Improved NOVSF-TM based Addressing and Energy Efficient Routing in ETR Protocol

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Received: 9 April 2012 Accepted: 4 May 2012 Published: 15 May 2012

Abstract

A small WSN is a collection of micro-sensors. Sensors send or receive data to a sink node, which collect and processes it. The Tree-Routing (TR) protocol was initially designed for such network. TR uses strict parent-child links for data forwarding. Hence, it saves bandwidth and energy by preventing network from flooding path search messages. For a large network TR shows large hop-count and more energy consumption. The Enhanced-Tree-Routing (ETR) protocol implemented over TR has structured node address assignment scheme. It considers other one-hop neighbor links, along with parent-child links, for packet forwarding if, it is found to be the shortest path to sink. Such decision in ETR involves minimum computation energy. Instead ETR, the emerging demand for data intensive and energyâ??"efficient applications, needs new or improved routing protocols. In this paper we have proposed Non-Blocking-Orthogonal-Vector Spreading- Factor-Time-Multiplexing (NOVSF-TM) technique for sensor node addressing and Mobile Sinks placement so as to improve ETR protocol. The addressing scheme of NOVSF TM is shorter than ETR. Mobile Sinks positioning, at feasible sites, helps reducing excessive hop-count. This eliminate excessive multi-hoping and save energy. Simulation result shows that NOVSFTM technique is more energy-efficient than ETR protocol.

Index terms— NOVSF-TM, ETR, TR, Hop-count, Energy

batteries. Manually recharging batteries of deployed sensors is extremely difficult task. Therefore, solutions to increase the network lifetime are important. Moreover every aspect of design, deployment and management of WSN has to be energy-efficient [V. Raghunathan et al.,2002] to meet stringent power requirements. Among various components of sensors radio communication is the most energy consuming operation a node performs, and thus, it must be used sparingly and only as dictated by the task requirements [F. Zhao, L. **??**uibas, 2004]. Since the transmit power of a wireless radio is proportional to distance squared, a direct communication over long distance consumes more energy than multi-hop communication. Moreover in a large area of interest multi-hop transmission is the appropriate way of communication. Topology creation, therefore, is an essential function of multi-hop WSN and routing is the method built into the firmware of each sensor node for finding paths between source and destinations. The elementary method of sensor network construction is to start with a root node (usually sink) and expand as new nodes join as child nodes. Each node can have multiple children but only one parent. The resultant network structure is like a tree as depicted in Fig. **??**. In Fig. **??**, nodes A, B and C are the child nodes of root node. Both root and C are the ancestors of node E and F while all nodes except root are descendants' nodes.

Fig. **??**: Basic Tree Topology Tree routing (TR) is well suited for such network. The inter-node communication is restricted to parentchild links only. By relying solely on the parent-child links, TR eliminates path searching and updating complexities. TR is suitable for networks consisting of small-memory, low-power and low-complexity lightweight nodes. The main drawback of TR is the increased hop-counts as compared with other path search protocols. TR does not utilized neighbor table fully. A neighbor table records information such as addresses of nodes within the radio range, information of parent and child nodes etc. The neighbor table is created when the node joins a parent node. The proposed Non-blocking Orthogonal Vector Spreading Factor with Time Multiplexing (NOVSFTM) [Kiran Vadde and Hasan Cam, 2004] technique uses a spreading factor (SF-8) to generate orthogonal codes assigned to the mobile sink nodes. The mobile sink nodes are positioned at the centroid location of the polygon, logically created by joining the extreme sensors as coordinates, in the region where sensors are deployed. Fig. 3 shows the basic architecture of the protocol with one mobile sink and a fixed sink node. Overall four mobile sink with orthogonal code (as address) MS1=1111, MS2=11-1-1, MS3=1-11-1 and MS4=1-1-11 can be positioned in the region with SF-8. The mobile sink reduces the excessive of hop-count as appears in ETR protocol with increase in network density. The simulation results also shows noticeable differences in terms of energy consumption while transmission.

This paper is organized as follows. Section II reviews the related work. Section III presents the proposed NOVSF-TM technique for addressing and improvement to ETR for energy saving. Section IV provides the simulation results and Section V concludes the paper.

