ISSN- 2350-0530
DOI: https://doi.org/10.29121/granthaalayah.v1.i1.2014.3084

INTERNATIONAL JOURNAL of RESEARCH –GRANTHAALAYAH
A knowledge Repository
Science

EFFICIENT AND FAST INFORMATION GATHERING IN SENSOR NETWORK ORGANISED AS A TREE

Pavitha N *[1]
*[1] Dept. of Computer Engineering, Sinhgad Academy of Engineering, Pune, Maharashtra, India
*Correspondence Author: pavithanrai@gmail.com

Abstract:
In a network organised as a tree how fast the data can be collected is a fundamental objective of this paper. To address this, a number of different techniques are explored and evaluated using realistic simulation models under the many-to-one communication paradigm known as converge cast. Use of TDMA scheduling gives better performance in case of many to one communication. Channel assignment methods such as BFS time slot assignment, Local time slot assignment and multichannel scheduling algorithm Joint Frequency time slot scheduling for moderate size networks of about 100 nodes, by using multiple frequencies are implemented. Performance of these algorithms is evaluated using JProwler simulator. The data rate for each of these algorithms is calculated using simulation. For moderate size networks of about 100 nodes, the use of multi-frequency scheduling can suffice to eliminate most of the interference.

Keywords:
Convergecast, TDMA scheduling, multichannel.

1. INTRODUCTION

CONVERGECAST, namely, the collection of data from a set of sensors toward a common sink over a tree-based routing topology, is a fundamental operation in wireless sensor networks (WSNs) [1]. In many applications, it is crucial to provide a guarantee on the delivery time as well as increase the rate of such data collection. For instance, in safety and mission-critical applications where sensor nodes are deployed to detect oil/gas leak or structural damage, the actuators and controllers need to receive data from all the sensors within a specific deadline [2], failure of which might lead to unpredictable and catastrophic events. This falls under the category of one-shot data collection. On the other hand, applications such as permafrost monitoring [3] require periodic and fast data delivery over long periods of time, which falls under the category of continuous data collection. In this paper the focus is on such applications and the fundamental question is: How fast can data be streamed from a set of sensors to a sink over a tree-based topology?
Two types of data collections are considered in this paper. They are
1) Aggregated convergecast where packets are aggregated at each hop, and
2) raw-data convergecast where packets are individually relayed toward the sink.

INTERNATIONAL JOURNAL of RESEARCH –GRANTHAALAYAH
A knowledge Repository
Science

Aggregated convergecast is applicable when a strong spatial correlation exists in the data, or the goal is to collect summarized information such as the maximum sensor reading. Raw-data convergecast, on the other hand, is applicable when every sensor reading is equally important, or the correlation is minimal. In this paper aggregated convergecast in the context of continuous data collection, and raw-data convergecast for one-shot data collection is considered.

2. RELATED WORK

2.1. MINIMIZATION OF THE SCHEDULE LENGTH FOR AGGREGATED CONVERGECAST

Fast data collection with the goal to minimize the schedule length for aggregated convergecast has been explained in [7],[9], and also in [5], [10], and [11]. In [7], the authors had experimentally investigated the impact of transmission power control and multiple frequency channels on the schedule length, while the theoretical aspects were discussed in [9], where the authors proposed constant factor and logarithmic approximation algorithms on geometric networks (disk graphs).

2.2. RAW-DATA CONVERGECAST

Raw-data converge cast has been studied in [1], [12], [13], and [14], where a distributed time slot assignment scheme is proposed by Gandham et al. [1] to minimize the TDMA schedule length for a single channel.

2.3. JOINT SCHEDULING AND TRANSMISSION POWER CONTROL

The problem of joint scheduling and transmission power control is studied by Moscibroda [5] for constant and uniform traffic demands.

2.4. USE OF ORTHOGONAL CODES TO ELIMINATE INTERFERENCE

The use of orthogonal codes to eliminate interference has been studied by Annamalai et al. [10], where nodes are assigned time slots from the bottom of the tree to the top such that a parent node does not transmit before it receives all the packets from its children. This problem and the one addressed by Chen et al. [11] are for one-shot raw-data convergecast.

