Fast and Variable Amount of Data Collection in Tree Based Wireless Sensor Networks

Sivakumar M.
PG Scholar, Department of Information Technology
SNS College of Technology
Coimbatore, India
sivamtechit@gmail.com

Suguna M
Associate Professor, Department of Information Technology
SNS College of Technology
Coimbatore, India
suguna.marappan@gmail.com

Abstract: The fast data collection used for receiving information quickly and thus preventing major failure due to the delay in reception. Convergecast method is employed here to facilitate many to one communication paradigm in sensor network. Existing simulation work demonstrate that the schedule length is reduced to complete a convergecast in a tree structural network topology and combine the scheduling with transmission power control to alleviate the interference effects. Simulation results evaluated the performance by collecting fixed data. We propose the variable amounts of data collection using convergecast technique in Wireless sensor networks. We also evaluate the performance of various channel assignment methods and find empirically that for moderate size networks of about 100 nodes the use of multi-frequency scheduling can suffice to eliminate most of the interference. The data collection rate no longer remains limited by interference but by the topology of the routing tree. To this end construct the degree-constrained spanning trees and capacitated minimal spanning trees and show significant improvement in scheduling performance over different deployment densities. Lastly evaluate the impact of different interference and channel models on the schedule length.

Keywords - Convergecast, PDR, CMST, TDMA scheduling, JFTSS, RBCA, TMCP.

I. Introduction

Wireless Sensor Network (WSNs) is a highly distributed network of small lightweight wireless nodes. Monitors the environment or system by measuring physical parameters such as temperature, pressure, humidity. Convergecast means the collection of data from a set of sensors over tree based routing topology [2]. We focus two types of data collections are aggregated convergecast and raw data convergecast. Aggregated convergecast means, the packets are grouped at each hop, the goal is to gather the summerized information such as maximum sensor reading. Raw data convergecast means the packets are individually relayed toward the sink or the correlation is minimal. TDMA (Time Division Multiple Access) framework is used to minimize the schedule length for both types of convergecast [2]. We also find lower bound on the achievable schedule length.

Some primary factors of fast data collection, which are: 1) interference, 2) half- duplex, 3) topology of network. We investigate number of different techniques for successive improvements.

To achieve the further improvements, we combine transmission power control with scheduling and use multiple frequency channels to enable more concurrent transmission. Thus, in the final step, we construct network topologies with specific properties that help in further enhancing the rate.

Our primary conclusion is that combining these different techniques can provide an order of magnitude improvement for aggregated convergecast, and a factor of 2 improvements for raw-data convergecast compared to single-channel TDMA scheduling on minimum-hop routing trees. Polynomial-time heuristics for TDMA scheduling for both types of data collection, i.e., Our algorithms prove that they do achieve the lower bound of data collection time once interference is eliminated.

II. Related Work

The schedule length is minimized for aggregated convergecast has been studied by us in [3] and [4]. Raw-data convergecast has been studied in [5], [6] and [7], where distributed time slot scheme is proposed in [2] to reduce a TDMA schedule length for a single channel. The orthogonal code is used to eliminate interference has been studied in [8], where each and every node is assigned time slots from bottom to top of the tree such that a parent node does not transmit before its receive all the packets from its children. The time optimal and energy-efficient packet scheduling algorithm for raw data convergecast presented by Song et al. [5]. Once interference is eliminated, the algorithm achieves the bound.

We studied fast convergecast in WSN; where nodes are communicate using TDMA protocol to minimize the schedule length. We observed that node-based and link-based channel assignment schemes are more efficient in terms of eliminating interference and we showed that the lower bounds are achievable once a suitable routing scheme is used [1].

Maximizing the throughput of convergecast by finding a shortest-length, conflict tree schedule is studied by Lai et al. [7], where a greedy graph coloring strategy assigns time slots to the senders and prevents interference.

