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Data Routing in In-network Aggregation in WSN: a Cluster Based approach

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Abstract: *Large scale wireless sensor networks (WSNs) consists of many sensor nodes & these networks are deployed in different classes of applications for accurate monitoring, health, environment etc. The sensor nodes equipped with limited power sources. Therefore, efficiently utilizing sensor nodes energy can maintain a prolonged network lifetime. One of the major issues in sensor networks is developing an energy-efficient routing protocol to improve the lifetime of the networks. The proposed approach is a Cluster Based Data Routing for In-Network Aggregation that has some key aspects such as a reduced number of messages for setting up a routing tree, maximized number of overlapping routes, high aggregation rate, and reliable data aggregation and transmission & provides the best aggregation quality when compared to other existing algorithms.*

Keywords: *cluster, data aggregation, energy efficient, Information fusion, In-Network Aggregation, Routing Protocol.*

I. Introduction

A Wireless Sensor Network (WSN) consists of several spatially distributed autonomous devices (sensor nodes) with sensing and communication capabilities that cooperatively sense physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants at different locations & used in applications such as environmental monitoring, homeland security, critical infrastructure systems, communications, manufacturing etc.WSNs are data-driven networks that usually produce a large amount of information that needs to be routed across the networks. As sensor nodes are energy-constrained devices and the energy consumption is generally associated with the amount of gathered data. Since energy conservation is a key issue in WSNs, Data fusion and Data aggregation is exploited in order to save energy[1][2]. A strategy to optimize the routing task for the available processing capacity can be provided by the intermediate sensor nodes along the routing paths.Data aggregation is defined as the process of aggregating the data from multiple sensors to eliminate redundant transmission and provide fused information to the base station. The main goal of data aggregation algorithms is to gather and aggregate data in an efficient manner so that lifetime of the network increases by decreasing the number of packets to be sent to sink or base station[3], intern reduces the communication costs and energy consumption.

The routing protocol of sensor networks is typically partitioned into two sub routings: (1) flat routing protocol and (2) hierarchical (tree-based or cluster-based) routing protocol [2][3]. In flat routing protocols, data aggregation is accomplished by data centric routing where the sink usually transmits a query message to the sensors, via flooding whereas in the Hierarchical routing protocol data aggregation and data fusion is performed in order to decrease the number of transmitted messages to the sink node. Numbers of algorithms have been proposed to provide data aggregation during the routing in WSNs, majority of them falls in either tree-based or cluster-based algorithms [3][4].Cluster-based algorithms with data aggregation and In-network processing can achieve significant energy savings in WSNs & will be effective in prolonging the network Lifetime[5] , can be either static clustering or dynamic clustering type. Static clustered type networks divide the network proactively into many clusters where as dynamic clustered type networks create a cluster reactively in the vicinity of the event sensing nodes. All the data are collected and aggregated by the cluster head (CH), and then sent to the sink. The main advantage of dynamic type over static type that only the necessary nodes, will participate in the data aggregation, preserving energy of the other sensor nodes. Hence, aggregation rate for dynamic clustered data aggregation is very high [6][11].

II. Hierarchical Cluster Based Approach

In clustered based approaches, each cluster has a cluster-head which is selected among cluster node (members). Cluster-heads plays the role of aggregator which aggregate data received from cluster members locally & then transmits the result to base station (sink)[6].Cluster formation in WSN, nodes in a sensor networks often need to organize themselves to form a cluster, one of the nodes in cluster will be cluster head (CH). Clustering allows hierarchical structures to be built on the nodes and enables more efficient use of resources, such as frequency spectrum, bandwidth, and power. To ensure fair distribution of the workload, the cluster leader is selected randomly at each round of aggregation. The clustering scheme [18] consists of:

Sensor Node: A sensor node of a WSN, a core component, can take on multiple roles in a network, such as simple sensing, data processing, data storage and routing,

Clusters: Clusters for WSNs, is an organizational unit, the dense nature of these networks needed to be broken down into clusters to simplify tasks such a communication.
Cluster-heads: Cluster-heads of a cluster, are the organization leader, often organize the various activities in the cluster such as data-aggregation and organizing the communication schedule of a cluster so on.
Base Station: The base station of the hierarchical WSN, acts as communication link between the sensor network and the end-user.
End User: who generates the query for sensor network, which depend on the application.
Some of cluster based algorithms which are energy constraint protocols are: TEEN [7], APTEEN [8], PEGASIS [9], LEACH [13], InFRA[21] etc. In the Low-Energy Adaptive Clustering Hierarchy (LEACH) [13] algorithm, clustered structures are exploited to perform data aggregation. Cluster-heads (CHs) can act as aggregation points and will communicate directly to the sink node. LEACH-based algorithms assume that the sink can be reached by any node in only one hop, which limits the size of the network for which such protocols can be used. In the Information Fusion-based Role Assignment (InFRA) [21], the algorithm which aims at building the shortest path tree to maximizes information fusion.