2.5. MINIMIZE THE MAXIMUM LATENCY

A study along this line with the objective to minimize the maximum latency is presented by Pan and Tseng [15], where they assign a beacon period to each node in a Zigbee network during which it can receive data from all its children.

2.6. TIME-OPTIMAL, ENERGY-EFFICIENT PACKET SCHEDULING AL- GORITHM WITH PERIODIC TRAFFIC FROM ALL THE NODES TO THE SINK

INTERNATIONAL JOURNAL of RESEARCH –GRANTHAALAYAH
A knowledge Repository
Science

For raw-data convergecast, Song et al. [12] presented a time-optimal, energy-e_cient packet scheduling algorithm with periodic tra_c from all the nodes to the sink. Once interference is eliminated, their algorithm achieves the bound. They briey mention a 3-coloring channel assignment scheme to eliminate interference. They assume a simple interference model where each node has a circular transmission range and cumulative interference from concurrent multiple senders is avoided.

2.7. TDMA BASED MAC PROTOCOL FOR HIGH-DATA-RATE WSNS

Song et al. [12] extended the previous work and proposed a Time-based MAC protocol for high-data-rate WSNs in [16]. Tree MAC considers the differences in load at different levels of a routing tree and assigns time slots according to the depth, i.e., the hop count, of the nodes on the routing tree, such that nodes closer to the sink are assigned more slots than their children in order to mitigate congestion.

2.8. MAXIMIZING THE THROUGHPUT OF CONVERGECAST BY FINDING A SHORTEST-LENGTH, CONFLICT-FREE SCHEDULE

Maximizing the throughput of convergecast by finding a shortest-length, conflict-free schedule is studied by Lai et al. [14], where a greedy graph colouring strategy assigns time slots to the senders and prevents interference. They also discussed the impact of routing trees on the schedule length and proposed a routing scheme called disjoint strips to transmit data over different shortest paths.

3. DESIGN OBJECTIVE

To implement channel assignment methods such as BFS time slot assignment, Local time slot assignment and multichannel scheduling algorithm Joint Frequency time slot scheduling for moderate size networks of about 100 nodes, by using multiple frequencies.

4. PROPOSED TECHNIQUE

4.1. BFS-TIMESLOTASSIGNMENT ALGORITHM

Algorithm1. BFS-TIMESLOTASSIGNMENT
1. Input: T =(V,E)
2. while E!=NULL do
3. e = next edge from E in BFS order
4. Assign minimum time slot t to edge e respecting adjacency and interfering constraints
5. Add e to the set.
6. end while

INTERNATIONAL JOURNAL of RESEARCH –GRANTHAALAYAH
A knowledge Repository
Science

In each iteration of BFS-TIMESLOTASSIGNMENT an edge e is chosen in the Breadth First Search (BFS) order starting from any node, and is assigned the minimum time slot that is different from all its adjacent edges respecting interfering constraints. Although BFS-TIMESLOTASSIGNMENT may not be an approximation to ideal scheduling under the physical interference model, it is a heuristic that can achieve the lower bound if all the interfering links are eliminated. Therefore, together with a method to eliminate interference, the algorithm can optimally schedule the network.

4.2. LOCAL-TIMESLOTASSIGNMENT ALGORITHM

Algorithm2. LOCAL-TIMESLOTASSIGNMENT
1. node.buffer == full
2. if node is sink then
3. Among the eligible top-subtrees, choose the one with the largest number of total (remaining) packets, say top-subtree i
4. Schedule link (root(i),s) respecting interfering constraint
5. else
6. if node.bu_er == empty then
7. Choose a random child c of node whose buffer is full
8. Schedule link (c,node) respecting interfering constraint
9. c.buffer = empty
10. node.buffer = full
11. end if
12. end if

LOCAL TIME SLOT ASSIGNMENT Algorithm assumes that the sink is aware of the number of nodes in each top sub tree. Each source node maintains a buffer and its associated state, which can be either full or empty depending on whether it contains a packet or not. Our algorithm does not require any of the nodes to store more than one packet in their buffer at any time. We initialize all the buffers as full, and assume that the sinks buffer is always full for the ease of explanation. The first block of the algorithm in lines 2-4 gives the scheduling rules between the sink and the roots of the top sub trees. For a given time slot, we schedule the root of an eligible top sub tree which has the largest number of total (remaining) packets. If none of the top sub trees are eligible, the sink does not receive any packet during that time slot. Inside each top sub tree, nodes are scheduled according to the rules in lines 5-12. If a nodes buffer is empty and the sub tree rooted at this node is active, we schedule one of its children at random whose buffer is not empty.

