듀티 사이클 MWSN에서 데이터 집계를위한 개선 지연 효율적인 스케줄링 체계

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An Improvement Delay Efficient Scheduling Scheme for Data Aggregation in Duty-Cycle MWSNs

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Abstract

In multi-channel wireless sensor networks, optimizing data aggregation delay without any channels and timeslots conflicts has been concerned these days. The aggregation delay can be reduced by using different aggregation tree construction methods or scheduling in different methods in bottom-up or top-down manners. In this paper, we propose a new way of constructing aggregation tree purposing to decrease the total aggregation delay. The result shows that our proposed scheme can improve up to 64% comparing with state-of-the-art schemes.

1. Introduction

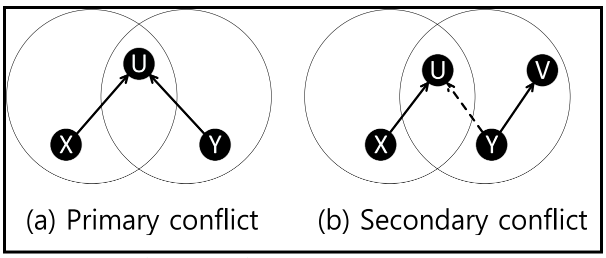
These days multi-channel wireless sensor networks (MWSN) are getting concerned in data aggregation [1] since they have more advantages than single-channel wireless sensor networks (SWSNs) such as reducing data aggregation delay, preserving sensors' energy leading to increasing network lifetime. However, we only consider timeslots conflicts in SWSNs while aggregating data whereas we have to consider both channels conflicts and timeslots conflicts in MWSNs while doing data aggregation, this problem is more challenging when channels conflicts and timeslots conflicts are considered separately [2].

Energy preservation is one of the most important problem that most researchers are focusing on because this factor helps the sensor network to live in longer time since sensors are limited in battery life. There are some researching approaches that increase the network lifetime like reducing the number of time that sensors switch channels, instead of always-on sensor networks we use duty-cycle networks [3], or we design optimal methods for data aggregation to reduce the time for collecting data since this is the NP-hard problem.

This paper focuses on reduce the data aggregation delay by proposing a new way to construct the aggregation tree then applying the same node scheduling scheme of the state-of-the-art scheme in [4]. The structure of this paper is organized as follows: We present the network model and problem formulation in the section 2. In the section 3, we describe the target schemes in general, our proposed scheme and present the simulation settings and results. We conclude the paper in the section 4.

2. Network Model and Problem Formulation

We consider a WSN presented as a graph G(V, E) with V is a set of sensor nodes including a sink node randomly deployed in an area, and E is a set of edges. We assume that every sensor node in a network can connect to each other and possibly have at least path to transmit its data to the sink node. Each sensor node operates half-duplex which means it cannot transmit to and receive data from its neighbors at the same time. If a node receives data from two neighbors or more, a data conflict happens. In general, primary conflicts and secondary conflicts are two types of conflicts happening in data collection in WSNs. As shown in the Figure 1.a, the primary conflict occurs when nodes X and Y transmit data to node U at the same time, conflict happens at U; The second



(Figure 1) Conflicts in WSNs

conflict happens as presented in Figure 1.b, if node U receives data from node Y accidently while node U wants to get data from X, and Y wants to send its data to node V, since nodes U and Y are neighbors so that when X and Y transmit their data to their parents (U and V, respectively) at the same time, node U also receives data from Y, then a conflict occurs at node U.

We assume that the lifetime of a sensor node is divided into multiple working periods with the same length. A working period has T timeslots where the sensor nodes operate in duty-cycled mechanism in which nodes change between active state and dormant state independently. A sensor node wakes up in the active state to collect data from its neighbors at any time whenever it is required then sleeps at the dormant state when it is in idle time.

In previous studies, the data aggregation is completed by two phases which are aggregation tree construction phase and nodes scheduling phase. So that the method applied in either tree construction phase or nodes scheduling phase changes, leading to change the total aggregation delay of the whole network. In this paper, we examine different aggregation tree construction method with the same nodes scheduling scheme in the target paper aiming to reduce the total aggregation delay.

3. Proposed scheme

A. Related work

The authors in [4] propose two schemes named EDAS (Efficient Data Aggregation Scheduling) and NDAS (Novel Data Aggregation Scheduling) schemes aiming to accomplish data aggregation with minimum delay. When EDAS scheme is completed, there are many unused timeslots and channels occurred, so that the NDAS scheme is proposed to tackle the EDAS scheme's weakness. The NDAS scheme schedule more possible links by finding as many links as possible to schedule on those unused timeslots and channels that the EDAS has left. In the process of scheduling of EDAS and NDAS schemes, they build conflict graphs CACG (Candidate Active Conflict Graphs) and FACG (Feasible Active Conflict Graphs) to show the interference relationship of the current scheduling links based on that we can avoid the conflicts while assign timeslots and channels to the nodes.

In both EDAS and NDAS schemes, the aggregation tree is built based on maximal independent set (MIS); Firstly nodes in the network are divided into layers based on their hop distance to the sink, the MIS are constructed layer by layer after that, thirdly they construct the aggregation tree based on the MIS.