III. System Design & Problem Analysis

We model the multihop WSN as a graph G=(V,E), where V represents set of nodes and E represents set of edges i.e., E = { (i, j) | i, j ε V } representing wireless links. The euclidian distance of two nodes i and j denoted by dij. All the nodes are sources expect S, which generate packets and transmit them over routing tree to S. The spanning tree on G rooted at S by T = (V, E_T), where E_T represents the tree edges. Each node assumed as a half-duplex transceiver which prevents it from sending and receiving packets simultaneously.

First consider the TDMA protocol where time is divided into slots, and consecutive slots are grouped into equal-sized nonoverlapping frames.

Two types of interference models are used for our evaluation. The graph based protocol model and the Signal-to-interference-plus-Noise Ratio (SINR) based physical model. In protocol model, two links cannot be scheduled simultaneously if the receiver of atleast one link is within the range of the transmitter of the other link.

In the physical model, the successful reception of a packet from i to j depends on the ratio between the received signal strength at j and cumulative interference. Thus a packet is received successfully at j if the signal to-interference-plus-noise ratio, $SINR_{ij}$, is greater than a certain threshold value β. i.e,

$$SINR_{i,j} = Pi.\ gijk \neq iPk.\ gkj+N$$

P_i represents the transmitted signal power at node1, N represent noise level, g_{ij} represent propagation attenuation between i and j. The simple distance dependent path-loss model used to calculate the link gains as g_{ij} = dij-α, where α is the path-loss exponent represent a constant between 2 and 6 whose exact value depends on external conditions of the medium, as well as the sender-receiver distance. For simplicity and ease of illustration, we use the protocol model in all figures.

IV. TDMA Scheduling

We must focus on the periodic convergecast and raw-data convergecast. Our objective is calculating the minimum available schedule length using TDMA protocol. Data aggregation used to eliminate redundancy and minimizing number of transmission. Thus saving energy and improving network life time [9]. Each node is capable of aggregating all the packets received from its children's well as that generated by itself into single packet before transmitting to its parent. The transmitted aggregated data size is constant and does not depend on the size of the raw sensor readings. The Figure 1a and 1c illustrate the conception of the pipeling in aggregated convergecast and that of a schedule length on a network of six source nodes. The solid lines denote tree edges and a dotted line denotes interfering links. The numbers nearby links denote the timeslots at which the links are scheduled to broadcast. The numbers contained by the circle denote node ids. The entries in the table list the nodes from which packets are received by their corresponding receivers in each timeslot. In frame1, the sink does not have packets from nodes 5 and 6; however, as the schedule is repeated, it collect aggregated packets from nodes 2, 5 and 6 in slot 2 of the frame2. In the same way, the sink also collect aggregated packets from node1 and 4 from slot 1 of frame2. In the entries of table {1, 4} and {2,5,6} respectively. Hence, a pipeline is established from frame2 and the sink continuous to receive aggregated packets from all the nodes once every six time slots. Hence the minimum schedule length is 6.

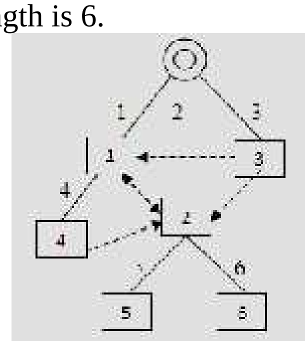

Figure 1a. Scheduling Length of 6 in the presence of Interfering Links

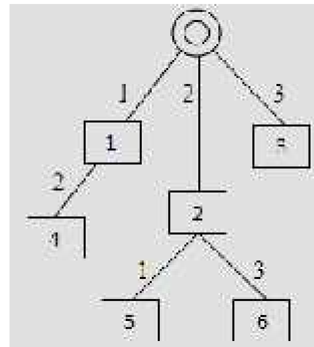

Figure 1b. Scheduling length of 3 using BFS-Timeslot Assignment when all the interfering links are eliminated

	Frame1					
	S1	S2	S3	S4	S5	S6
s	1	2	3	-	-	-
1	-	-	-	4	-	-
2	-	-	-	-	5	6

	Frame2					
	S1	S2	S3	S4	S5	S6
s	{1,4}	{2,5,6}	3	-	-	-
1	-	-	-	4	-	-
2	-	-	-	-	5	6

Figure 1c. Node ids from which packets are received by their corresponding parents in each timeslot

V. Assign the time slots

Assign the time slot to one-shot raw data convergecast using local timeslot assignment. The key idea of this algorithm is to: 1) Schedule transmission in parallel along multiple branches of true, and 2) keep the sink busy. Because the sink can receive from the root of at most one top subtree should be mode active. Our algorithm that is local time slot algorithm does not require any of the nodes to store more than one packet in their buffer at any time. First initialize all the buffers as full, and assumes that the sinks buffer is always full.

