAddr= Find_AddrRange(dstAddr, 0, 0)
2. Assign the next hop node of tree routing to NHDstAddr

3. Assign the remaining hop count when selecting NHDstAddr to minNHRouteCost
4. for each (neighbor n_a in neighbor table)
5. i=0
6. while(n_a is in AddrRange[i+1]&&i<depth_dstAddr)
7. ++i
8. myRouteCost=(depth_dstAddr-i)+(depth(n_a)-i)
9. if(minNHRouteCost>myRouteCost)
10. NHDstAddr=n_a
11. minNHRouteCost= myRouteCost
12. end if
13. end for each

End

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. The STR algorithm basically follows ZTR, but chooses one of neighbour nodes as the next hop node when the remaining tree hops to the destination can be reduced. The STR algorithm that solves problems of the ZTR by using 1-hop neighbour information.

2. Algorithm of find destination for Minimum Cost Routing Path

Find_AddrRange(dstAddr, startAddr, curDepth)

Input: dstAddr, startAddr, curDepth

Output: depth_dstAddr, AddrRange[depth_dstAddr]

begin

1. if(dstAddr=startAddr)
2. returen curDepth
3. else
4. for i=1 to Rm
5. if(dstAddr is in the address space of ith router)
6. store address space of ith router to AddrRange[curDepth+1]
7. return Find_AddrRange(dstAddr, ith router, curDepth+1)
8. end if
9. end for
10. if(Cm-Rm>0)
11. if(dstAddr is the end device of startAddr)

12 return curDepth+1

13. end if

13. end if

13. end if

End

Each device in ZigBee maintains a neighbour table which has all the neighbour information in the 1-hop transmission range. If users reduce the amount of the neighbour table, the picked numbers of neighbour entries are stored in the table.

Cskip(d)= (1+Cm-Rm-Cm*Rm^(Lm-d-1))/(1-Rm)

Ak= Aparent+Cskip(d).(k-1)+1(1<=k<=Rm)

An= Aparent+Cskip(d).Rm+n(1<=n<=Cm-Rm)

A< D< A+Cskip(d-1)

Detour path problem of ZTR: 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. It cannot provide the optimal routing path: because packet follows the tree topology. The ZigBee tree routing network conditions are network density, network traffic occurs degradation problem.

In addition to the detour path problem, ZTR has the traffic concentration problem due to limited tree links. Since all the packets pass through only tree links, especially around the root node, severe congestion and collision of packets are concentrated on the limited tree links. This symptom becomes worse and worse as the number of packets increases, and it finally causes the degradation of the packet delivery ratio, end-to-end latency, and other network performances.

V. PROBLEM DESCRIPTION

The tree routing protocol uses only parent and child relationship for routing, ignoring neighbour nodes. As a result of, packages may be routed through several hops towards the destination even if this is within sender's 1-hop transmission range.