Based on the constructed aggregation tree, nodes scheduling scheme is operated in a bottom-up manner. In each working period, at each active timeslot, some links are selected if the receiver nodes of the links are awake at that timeslot. Then those selected links are scheduled by constructing conflict graphs based on the interference relationship (CACG) and smallest- degree-first rule (FACG). After that, they assign transmitting timeslots and channels to the nodes in the conflict graphs. Up to this step, EDAS scheme completes the data aggregation of the current working period. The NDAS is proposed with one more step to schedule more links in the current working period by seeking as many more links as possible to schedule on unused timeslot and channels, after that the nodes scheduling is completed at that working period. In the new working periods, same procedures are applied until all nodes in the network are assigned channels and timeslots.

B. Proposed idea

We apply different method to build the aggregation tree, then apply the same nodes scheduling scheme as the NDAS scheme does. With this proposal, we are purposing to reduce the data aggregation delay.

Instead of using maximal independent set, we base on the subtraction values of sender nodes' active timeslot and receiver nodes' active timeslots, we call this value is active timeslot interval. This is actually the Dijkstra's algorithm where link weight is active timeslot interval between receiver and sender nodes. The overall idea of this tree construction is as following: Given a working period length T-timeslot, assuming that node u is a sender, and node v is a receiver. Both u and v are active at several timeslots, the active timeslot interval between u and v is the subtraction of active slot of node u and active slot of node v. We consider the subtraction values of active slots of receiver and sender until we find the link weight as minimum active timeslot interval value. Nodes u and v in the formula below are candidate sender and candidate receiver, respectively.

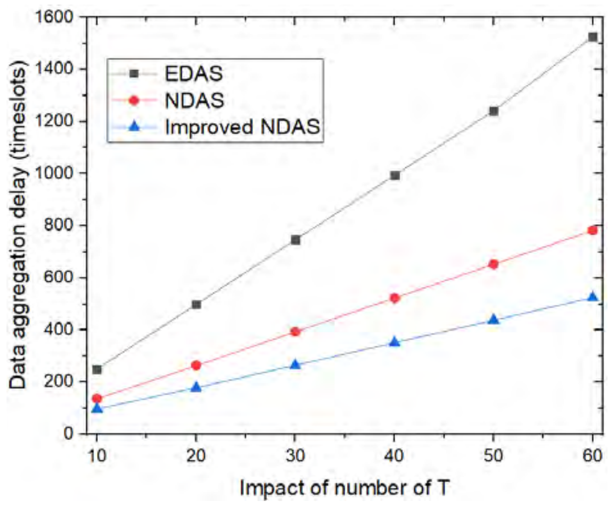
$$d(u, v, T) = \begin{cases} a(v) - a(u), & if\ a(v) > a(u) \\ a(v) - a(u) + T, & elsewhere \end{cases}$$

The procedure of active timeslot interval tree construction is as follows: We start from one of the sink node's active slots, we adopt its child node by calculating active timeslot interval between the sink with its neighbors. The child node of the sink is adopted when active timeslot interval between them is smallest value. The child node is then added to the aggregation tree. We decrease the considering timeslots one by one, then check if there is any node active at that timeslot, so we can adopt its child node then add that node to the aggregation tree. Applying the same procedures, we will find parent nodes as well as children for all nodes in the network in later working periods.

C. Performance Evaluation

We first randomly generate 100 connected network topologies. Each network topology includes 100 sensor nodes, including the sink, are randomly deployed in a two - dimensional areas with the size 100 x 100m^2. We assume that each node in the network is always ready to send its data to its parent. The transmission range is 20m, number of channels can be used is 2, each node can be active at 2 timeslots, the working period length is varying from 10 to 60 timeslots. We evaluate the impact of changing the working period length on the total data aggregation delay based on this environment settings.

The Figure 2 shows the data aggregation delay



(Figure 2) Impact of the number of T on data aggregation delay

comparing between EDAS, NDAS and the improvement of the scheme NDAS we name Improved NDAS (since we change the aggregation tree construction method and keep their nodes scheduling scheme). With the increase of number of working period length T, nodes have to wait more timeslots for their parent to wake up, so that all the schemes have data aggregation delay increasing trend. However, the gaps between those schemes are getting bigger when the T enlarges, the Improved NDAS cam improve up to 30% and 64% comparing to NDAS and EDAS, respectively. The reason that our proposed scheme has better result than previous studies, is that while constructing the aggregation tree based on active timeslots of receiver and sender, we build the pipeline tree to maximize the number of transmissions in one working period. So that more links can be scheduled in a working period, the scheduling delay is further reduced.

4. Conclusion

In this paper, we propose a method to build the aggregation tree aiming to reduce the total aggregation delay in multi-channel WSNs. The improvement named Improved NDAS uses different method to construct the aggregation tree, and then apply the same nodes scheduling scheme as NDAS uses. The result shows that the data aggregation delay improves significantly with different kinds of aggregation trees but same scheduling scheme.

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