VI. Multichannel Scheduling

Multiple frequencies are an efficient technique to eliminate interference by concurrent transmission over different techniques [10]. In this section we consider different channel assignment problem: the link level (JFTSS), node level (RBCA), or cluster level (TMCP).

A. Link level Channel Assignment Method

An advantage of JFTSS (Joint Frequency Time Slot Scheduling) is that it is easy to incorporate the physical interference model. JFTSS schedules a network starting from the link that has the highest number of packets to be transmitted. Approximation bounds on JFTSS for single channel systems are discussed in [11] its comparison with multichannel systems are discussed in [12]. The algorithm starts with an empty schedule and first sorts the links according to the loads or constraints. All the links have an adjacency constraint with the schedule links are excluded from the list of the links to be scheduled at a given slot. In Figure 2a, JFTSS starts with link (2, sink) on frequency1 and then schedules links (4, 1) next on the first slot on frequency2. Then, links (5,2) on frequency1 and (1,sink) on frequency2 and (3,sink) on frequency2 are scheduled on the last slot.

B. Cluster level Channel Assignment Method

Tree Based Multichannel Protocol partitions the network into multiple subtrees and reduces the intratree interference by assigning different channels to nodes. Figure 2b shows the same tree given on Figure 1a which is scheduled according to TMCP is a greedy based multichannel protocol for data collection application [13].

Here the nodes on the branch assigned frequency F1, F2 and F3 and after the channel assignments, time slots are assigned to the nodes using BFS-Timeslot Assignment algorithm. The advantage of TMCP is designed to support convergecast traffic and does not require channel switching.

C. Node level Channel Assignment Method

The children of a common parent transmit on the same channel. The algorithm initially assigns the same channel to all receivers. The set of interfering parents are created for each receiver by Receiver Based Channel Assignment (RBCA) based on SINR threshold. The SINR value at the receivers may not always be high enough to tolerate interference, In Figure. 2c, initially all nodes are on frequency F1, the RBCA starts with the most interfered parent node 2 in this example and assigns F2. Then assigns F3 to node 3 as the second most interfered parents. Since all interfering parents are assigned different frequencies and sink can receive on F1.

VII. Implementation

We implement and compare the packet interval with average end-end delay, packet delivery ratio and throughput. The Figure 3a shows the packet interval Vs average End-End delay, it describes how end to end delay performs from source to destination total duration to complete the transmission taken as a delay.