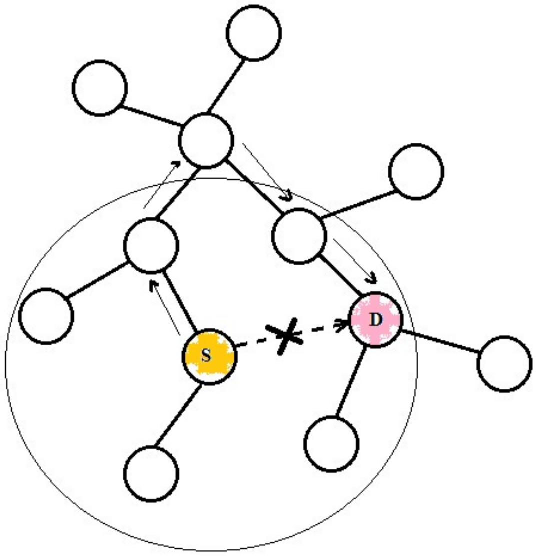

Figure 5(c) Parent and Child Relationship for Routing

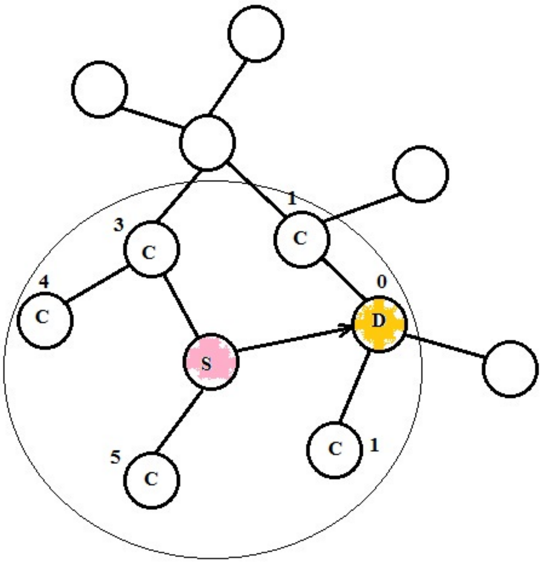

Figure 5(d) 1-hop transmission range

VI. PERFORMANCE EVALUATION

The STR in diverse metrics of the routing performance and overhead. The evaluation of the routing performance includes hop count, end-to-end latency, packet delivery ratio, and MAC level retransmissions, and the routing overhead is measured with the number of control packets and memory consumption for routing. The simulation is categorized into three subsections in order to analyse the effects of network density, traffic pattern, network in the framework, and the network traffic.

In this evaluation, the network simulator NS-2 and IEEE 802.15.4 PHY/MAC protocols are used for comparing STR with ZTR and AODV. The general parameter settings are use this configuration, unless otherwise noted in the following subsections. The network association procedure and ZigBee address assignment scheme are applied to the all routing protocols. Every node in each simulation starts association procedure at random time from 0sec and ends with assigned network address within 50sec.

In ZigBee, entries of neighbour table are created and maintained by the link status message with a 1-hop broadcast every nwkLink- Status Period seconds, which is set to 15sec in our simulation. This link state maintenance mechanism is mandatory function in ZigBee; thus, ZTR and STR have the same routing overhead and memory consumption in the real deployment. However in this evaluation, the routing overhead and memory consumption for the link state maintenance mechanism are considered as the overhead of AODV and STR.

On the contrary, we represent ZTR's overhead with the neighbour information from the successfully received beacons during an association process, since it is minimum information for ZTR to establish the hierarchical address used for the tree routing and the 1-hop neighbour information obtained from the link state maintenance mechanism which is not related to the pure routing performance of ZTR. All the statistics of the evaluations, except the routing overhead and memory consumption, are measured from the successfully delivered packets, and all the figures in this section represent the average value and the 95% of confidence interval.

A. Time Complexity

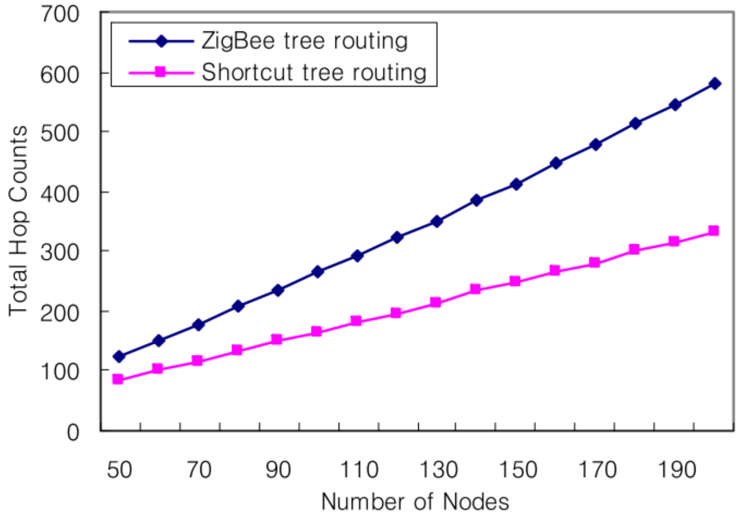

Figure 6.1(a) Total Hop Counts in old process

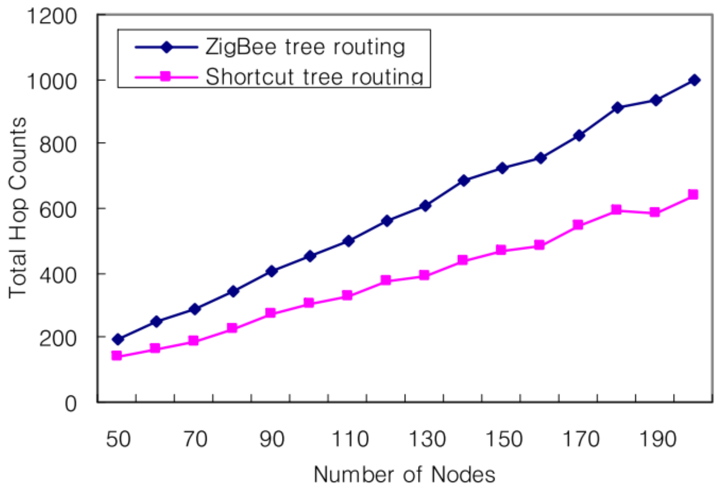

Figure 6.1(b) Total Hop Counts in New process

Let n be the number of neighbour nodes of a certain intermediate or source node. The time complexity of the shortcut three routing algorithm is O(LM *n).

