MWSN 에서 채널 및 타임 슬롯 공동 스케줄링 데이터 집계를 위한 제안 계획 : 알고리즘 설계

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A Proposed Scheme for Channel and Timeslot Co-Scheduling Data Aggregation in MWSNs: An Algorithm Design

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요 약

Aggregating data with an optimal delay, which is a critical problem in Wireless Sensor Networks applications, is proven as NP-hard. In this paper, we focus on optimizing the aggregation delay by presenting an idea for channel and timeslot co-scheduling data aggregation in MWSNs. The proposed scheme, which names Break and Join, maximizes the number of sensor nodes to be scheduled in a working period, so that the overall number of working periods and data collection delay are reduced.

1. Introduction

In Wireless Sensor Networks (WSNs), data aggregation is essential in many application scenarios which are limited in energy resources such as spatial exploration, battlefield surveillance, or environment monitoring, etc. to save the energy of sensor nodes. The energy conserving approaches are used by switching sensor nodes between active and dormant modes [1]. The sensor nodes only receive data when they are in active mode, this is one of interesting challenges for proposing some delay efficiency data aggregation algorithms.

Data aggregation is one of two terms named data aggregation convergecast along with raw data convergecast [2]. The convergecast is a many-to-one pattern where one node in a sensor network as a sink node role collects data from others in the network by using wireless communication links. Data aggregation is the process that intermediate nodes will maximize, summarize or moderate data before sending it to their parent nodes. Whereas raw data convergecast transfer the data directly to the next hop without modification.

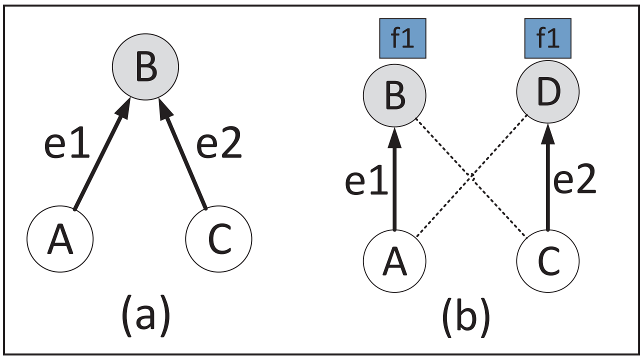
Scheduling by using multi-channel technique in multi-channel wireless sensor network (MWSNs) helps conflict links can communicate to each other simultaneously. This overcomes the drawback of single channel scheduling, that when two nodes in the network communicate, other neighbor nodes cannot transmit their data until those nodes above complete. With multi-channel allocation, nodes are assigned in different channels, so that while two nodes are communicating, other their surrounding nodes can also transmit or receive the data from other nodes without worrying about collisions occur if they are assigned channels in properly ways. Moreover, while single channel scheduling only considers timeslots conflict, multi-channel needs to take care both channel and timeslot conflicts when scheduling.

In this paper, we design an improvement scheme to reduce the aggregation delay. The structure of this paper is organized as follows: In the section 2, we provide the model and problem statement. We present the relate work and our proposed idea in section 3. Finally, we summarize our scheme and outline the future research direction.

2. Model and Problem Statement

A WSN model consists a number of sensor nodes and a sink node which aggregates data from all others. All nodes in the network are randomly deployed in a limited field, and they have a limited transmission range and omnidirectional antennas. The network topology is represented as an undirected graph G = (V, E) whereas V is a set of nodes in the network and E is a set of edges in the network. This network topology is connected, in the other hand there is always a path connecting any node to a sink node in the network. The transmission range between nodes is their Euclidean distance.

Nodes in the network can transmit and receive data in designated channels and timeslots, they cannot communicate simultaneously. There are two types of collision happens that should be avoided while scheduling which are primary collisions and secondary collisions as shown in figure 1 (a) and (b) respectively. One node receives data from two or more nodes at the same time causing primary conflicts. The secondary conflicts happen when a node is unintended to receive data from its neighbor while the node is receiving data from its child node.

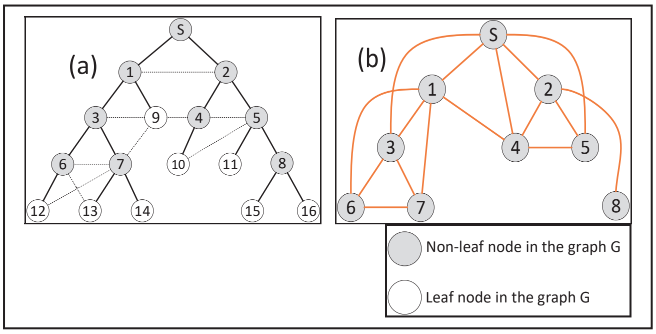


(Figure 1) (a) Primary collision between edges e1 and e2. (b) Secondary collision between edges if they transmit data on the same channel, one of the receiver nodes is unintended to receive the data.

3. Proposed Scheme

A. Related work

In the paper [3], the authors proposed a scheme to allocate channels and timeslots to reduce used channels and minimize the data aggregation delays in a multichannel WSNs. The scheme consists of two stages which are channel allocation to avoid the secondary collisions and timeslot assignment to avoid primary collisions.