4.3. JOINT FREQUENCY TIME SLOT SCHEDULING ALGORITHM

JFTSS offers a greedy joint solution for constructing a maximal schedule, such that a schedule is said to be maximal if it meets the adjacency and interfering constraints, and no more links can be

INTERNATIONAL JOURNAL of RESEARCH –GRANTHAALAYAH
A knowledge Repository
Science

scheduled for concurrent transmissions on any time slot and channel without violating the constraints.

JFTSS schedules a network starting from the link that has the highest number of packets (load) to be transmitted. When the link loads are equal, such as in aggregated convergecast, the most constrained link is considered first, i.e., the link for which the number of other links violating the interfering and adjacency constraints when scheduled simultaneously is the maximum. The algorithm starts with an empty schedule and first sorts the links according to the loads or constraints. The most loaded or constrained link in the first available slot-channel pair is scheduled first and added to the schedule. All the links that have an adjacency constraint with the scheduled link are excluded from the list of the links to be scheduled at a given slot. The links that do not have an interfering constraint with the scheduled link can be scheduled in the same slot and channel whereas the links that have an interfering constraint should be scheduled on different channels, if possible. The algorithm continues to schedule the links according to the most loaded (or most constrained) metric. When no more links can be scheduled for a given slot, the scheduler continues with scheduling in the next slot.

