Fast and Efficient Data Collection in Wireless Sensor Networks: A Survey

Pavitha N[1*]

[1] *Department of Computer Engineering, Sinhgad Academy of Engineering, Pune,Maharashtra, India*

Email: pavithanrai@gmail.com

Abstract:

In Wireless Sensor Networks (WSN) fast and efficient data collection is a fundamental question that is how fast the data can be collected. To address this, this paper explores a number of different techniques under the many-to-one communication paradigm known as convergecast. Using Time Division Multiple Access (TDMA) scheduling we can get better results for data collection in tree based wireless sensor networks. Researchers have developed a number of techniques for efficient and fast data collection in tree based wireless sensor networks. This paper analyses all these techniques.

Keywords:

Convergecast, TDMA scheduling, Wireless Sensor Network.

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 two types of data collection techniques are studied:

1) Aggregated convergecast where packets are aggregated at each hop, and

2) Raw-data convergecast where packets are individually relayed toward the sink.

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. We study aggregated convergecast in the context of continuous data collection, and raw-data convergecast for one-shot data collection.

2. FAST AND EFFICIENT DATA COLLECTION TECHNIQUES

A. 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).

B. Raw-data convergecast

Raw-data convergecast 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.

C. 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.

D. 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.

E. 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.

F. Time-optimal, energy-efficient packet scheduling al- gorithm with periodic traffic from all the nodes to the sink

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.

G. 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.

H. 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. CONCLUSION

In Wireless Sensor Networks (WSN) fast and efficient data collection is a fundamental question that is how fast the data can be collected. To address this, in this paper a number of different techniques under the many-to-one communication paradigm known as convergecast is explored. Using Time Division Multiple Access (TDMA) scheduling we can get better results for data collection in tree based wireless sensor networks. Researchers have developed a number of techniques for efficient and fast data collection in tree based wireless sensor networks. This paper analysed all these techniques.

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.

[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.

[29] N, Pavitha, and S.N. Shelke. "Providing Source and Sink Location Privacy against a Global Eavesdropper in Sensor Networks: a Survey." *International Journal of Research* 1.6 (2014): 63-68.

[30] Guragain, Bijay. "Power Efficient Routing Protocol for Mobile Ad Hoc Networks." *International Journal of Research* 1.4 (2014): 353-360.