DELAY EFFICIENT BROADCAST SCHEDULING FOR CRITICAL EVENT MONITORING IN WIRELESS SENSOR NETWORKS

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Abstract

Wireless sensor networks are expected to work for a longtime without replacing the batteries frequently. In critical event monitoring applications in wireless sensor networks only a small number of packets need to be transmitted most of the time, when a critical event occurs in the monitoring area and is detected by a sensor node, a message is needed to be broadcast to the other nodes as soon as possible. After that, the sensor nodes can warn users nearby to flee or take some response to the event. As sensor nodes for monitoring an event are expected to work for a long time without recharging their batteries, sleep scheduling method is needed during the monitoring process. But they are only significantly reducing the energy consumption and the broadcasting delay increases. The sleep scheduling scheme in this work could essentially decrease the communication latency of alarm broadcasting from any node in WSN and the energy of all of the sensor nodes in the network is fully utilized, which in turn increases the network lifetime.

Key words – *Wireless Sensor Networks (WSN), critical event monitoring, sleep scheduling, broadcasting delay*

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1. INTRODUCTION

Wireless Sensor Networks, is a key technology for various applications that involve long-term and minimum-cost monitoring. The wireless sensor network was initially developed as a military application to survey a battlefield. However, now WSN is commonly used in many industrial applications and also in various commercial applications to monitor environmental conditions, traffic controls health care applications. There are normally equipped with a radio transceiver or a wireless communication device or a power source. In wireless sensor networks battery is soul energy source .The WSNs needs the battery as the only energy source of the sensor node. Sensor nodes are normally working on batteries for several months to a few years without replacing. Thus, energy efficiency becomes a critical issue in WSNs. Among the functional components of a sensor node, major portion of the energy is consumed by radio. Various scheduling algorithms are projected to minimize its energy consumption. However, most of them focus on minimizing the energy consumption.

In this paper, a sleep scheduling method, which is based on the level-by-level offset schedule for achieving low broadcasting delay in a large scale WSN for critical event monitoring, is used. The scheduling method includes two phases:
1) any node detecting a critical event sends an alarm packet to the center node(sink) along a predetermined path according to level-by-level offset schedule; As shown in Fig.1, the packet can be delivered from node a to node c via node b with

minimum delay. So with the level-by-level offset schedule it is possible to achieve low transmission delay in multi-hop WSNs.
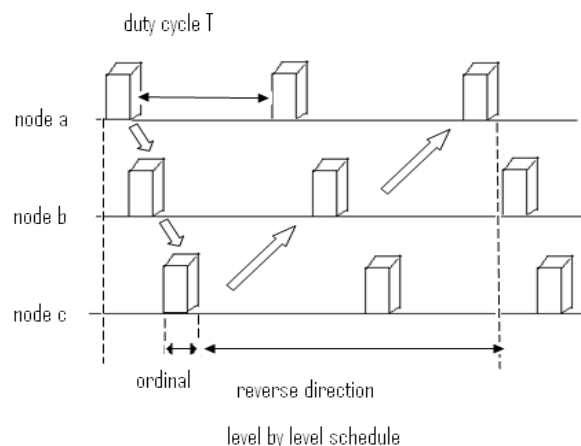
Fig.1 The level-by-level offset schedule

2) The center node(sink) broadcasts the alarm packet to the entire network also according to level-by-level offset .In this way, the energy of all of the sensor nodes in the network is fully utilized, which in turn increases the network lifetime and it could essentially decrease the delay of alarm broadcasting from any node in WSN.
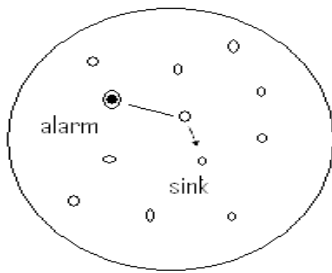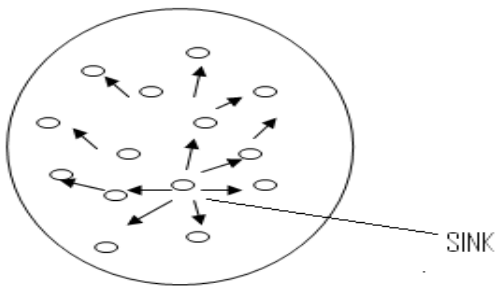
Fig.2 Phase 1.Send the alarm to sink