5. RESULTS

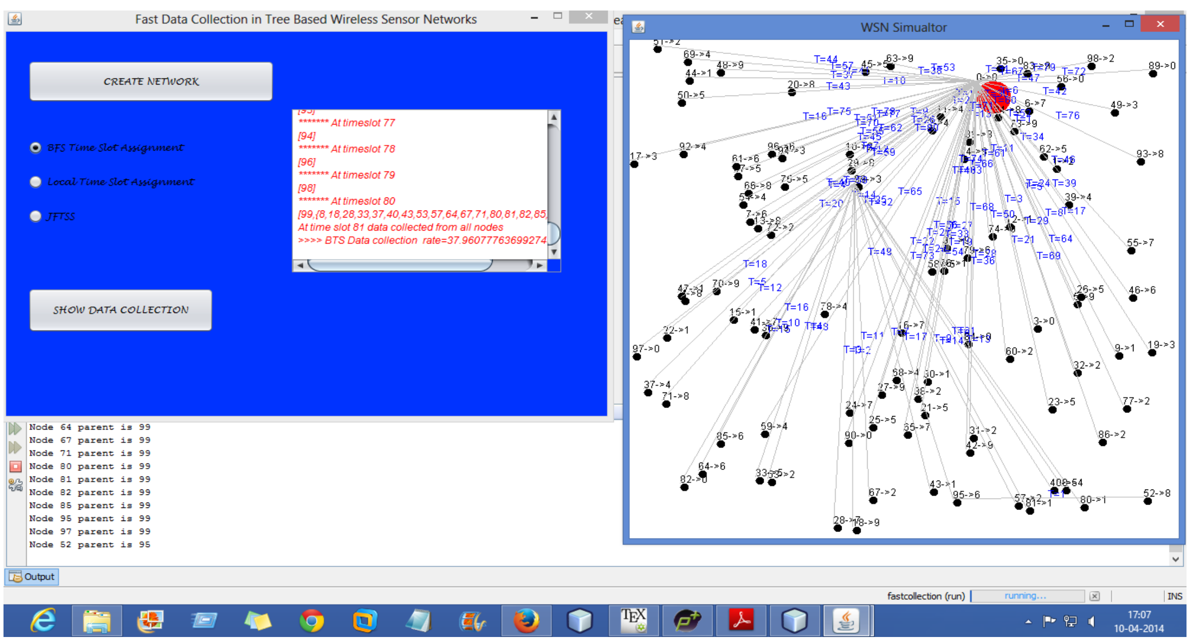

Figure 1: BFS-TIMESLOTASSIGNMENT

INTERNATIONAL JOURNAL of RESEARCH –GRANTHAALAYAH
A knowledge Repository
Science

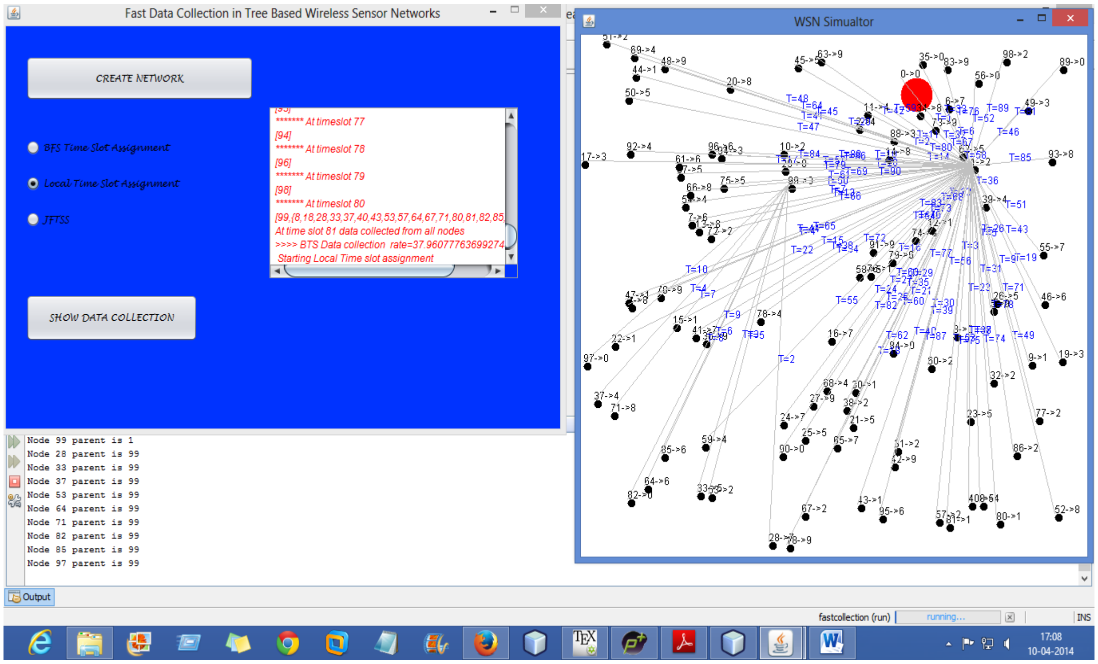

Figure 2: LOCAL-TIMESLOTASSIGNMENT

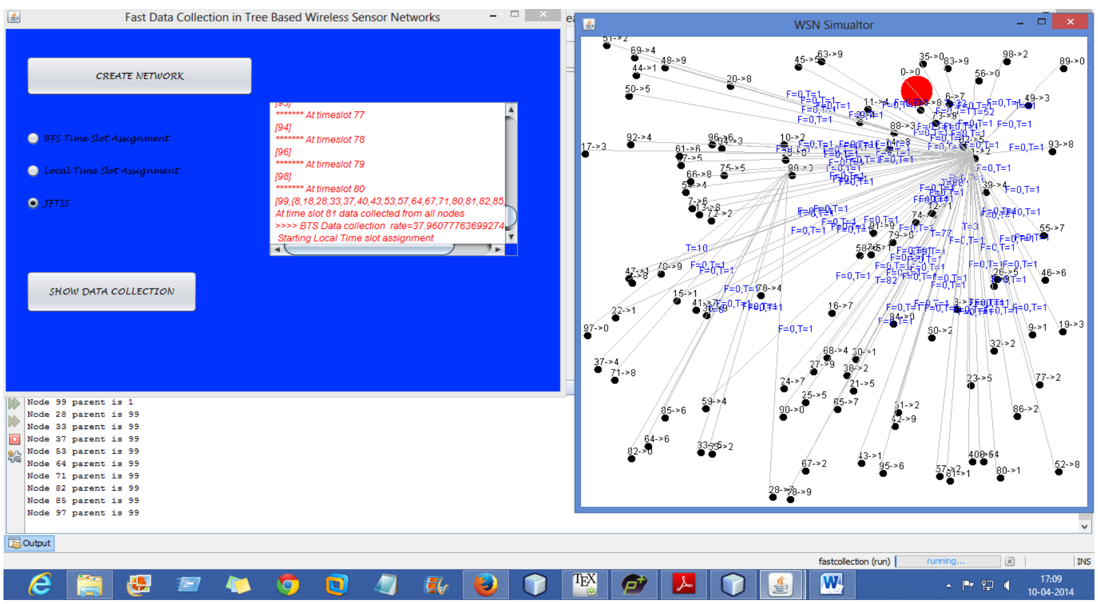

Figure 3: JFTSS SCHEDULING

6. CONCLUSION

In this paper, fast convergecast in WSN where nodes communicate using a TDMA protocol to minimize the schedule length is studied. The fundamental limitations due to interference and half-duplex transceivers on the nodes and explored techniques to overcome the same are

INTERNATIONAL JOURNAL of RESEARCH –GRANTHAALAYAH
A knowledge Repository
Science

addressed. The simulation shows that while transmission power control helps in reducing the schedule length, multiple channels are more effective. Channel assignment methods such as BFS time slot assignment, Local time slot assignment and multichannel scheduling algorithm Joint Frequency time slot scheduling for moderate size networks of about 100 nodes, by using multiple frequencies are implemented. The data rate for each of the algorithms is calculated. For moderate size networks of about 100 nodes, the use of multi-frequency scheduling can suffice to eliminate most of the interference.

7. REFERENCES

[1] S. Gandham, Y. Zhang, and Q. Huang, Distributed Time-Optimal Scheduling for Convergecast in Wireless Sensor Networks,Computer Networks, vol. 52, no. 3, pp. 610-629, 2008.

[2] K.K. Chintalapudi and L. Venkatraman, On the Design of MAC Protocols for Low-Latency Hard Real-Time Discrete Control Applications over 802.15.4 Hardware, Proc. Intl Conf. Information Processing in Sensor Networks (IPSN 08) , pp. 356-367, 2008.

