A Survey - Confrontation with Data Aggregation in Wireless Sensor Networks

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Abstract

The main objective to use wireless sensor network (WSN) is to collect data across various nodes and send the collected data to sink for processing. This is typically the scenario in any real-time application of WSN. In this paper, the authors review various existing methods in data aggregation, list out the research challenges faced by the researchers and propose solutions for each method.

1. INTRODUCTION

Data should be aggregated in WSN to reserve energy and to avoid burst traffic in the network. This would reduce the data packet transmission to the sink. This is a must to eliminate redundancy of data transmission and enhance the energy of node in wireless sensor network (WSN). A sensor node is made responsible to collect and store the aggregated data and process it quickly, to avoid transmission delay before sending it to the sink on the base station. The wireless sensor network has consisted three different types of nodes.

1. Simple regular sensor nodes
2. Aggregator node
3. Queried.

In regular sensor node senses the data from the environment and sends the data to the aggregator node. The aggregator node gathers data from multiple sensor nodes and aggregates the data packet using some aggregation function then sends the aggregated result to upper queried node which generates the query. The various Quality of service (QoS) metrics[22] needs to be considered for designing a routing framework for data aggregation in WSN.

The literature survey in this area of research is as follows;

P. Anbumani et al. [1]discuss various data aggregation approaches based on routing protocols, algorithm and the performance measures in data aggregation in wireless sensor network. The authors discuss the various types of nodes and the involvement of each node in the whole process of data aggregation. The authors also discuss various merits and demerits of data aggregation in WSN. In the paper the authors consider various parameters such as energy efficiency, latency, data accuracy as a performance measure of data aggregation.

Nandini. Set al. [2] discusses a data aggregation framework on wireless sensor networks. This framework works as a middleware for aggregated data measured by number of nodes. This paper discusses about data aggregation and query processing with various simulation tools. The authors also discuss energy conservation for various methods of data aggregation.

Bhaskar Krishnama chariet al. [3] discusses data-centric routing and its performance with traditional end-to end routing schemes. The authors also discuss about the impact of source destination placement and communication network density on the energy costs and delay associated with data aggregation. They also point out the complexity of optimal data aggregation. The authors proposed and modeled performance of data aggregation in resource-constrained distributed event-based system.

Y. E. Massadet al. [4]proposes a linear distributed algorithm to aggregate data and consumes energy in a uniform way and simulated it for different scenarios using the network simulator (ns2) . The proposed algorithm is distributed, there is no sensor synchronization and there is total absence of global knowledge of the wireless sensor network. The absence of global knowledge differentiates this proposal from others as PEGASIS being a significant contribution.

K. Sruthiet al. [6] proposes Enhanced Link aware Clustering Mechanism (LDAM) and a data aggregation algorithm based on passive clustering technique that target both on the efficient CH and GW selection process and varied transmission power during the data aggregation process. Passive clustering concentrates on the link condition and state of the nodes.

R. Jayalakshmiet al. [7] proposes an algorithm AST that implies logical separation of sensor network i. e. same type of sensors forms a virtual path to group together. After sorting out sensor groups examine MST among sensor nodes of each group. MST connects all sensors by choosing shortest distance to travel from one node to another. It generates graph to include all nodes without forming cyclic group among nodes. Data aggregation is done at MST graph nodes to avoid reaching same node again.

Swapna B. Sasiet al. [8] shows the intent provide the secure communication in the wireless sensor networks. For that, several cryptography using optimization algorithms is investigated. Survey has been made on the cryptography using optimization methods for secure communication. Several optimization algorithms are presented for cryptography to create the keys for the encryption. One of the suggested techniques is ant Colony Optimization Key Generation based image encryption method that is used to create the keys for encryption of text. The ant colony optimization method is used to generate the keys for encryption.

S. Saranyaet al. [9] proposes an objective to aggregate the data in a secure way such that the tampering caused by the adversaries can be avoided and these secure authentication mechanisms ensure that the base station does not accept forged aggregation value.

S. Saranyaet al. [10] proposes Energy aware Data Aggregation with Sink Relocation (EDASR) technique to improve the network lifetime. The nodes that are closer to sink will consume additional energy than others to compute and communicate data to sink.