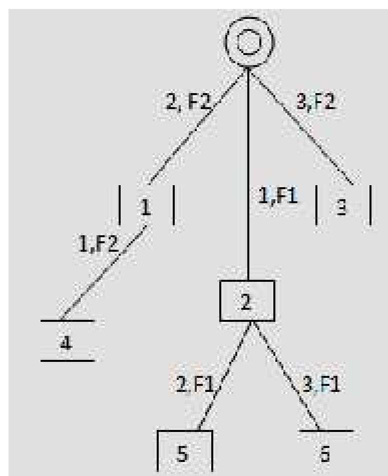

Figure 2a. Scheduled generated with JFTSS

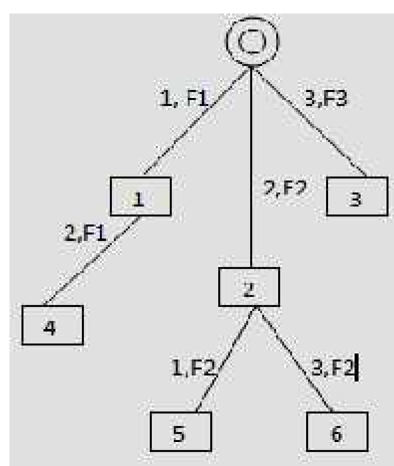

Figure 2b. Scheduled generated with TMCP

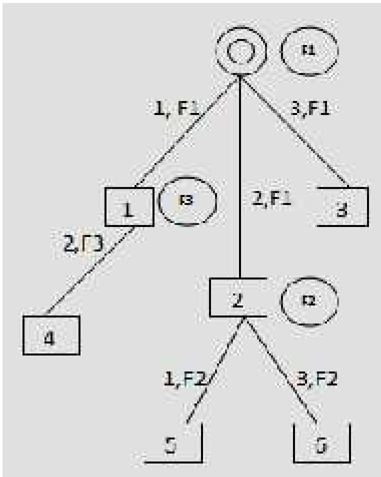

Figure 2c. Scheduled generated with RBCA

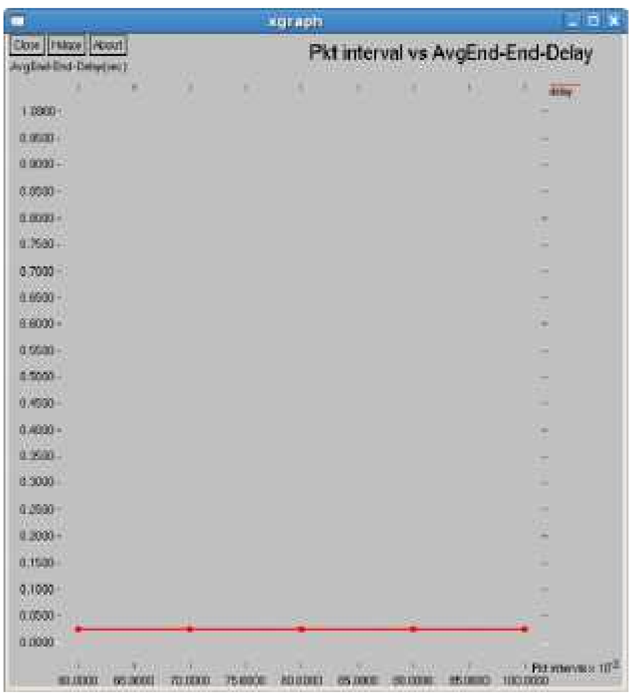

Figure 3a.Comparison between Packet Interval and Delay

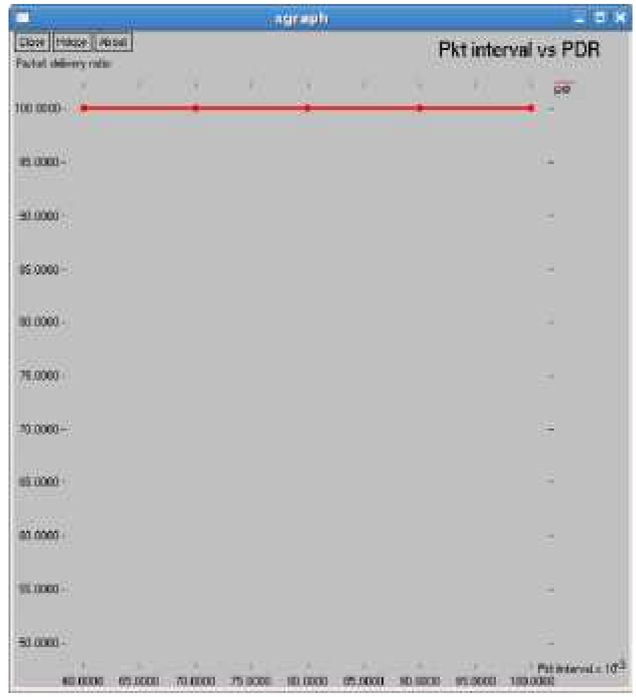

Figure 3b. Comparison between Packet Interval and Packet Delivery Ratio

The Figure 3b shows the Packet interval Vs PDR, it describes the achievements of receiving packet delivery ratio in percentage highest PDR shows best output.