[3] I. Talzi, A. Hasler, G. Stephan, and C. Tschudin, PermaSense: Investigating Permafrost with a WSN in the Swiss Alps, Proc. Workshop Embedded Networked Sensors (EmNets 07) , pp. 8-12, 2007.

[4] S. Upadhyayula and S.K.S. Gupta, Spanning Tree Based Algorithms for Low Latency and Energy E_cient Data Aggregation Enhanced Convergecast (DAC) in Wireless Sensor Networks, Ad Hoc Networks, vol. 5, no. 5, pp. 626-648, 2007.

[5] T. Moscibroda, The Worst-Case Capacity of Wireless Sensor Networks, Proc. Intl Conf. Information Processing in Sensor Networks (IPSN 07), pp. 1-10, 2007.

[6] T. ElBatt and A. Ephremides, Joint Scheduling and Power Control for Wireless Ad-Hoc Networks, Proc. IEEE INFOCOM, pp. 976-984, 2002.

[7] O. Durmaz Incel and B. Krishnamachari, Enhancing the Data Collection Rate of Tree-Based Aggregation in Wireless Sensor Networks, Proc. Ann. IEEE Comm. Soc. Conf. Sensor, Mesh and Ad Hoc Comm. and Networks (SECON 08), pp. 569-577, 2008.

[8] Y. Wu, J.A. Stankovic, T. He, and S. Lin, Realistic and E_cient Multi-Channel Communications in Wireless Sensor Networks, Proc. IEEE INFOCOM, pp. 1193-1201, 2008.

[9] A. Ghosh, O . Durmaz Incel, V.A. Kumar, and B. Krishnamachari, Multi-Channel Scheduling Algorithms for Fast Aggregated Convergecast in Sensor Networks, Proc. IEEE Intl Conf. Mobile Adhoc and Sensor Systems (MASS 09), pp. 363-372, 2009.

[10] V. Annamalai, S.K.S. Gupta, and L. Schwiebert, On Tree-Based Convergecasting in Wireless Sensor Networks, Proc. IEEE Wireless Comm. and Networking Conf. (WCNC 03), vol. 3, pp. 1942-1947, 2003.