Tree routing (TR) **??**Wanzhi Qiu et al., 2009] is a simple routing algorithm where a node only forwards packets to its parent or child nodes. It prevents energy by avoiding intensive message exchanges of path search/update processes. Emerging architecture for large-scale urban wireless networks employ TR schemes as well. For example, IEEE 802.16j, the WLAN standard for 4.9-5 GHz operation in Japan mandates tree forwarding. Fig. 2 depicts this procedure, where DEST is the destination node, DOWN and UP is the produced next hops and NODEp is the parent of the node making the routing decision. Enhanced Tree Routing (ETR) **??**Wanzhi Qiu et al., 2009] assumes that each node has an updated neighbor table having the address of its immediate one-hop neighbours. This neighbor table is utilized to identify the alternate path to the sink node with hopcount less than the actual path. unique identification number. This number is assigned to the node as it joins the network.

The NOVSF-TM technique provides unique orthogonal codes that are timely shared by number of channels without contention in W-CDMA system. We have planned to utilize these unique codes to represent regions in large sensor network. The entire region of sensor deployment is divided among number of regions, depending on transmitter range of the sensor. Each region is hosted by a mobile sink, placed at the center place of the region. Each region has a unique code for its identification; here orthogonal code plays this role. The mobile sink of the region provides addressing to the sensors deployed in the region by combining its assigned code and a sequence number, to uniquely identify sensor node (see **??**ig 4). For analysis, we have utilized SF-8 OVSF code for address assignment to the mobile sink stations. Each mobile sink have two NOVSF codes, generated from its address and are used to generate sensor node addresses (see Table 1). For analysis we have assumed a small region of 500 x 500 for sensors random deployment. A sink node is randomly placed at a location and sensors are placed randomly in the region. The mobile sink station is placed at the centroid location of the region so as to cover a maximum range and can reduce hop-count to sink node. After the sensors are randomly deployed in the region, a logical polygon is created with the sensor nodes at extreme location, as coordinates of the polygon. The centroid is the central position of the polygon that can cover maximum number of sensors. With SF-8 the architecture can support maximum of 4 mobile stations in the region. An orthogonal code can support addresses in the rage (0000 0001 to **??**111 1111), for simplicity we have taken only 64 addresses for results comparisons i.e in the range (0000 0001 to 0100 0000)(see Fig. 5). Initially one mobile sink is placed in the region. As the number of sensors increases beyond 128 (64+64), second mobile sink is positioned, if it increases beyond 256 the third mobile sink is positioned and after 384, third mobile sink is placed and finally, fourth is placed to support a maximum of 512 sensors. Sensors node send their sensed data to the mobile sinks either by single-hop or multi-hop manner. In this section we have conducted simulations in an event-driven simulator developed in MATLAB to compare the performance of TR, ETR and NOVSFTM in terms of hop-count and energy consumption. We have generated some dynamic network topologies and tested the three protocols on it. In particular, after the nodes are deployed, the coordinator is powered on to start network. All the nodes then power on and search their neighbourhood for parents. The new node and its identified parent exchange joining information and a network address is assigned to the new node. The network is established when all the nodes join the network. An event is a transmission of packet from a source node to a destination node along the route determined by the three protocols. For each event number of hops and energy consumption of each hop is recorded. There is a sequential execution of events i.e. the second event triggers only when first one finishes. We have considered random deployment of the sensors in a fixed region of 500m by 500m. The energy consumption model specified in [J. Park, S. Sahni, 2006] is used. According to which the energy required by a single-hop transmission of a packet is (0.001 x d3) Where d is the distance between two nodes. For each network simulation scenario, NWKS = (40, 45, 50, 60, 65) instances of sensor networks are randomly generated and RUNS=10,000 runs are conducted for each instance. For each instance the hop-count and energy consumption are recorded. The results of network instances are average to find the metrics:

We have considered two cases for the simulation:

C Case 1: The transmitter range is set to 235m and the numbers of nodes deployed are taken in the range (40, 45, 50, 60 and 65). The simulation results are shown in Fig. 5 and Fig. **??**. It is clear from Fig. 5 that for randomly selected sensors the TR, ETR and NOVSFTM shows a noticeable difference in hop-count to the sink node. The TR protocol shows high line of hopcount as it follows strict parent-child path to the sink node.