Gaurav Kumar Pandeyet al. [11] focuses on a survey of various techniques for lowering latency, routing data to Mobile Elements (ME) with motion control mechanisms, scheduling during data collection in WSN-ME and technique for energy conservation by using Fuzzy logic.

Jatinder Kauret al. [12] discussed the rapidly increase the lifetime of the network.

S. Sasirekhaet al. [13] provides a comprehensive survey of different data aggregation algorithms in wireless sensor networks.

Claude Castellucciaet al. [19] propose a secure additively homomorphic stream cipher which uses modular additions thereby well adaptive for resource constrained devices. This security scheme allows aggregators to consolidate the encrypted data of the nodes without decrypting them.

Yingpeng Sanget al. [20] surveys security issues data confidentiality and integrity. The authors also propose security frameworks which use pair wise key distribution respectively for hop-by-hop and end-to-end encrypted data aggregation.

Wenbo Heet al. [21] propose privacy-preserving data aggregation methods for additive aggregation functions. Cluster-based Private Data Aggregation method controls clustering protocol and algebraic properties of polynomials thereby reducing the communication overhead. Slice-Mix-Aggregate (SMART) method develops on slicing techniques and the associative property of addition which reduces computation overhead.

2. EXISTING METHODS AND CHALLENGES

2.1 Tree Based Approach

Construction of minimum spanning tree considering the sink as the root and source node as leaves.

Demerits :If there is a failure of node, the whole sub tree is affected with a huge data loss.

2.2 In-Network Aggregation

In-Network Aggregation is a mechanism for reducing the overall amount of power and bandwidth required to process the user's query by allowing sensor readings to be aggregated by intermediate nodes.

Demerits : Intermediate node failures.

3. APPROACHES FOR IN-NETWORK

3.1 Aggregation Routing Trees

Almost all techniques for in-network aggregation require the construction of a routing tree for propagating data from the source nodes to the sink nodes. Once established, each node utilizes the routing tree to find a path to the host node. A simple method for constructing the routing tree is as follows. The host node broadcasts an initialization message into the network. The message contains a hop count parameter, which specifies the distance from the host node. All nodes that hear the initialization message will select the host as their parent, increment the hop count by one, and then rebroadcast the message. The message will propagate down the network until every node has established a parent.

3.2 Research challenges in the above method

1. Time taken for each node to acknowledge the message.
2. Loss of the message itself.
3. No guarantee that all nodes in network acknowledge the message.

3.3 Proposed Solutions for the research challenges mentioned above

For challenge 1, 2: Maintaining a threshold time.

For challenge 3: Having a count which increments when the message is received by a node.

4. GROUPING

Some aggregate functions require sensors to be partitioned into distinct groups. Researchers at the University of Pittsburgh propose a *Group-Aware Network Configuration* in which child nodes attempt to select parents in the same group[5]. During tree initialization, parent nodes broadcast their group ID along with the tree initialization message. Child nodes listen to messages from nodes one level higher in the tree. A child node may choose to switch parents if it hears from a node one level higher that is in the same group as itself. The advantage of this approach is that nodes with children in the same group may aggregate values reported from the child nodes into one value to be passed on to the host node. If a parent node receives readings from children in different groups, it must send a larger message up the tree containing the values and the associated group. This reduces the amount of aggregation that can be performed in network.

4.1 Research challenges in the above method

1. Parent node failure.
2. If a parent node receives readings from children in different groups, it must send a larger

message up the tree containing the values and the associated group. Burstiness of traffic increases may end in bottleneck.

4.2 Proposed Solutions for the research challenges mentioned above

Challenge 1: The child should send ICMP message to parent node at regular intervals of time, if the parent does not respond in time t, the child nodes should select the next active node to serve as parent. [Active node= a node with good battery life]

4.3 Reliability in data aggregation

Muhammad Adeel Mahmoodet al. [14] discuses on several existing reliability mechanism and challenges in WSN. The authors also propose a 3D reference model for categorizing research in WSN reliability. The authors also distinguish between the two major parameter used for reliability i. e. retransmission and redundancy. The authors classify the methods of reliability as hop-by-hop, end-to-end, packet level and event level reliability. The authors also review sensor transmission control protocol (STCP), a sink-centric end-to-end reliability protocol which works on controlled variable reliability mechanism.

4.4 Research challenges for above method

Retransmission of packets adds to network delay and waiting for acknowledgement adds to the overhead in processing data.