Fig.3 Phase 2 sink send the alarm to other nodes

2. PROBLEM DESCRIPTIONS

It is assumed that initially the center node in the network has already obtained the network topology. The center node computes the sleep scheduling and broadcasts it to other nodes. The following terms are defined in this paper,

Event detection:

In WSN for the critical event monitoring, sensor nodes are usually prepared with passive event detection capabilities that allow a node to detect an event even when its wireless communication module is in sleep mode. When an event is detected by the sensor, the sensor node's radio module is immediately woken up and it is ready to send an alarm message.

Slot and duty cycle:

Time is split into time slots. The length of each slot is about the minimum time needed by sensor nodes to transmit or receive a packet, which is denoted as t. For example, to transmit a simple packet with a size of several bytes using the radio chip Chipcon CC2420; t could be less than 2 ms. the length of each duty cycle is $T= L * t$, i.e., there are L slots in each duty cycle.

Network topology

It is assumed that the network topology is unsteady and it is denoted as a graph G.

Synchronization:

Time of sensor nodes is assumed to be locally synchronous; it can be implemented and maintained with periodical beacon broadcasting from the center node.

F(nk) is defined as the slot assignment function. If f(nk)= s; s € {0, . . . , L − 1}, it means that node nk wakes up only at slot s to receive packets.F(nk) is defined as the channel assignment function which assigns a frequency channel to node nk.

3. DELAY EFFICIENT BROADCAST SCHEDULING METHOD

BFS tree

The result of BFS tree gives a division of all nodes into layers H1, H2, H3; . . .; HD, where Hi is the node set with minimum hop i to c in the WSN. Likewise, the uplink paths for nodes are obtained. The center node first announces about its location to the neighbors as a packet. Likewise all nodes broadcast the packet including its location to other nodes. The nodes calculate the distance and choose its parent with lowest distance. After a time period each node gets its parent. Finally a path from each node to center node is established. When a node gets the alarm it forwards the packet only to its parent, likewise the packet will be forwarded to the center node in a single path.

Construction of MIS

The MIS can be established layer by layer (i.e., hop by hop) in the BFS as follows: Start from the 0th hop, pick up a maximum independent set, then, move on to the first hop, pick up another maximum independent set, Likewise maximum independent set is constructed. The output of BFS tree gives some three to four layers. The node with 0th hop becomes layer 1 and the nodes with 1st hop become layer 2 and etc. From the given (x,y)axis nine such (x,y) coordinates are generated. From this four subsets are formed. The nodes in 0th layer and first subset are displayed. Likewise corresponding nodes are displayed.

Connector nodes selection and CDS formation

Construct the CDS by selecting connector nodes C to interconnect independent nodes. The idea of the IMC algorithm is used to select the connector nodes, which partitions independent nodes I \ Hi in each layer into four disjoint subsets. When one set of nodes broadcast simultaneously, it won't cause collision for the nodes in another set.

Colors assignment

Color the CDS to be CCDS. Divide all nodes in CDS into several sets according to their minimum hops to c in CDS. Sending channel is defined as chs(nk) and receiving channel is defined as chr(nk) for each node nk, corresponding to channels in which nk sends packets and receives packets respectively.

Wake up pattern

Sensor nodes take two level-by level offset schedules for the traffic paths.

* Sensor nodes on paths in the BFS wake up level-by-level according to their hop distances to the center node;
* Once the center node wakes up, the nodes in the CCDS wakes up level-by-level according to their hop distances in the CCDS.

The maximum hop from any node to the center node is no more than 2D.

Consider any independent node nj, there must be apparent in C connecting another independent node which is closer to the center node than nj. If the parent is in the same layer with nj in the BFS, then, it increases the hops of nj to c in the CCDS. Otherwise, the number of hops will not increase. The worst case is one increment on the shortest path from a node in layer HD to c for each hop with a maximum length of the shortest path in the CCDS is consequently 2D.

The upper bound of alarm broadcasting delay in WSN is no more than 3D + 2L.