B. Upper Boundary of the Routing Cost

Even if the scale of neighbour table is limited, the proposed protocol algorithm will not select a node with higher routing cost than the one selected by ZigBee tree routing. Therefore, the proposed algorithm can not exceed the routing cost of ZigBee routing.

C. Simulation Result

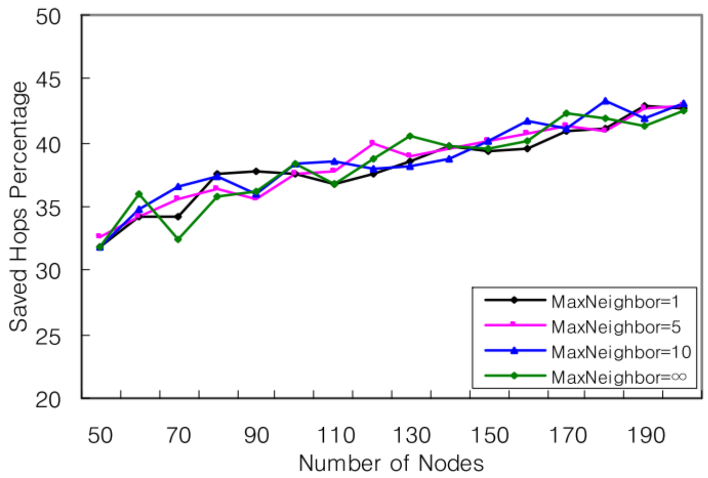

Figure 5.3(a) Saved Hops Percentage in Old Process

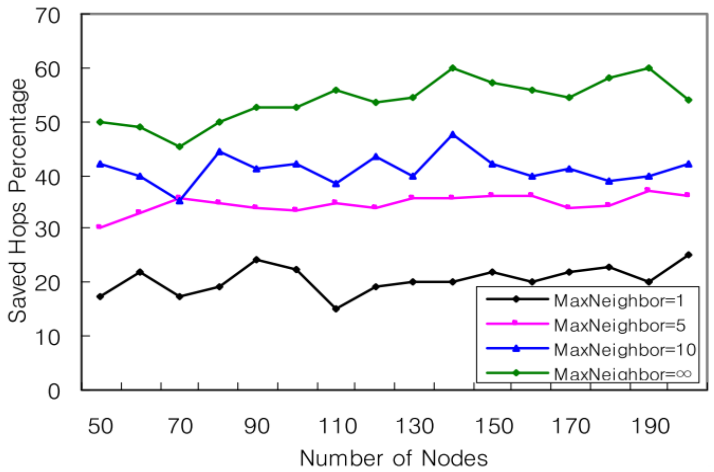

Figure 5.3(b) Saved Hops Percentage in New Process

This project work set the network size as 100*100 and the transmission range as 20 meters. Each node has in the same way transmission range and they are randomly deployed. In simulations, this project work only considers scenarios where more than 80 percent of the total number of node is able to join the network. This paper limit the number of children and maximum depth of the tree by setting Cm=4, Rm=4, and Lm=5.

VII. CONCLUSIONS

In this project work, is identified the detour path problem and traffic concentration problem of the ZTR. These are the basic problems of the general tree routing protocols, which cause the overall network performance degradation. In the order to overcome these problems are propose shortcut tree routing that uses the neighbour table, first defined in the ZigBee standard. In the shortcut tree routing, each node can find the Advantageous next hop node based on the remaining tree hops to the destination. The mathematical analyst's prove that the 1-hop neighbour information in STR reduces the traffic load concentrated on the tree links as well as provides an efficient routing path. The network simulations show that STR provides the comparable routing performance to AODV as well as scalability respect to the network density and the network traffic volume by suppressing the additional route discovery process. The ZigBee shortcut tree, routing method is efficient and time saving. But security measures are not available in this project work. So our enhancement concept is secure data communication. In the real world, most nodes may have a selfish behaviour, being unable to forward sending and receiving packets for others in order to save resources. A selfish node will typically not cooperate in the packages transmissions, extreme affecting network performance. Therefore, detecting these nodes is essential for network performance. So find out the selfish node and select alternative path for source to destination communication. The modeled its performance using Continuous Time Markov Chain method, this was the enhancement of the project work.

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