4.5 Proposed Solutions for the research challenges mentioned above

Each node can be given a time slot where only that node transfer at that time, thereby reducing the congestion in sink also reduces the packet loss.

Muhammad Mostafa Monowaret al.[15] propose Prioritized Heterogeneous Traffic-oriented Congestion Control Protocol which efficiently transmits priority packets dynamically. The authors talk about managing heterogeneous data from multiple sensors and setting the desired throughput based on the priority set by base station.

4.6 Research challenges for above method

Fairness in packet processing may be affected as low priority packets may go to starvation state.

4.7 Proposed Solutions for the research challenges mentioned above

A round robin kind of approach with priority can be followed to avoid starvation and to achieve fairness.

Özgür B. Akanet al.[16] propose event-to-sink reliable transport (ESRT) protocol which help for congestion control thereby achieving reliable event detection. The performance is recorded from source nodes to the sink in terms of the number of received data packets. This protocol runs on the sink thus saving the energy from resource constrained nodes.

4.8 Research challenges for above method

Single point of failure is possible in this method if the sink fails the entire network fails as the protocol is running in the sink.

4.9 Proposed Solutions for the research challenges mentioned above

Instead of protocol running in sink node, a dedicated server can be used to run the protocol and processing of packets so that energy life of sink can be saved.

Vehbi C. Gungoret al.[17] proposes delay sensitive transport (DST) protocol which helps to transmit the event features with less delay from sensor nodes to sink with minimum energy consumption. This protocol also uses the Time Critical Event First (TCEF) scheduling mechanism to achieve the application specific delay bounds at the sink node. This protocol runs on the sink thus saving the energy from resource constrained nodes. Its combined congestion detection and control mechanism serves the dual purpose of achieving

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reliability and conserving energy. Moreover, it considers event to-sink delay bounds, while dynamically adjusting reporting frequency of the source nodes and avoiding network congestion.

4.10 Research challenges for above method

Node failure or unresponsiveness of node may need to event reporting failure.

4.11 Proposed Solutions for the research challenges mentioned above

Each can be assigned weights and this weight can be incremented whenever that node is transmitting data. Based on the weight value we can detect any unresponsiveness of node.

Sezer Uzungenc et al.[18] proposed Dynamic Multi Threshold Priority (DMTPS) packet scheduling algorithm which warrants a decrease in loss ratio for the lower priority level data with acceptable fairness towards higher priority level data. This proposed method also tries to increase the level of QoS provided to different priority packets by reducing the loss ratio and waiting times. The aim of the DMTPS algorithm is to find lower priority packets and swap with higher priority arrival packets based on the threshold value.

4.12 Research challenges for above method

Delay in processing time critical data may occur and this protocol may not be useful in hard real time systems. Data accuracy may be affected.

4.13 Proposed Solutions for the research challenges mentioned above

Higher priority packets should be queued and processed first to achieve efficient time critical event reporting.

4.14 Overall Research challenges

1. Delay incurred in data processing in aggregator
2. Security (If the aggregator node is compromised)
3. Erroneous data (aggregated data may have missing values or errors in certain packets)
4. Node failure
5. Congestion of data in the aggregator node.
6. Since the network is dynamic in nature, the node may be out of range at any possible time t.

5. CONCLUSION

The main purpose to use wireless sensor network (WSN) is to collect data various nodes and send this data to sink for processing. In this paper, the authors have surveyed the various data aggregation techniques, listed out the challenges in each technique and also discusses solutions which we plan to implement in our future works.

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REFERENCES

[1] P. Anbumani, D. Arockia Nancy, M. Narendran. A Retrospective Survey on Data Aggregation in Wireless Sensor Networks. international journal of engineering sciences & research technology, sept 2013.

[2] Nandini. S. Patil, Prof. P. R. Patil. Data Aggregation in Wireless Sensor Network. IEEE International Conference on Computational Intelligence and Computing Research, Dec 2010.

[3] BhaskarKrishnamachari, Deborah Estrin, Stephen Wicker. The Impact of Data Aggregation in Wireless Sensor Networks, 22nd International Conference on Distributed Computing Systems Workshops, IEEE, Dec 2002.

[4] Y. E. Massad, M. Goyeneche, J. J. Astrain, J. Villadangos. Data Aggregation in Wireless Sensor Networks, IEEE Information and Communication Technologies from Theory to Applications, April 2008.