According to the scheme, alarm packet can be transmitted along the uplink traffic path in the BFS without waiting. As soon as the center node gets the packet, it immediately broadcasts the packet without waiting along the downlink traffic paths in the CCDS. Because the maximum hops of the shortest path in the BFS are not more than D, the upper bound of the delay to transmit an alarm from any node to the center node is D. Similarly, the upper bound of the delay to broadcast the alarm from the center node to all other nodes is no more than 2D. In addition, because the alarm may be originated at any time by a node and it has to wait for duration until the time for its uplink schedule comes. The duration is no more than 2L. Hence, the total delay is no more than 3D + 2L.

4. ANALYSIS AND SIMULATIONS

Ns2 simulator is used to evaluate the performances of the scheduling method in unsteady WSNs.225 sensor nodes are randomly deployed in an area of 150*150 m2.The initial energy level of the sensors are set to 100 joules. The table 4.1 gives the description of the simulation environment.

For comparison some simulations for the ADB schemes are conducted.

ADB is composed of two basic components: (i) efficient encoding of ADB control information, which helps to distribute information on the progress of a broadcast and information for delegation decisions; and (ii) the delegation procedure, which runs whenever a broadcast DATA packet or a beacon with an ADB footer is received or overheard, determining which nodes

the DATA packet should be forwarded to and which nodes should be delegated. A node using ADB needs knowledge of its neighbors and the quality of the wireless link to each, which can be provided by existing mechanisms such as the four-bit link estimation.

Table 4.1 Description of simulation environment

| Trails	1	2	3	4
Our scheme	0.13768	0.13768	0.13768	0.13768
ADB	0.19266	0.19266	0.19266	0.19266

The time slot was set to 1 ms and the simulation is conducted. The broadcasting delay with the anticipated scheme becomes much lower when compared to ADB scheme.

Table 4.2 shows the various results for the experiments conducted to examine the broadcasting delay.

Table 4.2 Average broadcasting delay in different trials

Sensor nodes	225
Area	100 *100 m2
Initial energy level	100 joules
Transmission power consumption	0.02 watts
Reception power consumption	0.01watts
No of independent nodes	112
No of connector nodes	66
Broadcast delay	0.0171374ms

Fig 4.1 shows the simulation results in the same network. It can be seen; the broadcasting delay with the delay efficient broadcast scheduling scheme becomes much lower when compared to ADB scheme.
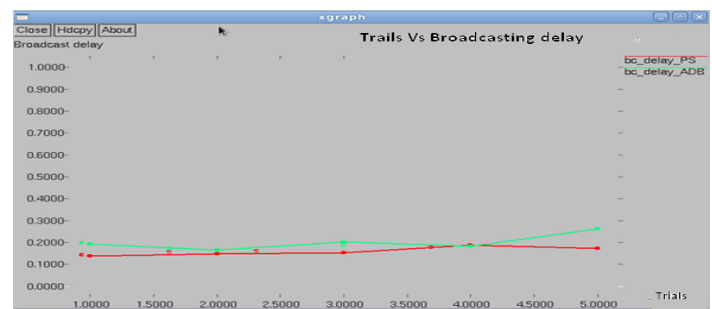
Fig 4 broadcast delay for ADB and Delay Efficient Broadcast Scheduling

The average broadcasting delay and the total delay is calculated from the following   formula,

Total delay =   receiving time of packet -
                Starting time of packet

Average broadcasting delay = Total delay /
Total number of packets transmitted

The total delay is first calculated from the difference of the receiving time of the packet and the starting time of the packet. The average broadcasting delay is equal to the ratio of total delay and the total number of packets transmitted.

CONCLUSIONS

In this paper, a sleeping scheme for critical event monitoring in WSNs is projected. This sleeping scheme could essentially decrease the delay of alarm broadcasting from any node in WSN. By using the sleep scheduling scheme which follows the concept of level by level offset scheduling and wake up patterns it was examined that it produces minimum broadcasting delay when compared to ADB: an efficient multi hop broadcast protocol on asynchronous duty-cycling.

The major aim of this paper is to develop a better algorithm than existing algorithms to achieve the minimum broadcasting delay for critical event monitoring in WSNs .To achieve this the sleep scheduling algorithm projected gave a better result when compared to the existing ADB algorithm. This algorithm is then compared with advanced algorithms to achieve better result.

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