The Figure 3c shows the packet interval Vs throughput, it describes the bits per second calculated in throughput that is calculate the packet delivery rate in a particular time.

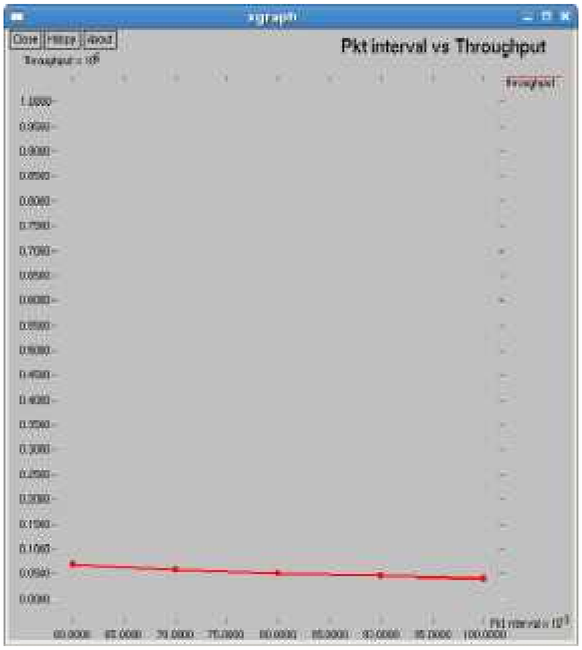

Figure 3c. Comparison between Packet Interval and Throughput

VIII. Conclusion and Future Work

In this paper we compare the packet interval with average End to End delay, Packet delivery ratio (PDR) and throughput. We observed that node-based and link-based channel assignment schemes are more efficient compared to assigning different channels on different branches of the tree (TMCP). In future, we will examine the variable amount of data collection and implement the combination of the schemes considered.

IX. References

[1] O. Durmaz Incel, et al,"Fast Data Collection in Tree based Wireless Sensor Networks," vol. 11, no. 1, pp. 86-99, 2012.

[2] S. Gandham, et al, "Distributed Time-Optimal Scheduling for Convergecast in Wireless Sensor Networks," vol. 52, no. 3, pp. 610-629, 2008.

[3] O.Durmaz Incel and B. Krishnamachari. "Enhancing the Data Collection Rate of Tree-Based Aggregation in Wireless Sensor Networks," pp. 569-577, 2008.

[4] A. Ghosh, et al, "Multi-Channel Scheduling Algorithms for Fast Aggregated Convergecast in Sensor Networks," pp. 363-372, 2009.

[5] W.Song , et al, "Time-Optimum Packet Scheduling for Many-to-One Routing in Wireless Sensor Networks," pp. 81-90, 2006.

[6] H. Choi, et al," Scheduling for Information Gathering on Sensor Network," vol. 15, pp. 127-140, 2009.

[7] N. Lai, et al, "On Maximizing the throughput of Convergecast in Wireless Sensor Networks," pp. 396-408, 2008.

[8] V. Annamalai, et al, "On Tree-Based Converegecasting in Wireless Sensor Networks," vol. 3, pp. 1942-1947, 2003.

[9] B. Krishnamachari, et al, "The Impact of Data Aggregation in Wireless Sensor Networks," pp. 575-578, 2002.

[10] P. Kyasanur, et al, "Capacity of Multi-Channel Wireless Networks: Impact of Number of Channels and Interfaces," pp. 43-57, Feb, 1992.

[11] G. Sharma, et al, "On the Complexity of Scheduling in Wireless Networks," pp. 227-238, 2006.

[12] X. Lin and S.Rasool," A Distributed Joint Channel Assignment Scheduling and Routing Algorithm for Multi-Channel Ad-Hoc Ad-Hoc Wireless networks pp 1118-1126, 2007.

[13] Y. Wu, et al, "Realistic and Efficient Multi-Channel Communications in Wireless Sensor Networks," pp. 1193-1201, 2008.