[5] Rajnish Kumar, Matthew Wolenetz, Bikash Agarwalla, JunSuk Shin, Phillip Hutto, Arnab Paul, Umakishore Ramachandran.DFuse: A Framework for Distributed Data Fusion, ACMSenSys, Nov 2003.

[6] K. Sruthi, A.Umamakeswari. Link Aware Data Aggregation Mechanism based on Passive Clustering in Wireless Sensor Network. International Journal of science and technology. P. 1236–1242, Aug, 2014.

[7] R.Jayalakshmi, B.Baranidharan and B.Santhi. Attribute based Spanning Tree Construction for Data Aggregation in Heterogeneous Wireless Sensor Networks. International Journal of science and technology. P. 76-79, April, 2014.

[8] Swapna B. Sasi and N. Sivanandam. A Survey on Cryptography using Optimization algorithms in WSNs. International Journal of science and technology. P. 216-221, Feb, 2015.

[9] S. Saranya and N. Bharathi. Hierarchical Approach to Secure Data Aggregation in Wireless Sensor Networks. International Journal of science and technology, July, 2015.

[10] R. Saranya and A. Umamakeswari. Energy Aware Data Aggregation with Sink Relocation to Improve the Network Lifetime. International Journal of science and technology, P. 312-317, May, 2015.

[11] Gaurav Kumar Pandey and Amrit Pal Singh. Energy Conservation and Efficient Data Collection in WSN-ME: A Survey. International Journal of science and technology, August, 2015.

[12] Jatinder Kaur, Gurjot Singh Gaba, RajanMiglani and RuchiPasricha. Energy Efficient and Reliable WSN based on Improved Leach-R Clustering Techniques. International Journal of science and technology. July, 2015.

[13] S.Sasirekha and S.Swamynathan. A Comparative Study and Analysis of Data Aggregation Techniques in WSN. International Journal of science and technology. October, 2015.

[14] Muhammad Adeel Mahmood, Winston K. G. Seah, Ian Welch. Reliability in wireless sensor networks: A survey and challenges ahead, Computer Networks,Elsevier, P. 166-187, March 2015.

[15] Muhammad Mostafa Monowar, Md. Obaidur Rahman, Al-Sakib Khan Pathan, and ChoongSeon Hong.Congestion Control Protocol for Wireless Sensor Networks Handling Prioritized Heterogeneous Traffic. Mobiquitous '08 Proceedings of the 5th Annual International Conference on Mobile and Ubiquitous Systems: Computing, Networking, and Services, Article No. 17, 2008.

[16] Özgür B.Akan, and Ian F.Akyildiz. Event-to-Sink Reliable Transport in Wireless Sensor Networks, IEEE/ACM Transactions on Networking, Vol. 13, issue 5, Oct 2005.

[17] Vehbi C. Gungor, Ozgur B. Akan. DST: Delay Sensitive Transport in Wireless Sensor Networks, Computer Networks, International Symposium, IEEE, pp 116 – 122, 2006.

[18] Sezer Uzungenc, Tamer Dag, QoS Efficient Scheduling Algorithm for WirelessSensor Networks. International Journal of Innovative Technology and Exploring Engineering, Volume-4 Issue-12, May 2015.

[19] Castelluccia, C., Mykletun, E. Tsudik G. Efficient aggregation of encrypted data in wireless sensor networks, Mobile and Ubiquitous Systems: Networking and Services pp 109-117, July 2005.

[20] Yingpeng Sang, Ishikawa Hong Shen, Inoguchi Y., Yasuo Tan, NaixueXiong. Secure Data Aggregation in Wireless Sensor Networks: A Survey. Parallel and Distributed Computing, Applications and Technologies, pp 315-320, Dec. 2006.

[21] Wenbo He, Xue Liu, Hoang Nguyen, Nahrstedt K., Abdelzaher T. PDA: Privacy-Preserving Data Aggregation in Wireless Sensor Networks, 26th IEEE International Conference on Computer Communications. IEEE, pp 2045-2053, May 2007.

[22] Siva Rama Krishnan Somayaji, Arunkumar Thangavelu, Analysis of routing mechanisms using QoS metrics in Data Aggregation for Wireless Sensor Network – A Survey, International Journal of Applied Engineering Research, Volume 10, Number 14, 2015