[11] X. Chen, X. Hu, and J. Zhu, Minimum Data Aggregation Time Problem in Wireless Sensor Networks, Proc. Intl Conf. Mobile Ad- Hoc and Sensor Networks (MSN 05), pp. 133-142, 2005.

[12] W. Song, F. Yuan, and R. LaHusen, Time-Optimum Packet Scheduling for Many-to-One Routing in Wireless Sensor Networks, Proc. IEEE Intl Conf. Mobile Ad-Hoc and Sensor Systems (MASS 06), pp. 81-90, 2006.

INTERNATIONAL JOURNAL of RESEARCH –GRANTHAALAYAH
A knowledge Repository
Science

[13] H. Choi, J.Wang, and E. Hughes, Scheduling for Information Gathering on Sensor Network, Wireless Networks, vol. 15, pp. 127- 140, 2009.
[14] N. Lai, C. King, and C. Lin, On Maximizing the Throughput of Convergecast in Wireless Sensor Networks, Proc. Intl Conf. Advances in Grid and Pervasive Computing (GPC 08), pp. 396-408, 2008.
[15] M. Pan and Y. Tseng, Quick Convergecast in ZigBee Beacon- Enabled Tree-Based Wireless Sensor Networks, Computer Comm., vol. 31, no. 5, pp. 999-1011, 2008.
[16] W. Song, H. Renjie, B. Shirazi, and R. LaHusen, TreeMAC: Localized TDMA MAC Protocol for Real-Time High-Data-Rate Sensor Networks, J. Pervasive and Mobile Computing, vol. 5, no. 6, pp. 750-765, 2009.
[17] G. Zhou, C. Huang, T. Yan, T. He, J. Stankovic, and T. Abdelzaher, MMSN: MultiFrequency Media Access Control for Wireless Sensor Networks, Proc. IEEE INFOCOM, pp. 1-13, 2006.
[18] Y. Kim, H. Shin, and H. Cha, Y-MAC: An Energy-Efficient Multi- Channel MAC Protocol for Dense Wireless Sensor Networks, Proc. Intl Conf. Information Processing in Sensor Networks (IPSN 08), pp. 53-63, Apr. 2008.
[19] B. Krishnamachari, D. Estrin, and S.B. Wicker, The Impact of Data Aggregation in Wireless Sensor Networks, Proc. Intl Conf. Distributed Computing Systems Workshops (ICDCSW02), pp. 575- 578, 2002.
[20] J. Zander, Performance of Optimum Transmitter Power Control in Cellular Radio Systems, IEEE Trans. on Vehicular Technology, vol. 41, no. 1, pp. 57-62, Feb. 1992.
[21] P. Kyasanur and N.H. Vaidya, Capacity of Multi-Channel Wireless Networks: Impact of Number of Channels and Interfaces, Proc. ACM MobiCom, pp. 43-57, 2005.
[22] G. Sharma, R.R. Mazumdar, and N.B. Shro_, On the Complexity of Scheduling in Wireless Networks, Proc. ACM MobiCom, pp. 227-238, 2006.
[23] X. Lin and S. Rasool, A Distributed Joint Channel-Assignment, Scheduling and Routing Algorithm for Multi-Channel Ad-Hoc Wireless Networks, Proc. IEEE INFOCOM, pp. 1118-1126, 2007.
[24] C.H. Papadimitriou, The Complexity of the Capacitated Tree Problem, Networks, vol. 8, no. 3, pp. 217-230, 1978.
[25] H. Dai and R. Han, A Node-Centric Load Balancing Algorithm for Wireless Sensor Networks, Proc. IEEE Conf. Global Telecomm. (GlobeCom 03), pp. 548-552, 2003.
[26] M. Zuniga and B. Krishnamachari, An Analysis of Unreliability and Asymmetry in Low Power Wireless Links, ACM Trans. Sensor Networks, vol. 3, no. 2, p. 7, 2007.
[27] J. Gronkvist and A. Hansson, Comparison between Graph-Based and Interference-Based STDMA Scheduling, Proc. ACM Mobi-Hoc, pp.255-258,2001.
[28] O.zlem Durmaz Incel, Amitabha Ghosh, Bhaskar Krishnamachari, and Krishnakant Chintalapudi "Fast Data Collection in Tree-Based Wireless Sensor Networks", IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL. 11, NO. 1, JANUARY 2012.