(Figure 2) (a) Aggregation tree; (b) Constraint graph built for the receiver nodes from the tree

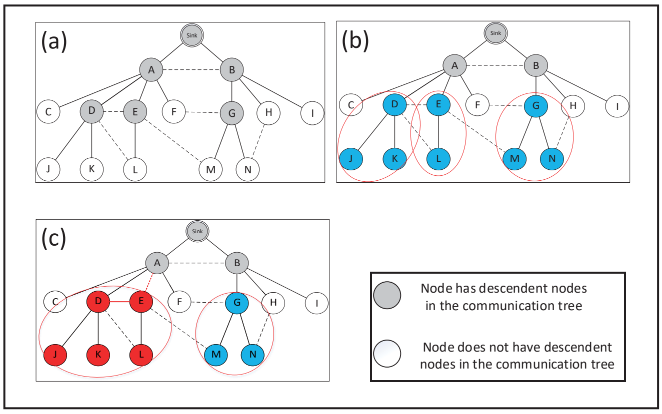
In the channel allocation stage, determine all subtrees in which the number of descendent nodes is fewer than or equal to the number of timeslots in a working period L (L is given). Allocating channels to all subtrees one by one from the largest subtree. The channel allocation work based on the constraint graph (CG) which is proposed in [4]. All nodes in a specific subtree is assigned in the same channel. The constraint graph is used to avoid the secondary collisions. The CG, which is created from the original graph G, contains all non-leaf nodes of graph G. Any two nodes in the CG connects to each other when their edges that cause secondary collisions as illustrated in the figure 2. In the other word, a node in the CG graph connects to others if it finds secondary collisions with its child and neighbor nodes. The figure 2 shows how the CG works and how the channel allocation operates based on the CG. Assume that the aggregation tree is given in the figure 2 (a), the constraint graph is built from the aggregation tree in the figure 2 (b). Any two adjacent nodes in the constraint graph must not be assigned same channel.

In the timeslot assignment stage, the subtree is assigned the timeslot in a bottom-up manner starting from 1 to L right after the channel allocation completes. Because all nodes in the subtree has the same channel, the scheme assigns different timeslots to each node in the that subtree to avoid the primary collisions.

B. Proposed idea

In this section, we apply the Break and Joint method to the reference scheme aiming to reduce the aggregation delay of the network. Given a tree and a feasible aggregation schedule, in which each node is scheduled to transmit its data to the parent node at a specific timeslot. The Break and Join scheme operate on node u and its neighbor v consists of two actions: First, node u breaks its edge with its parent; Second, the node u joins as a child of node v.

There are two reasons that we apply the Break and Join method to the reference scheme. We want to maximize the number of descendent nodes in a subtree (equal or approximate to L). So that the number of subtrees to be scheduled is reduced, this lead reducing the number of channels using to allocate all nodes in the network. The second reason, when number of descendent nodes in subtrees is maximized, parallel transmissions in a timeslot increase also, the aggregation delay of the network, therefore, is reduced.



(Figure 3) Break and Join scheme operation

As follow the procedure of reference scheme, in each iteration, a subtree is chosen to schedule in which the number of descendent nodes is equal or less than the length of timeslots in one working period. If the selected subtree having number of descendent nodes is equal to the length of timeslots in the working period, the scheme works follow as the procedure. If the selected subtree having number of descendent nodes is fewer than the length of timeslots in the working period, the Break and Join scheme is executed aiming to increase the number of descendent nodes in that subtree as well as increase number of nodes in the network can be scheduled in a working period.

An example run below in the figure 3 is to illustrate how the Break and Join scheme works and somehow show that how it increases a subtree in one iteration.

Assume that a communication tree is built by using Short Path Tree algorithm (Figure 3 (a)), and there are 4 timeslots in a working period (L = 4). In the first iteration, three subtrees rooted at D (two descendent nodes), E (one descendent nodes) and G (two descendent nodes) are candidates (Figure 3 (b)). If following procedure of the reference scheme, the subtree rooted at D is selected due to maximum descendent nodes and D has a lower ID than G. However, because number of descendent nodes is lower than L, the Break and Join scheme is executed in this case. D has two neighbor nodes E and L. If node E breaks its parent (A) then joins as a child of node D, the subtree rooted at D has 4 descendent nodes. Similar for node L, the subtree rooted at D has 3 descendent nodes. Therefore, the node E is chosen as the child of node D. After applying the Break and Join scheme, the selected subtree now has 4 descendent nodes (as maximizing the number of descendent nodes) to be assigned channel and timeslots nodes in that subtree. So on and so forth, with the Break and Join scheme, after a number of iteration to do the scheduling for all nodes in the network the aggregation time can be reduced.

4. Conclusion

In this paper, we present an idea of improving aggregation delay for channel and timeslot co-scheduling data aggregation in MWSNs. The idea, named Break and Join, maximizes the number of descendent nodes in a selected subtree if the length of node number in the subtree is smaller than the timeslot number in a working period. The robust feature of our proposed idea is the scheme can run if there is any chance to maximize nodes in a working period so that the delay performance can be improved too. The performance evaluation of our proposed idea compared with the reference scheme is performed in our future research.

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