ETR shows comparatively less number of hopcounts to TR protocol because it considers neighbor table to select shortest path to reach sink node. Finally NOVSF-TM based improved ETR has the lowest hop-count. The hop-count reduction in it is observed because of positioning of mobile sinks to the centroid location of the region and elimination of excessive hop-counts as most of the sensors are now directly connected to the mobile sink to send data. Mobile sink accumulate the data and forward it to the fixed sink node.

The energy consumption is based on the distance between two adjacent nodes. Small distance has less energy consumption as compared to the large distance. It is identified from Fig. **??** that energy consumption reduces slowly to a certain point, as more number of sensors is deployed. This is because of multihoping of data packets using small paths. The energy consumption increases thereafter because the excess in hop-counts outweighs any possible decrease in singlehop distances. In practice, dense deployment is used not for energy efficiency. Rather, it is for providing the required measurement density the radio connectivity redundancy needed to deal with issues such as node failure etc. Therefore, from Fig. **??** it is evident that improved ETR with NOVSF-TM technique reduce more energy than TR and ETR protocols. Where, h r.i and e r.i are the hop-count and energy consumption of the r th run for i th network instance respectively.

Fig. 5: HOP-counts in Case 1 Fig. **??**: Energy consumption in Case 1 C Case 2: The number of nodes deployed is fixed to 32 (one selected value from the range in case 1) while the maximum radio range is taken in the range (240, 245, 250, 255 and 260). The simulation results are shown in Fig. **??** and Fig. **??**. Fig. **??** shows that as transmitter range increase the coverage area of the sensor increases and thus hop-counts are tending to decrease. For ETR large radio range provides more number of neighbours and hence, availability of more number of alternative shortest paths. In improved ETR with NOVSF-TM technique the increase in transmitter range causes direct attachment of sensors to the mobile sink. This leads to reduction of multi-hoping to singlehoping and hence, reduction in hop-count.

As for energy consumption, it is clear from Fig. **??** that with increase in transmitter range the energy consumption increases in both TR and ETR protocols because of increase in per hop distance, while improved ETR with NOVSF-TM technique shows significantly low energy consumption. Hence, improved ETR with NOVSF-TM technique is more energy efficient than the two protocols. In this paper we have proposed an improved addressing and routing strategy over the two existing protocol called Tree Routing (TR) and Enhance Tree Routing (ETR). The TR protocol being simple and less complex is suitable for small sensor networks, but it does not utilize neighbor table for link optimization. The ETR protocol makes use of these alternative links available in neighbor table to optimize routing paths. ETR become complex when the density of the sensor nodes increases. NOVSFTM uses orthogonal codes as addresses to the sensor nodes. The sensor utilizes this orthogonal code as node address for data transmission. These orthogonal codes can be used further for spreading and dispreading of signals so as to avoid interferences occurring from the external environment. The positioning of mobile sink in the region at centroid causes reduction in excessive hop-count occurring in ETR protocol. The NOVSF-TM technique is found to be more energy efficient and easy to implement. The simulation results show that improved ETR with NOVSF-TM addressing can outperforms ETR and TR in terms of hop-count and energy. [1] [2]

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Figure 1: Fig. 2 :

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Figure 2: Fig. 3 :

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Figure 3:

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Figure 4: Fig. 4 :

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Figure 5: Fig. 5 :

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Figure 6: Fig. 7 :Fig. 8 :

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Figure 7:

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Figure 8: Table 1 :

8. Place the mobile sink at location (Cx,Cy).
9. Create a link from mobile sink to fix sink.
10. Find the distance of each coordinate from (Cx,Cy) using formula
11. If (dist <= T_Range) then
There is a link;
Else
Repeat step 8 and 9 for rest of the coordinate;
12. End

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Figure 9:

[/*y Coordinates Int T_Range] , /*y Coordinates Int T_Range .

[/* Transmitter range Int] , */* Transmitter range Int* p. 500.

[/* Region] , /* Region . p. .

[*] , * .

[/*draw the coordinates(sensors) in the region of 500*500 Plot (netXloc, netYloc)] */*draw the coordinates(sensors) in the region of 500*500 Plot (netXloc, netYloc)*,

[/*populate array with n random coordinates as netXloc =rand] */*populate array with n random coordinates as netXloc =rand*, (1,noOfnodes)*L)

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