III. In-Network Data Aggregation

In data gathering based applications, a considerable number of communication packets can be reduced by in-network aggregation, resulting in a longer network lifetime. In-network aggregation refers to the different ways intermediate nodes forward data packets toward the sink node while combining the data gathered from different source nodes.[2][3] In-network data aggregation is the synchronization of data transmission among the nodes, design of routing protocol is the key component for data aggregation. In-network algorithms, in which a node usually does not send data as soon as it is available since waiting for data from neighboring nodes may lead to better data aggregation opportunities, in turn, will improve the performance of the algorithm and save energy[10].There are two approaches for in-network aggregation with *size reduction* and *without size reduction*. In with size reduction, the size reduction refers to the process of combining & compressing the data packets received by the node & from its neighbors in order to reduce the packet length to be transmitted or forwarded towards sink. In without size reduction, the without size reduction refers to the merging data packets received from the different neighbors in to a single data packets but without processing the value of data [12].

IV. Proposed Approach

In the proposed approach first a routing tree constructed with the shortest paths that connect all source nodes to the sink, maximizing data aggregation. The approach is divided into four phases: setup phase, cluster setup phase, inter cluster routing phase and route repair mechanism.

1. Setup phase

In the setup phase, the base station (BS) transmits a level-1 message with the minimum power. All nodes which receive the message set their level as 1. After that the base station increases its power to attain the next level and transmit a level-2 message. This procedure continuous until the base station transmits corresponding messages to all level [10]. BS broadcast a hello message, figure (1). This message contains the information of upper limit and lower limit of each level and each node calculates the distance from the BS based on received signal strength [13].

Ui, Li	....	U3, L3	U2, L2	U1, L1

Figure 1.Structure of hello message

Where
Ui: Upper limits of level i
Li: Lower limit of level i

Algorithm 1. Setup phase
#No. of nodes N
BS can transmit i levels; i _1
1. For each level i, message transmitted by BS
2. If(Nodes does not assign previous level and receive new message or BS transmit level i=1)
3. Assign level i
4. End if
5. End for
6. BS broadcast hello message, which contains the information of upper limit and lower limit of each level.
7. Each node calculates the distance from the BS based on received signal strength

2. Cluster setup phase

In this phase each level is divided into clusters. For each level i, each node decide the cluster head for the current round by choosing a nodes randomly. The node which has the higher energy level will be considered as cluster head(CH)[14] .The cluster head for the current round, broadcast the message for the rest of the nodes with the same energy. Each node must inform to the cluster head that it will be a cluster member. Once the clusters are created and TDMA schedule is fixed for all nodes in cluster by CH & data transmission can begin. Each node sends data to its cluster heads with minimal transmission power. This power is estimated by received signal strength of the message. So that data transmission uses a minimal amount of energy [19].When all the data has been received from the cluster members, then the cluster head performs data aggregation function to compress the data into a single signal & process repeats for the next rounds.

Algorithm 2. Cluster setup phase

1. for each (node N)
2. if node N has highest energy level
3. N becomes CH.
4. N broadcasts an message for its cluster nodes.
5. Else
6. N becomes a NCH node.
7. N informs the selected CH and become a member of its cluster.
8. End if.
9. for each (CH)
10. CH creates TDMA schedule for each cluster member.
11. Each cluster member communicates to the CH in its time slot.
12. End for

3. Inter cluster routing

After the cluster formation, the cluster heads broadcast the aggregate data to the next level. At the next level, the nodes aggregate the data received and sends to their cluster heads. In this manner the cluster heads at the last level transmit the final aggregated data to the BS[15].

Algorithm 3.Inter cluster routing

1. For each (level i)
2. for each CH
3. CH receives the data from the cluster member
4. Aggregate the data.
5. If (i ==1)
6. CH transmits data to the BS.
7. Else
8. CH broadcasts data in the next level.
9. End if
10. End for
11. End for

4. Data Transmission Phase

The nodes are divided into different subnets including an cluster head and other nodes after cluster set-up phase. The cluster head may include all nodes of its subnet. The Shortest path from nodes to CH in subnet is calculated by Dijkstra algorithm with the product of the maximum energy consumption of the two nodes and the energy required for sending the data package as a weight. Then CH sends the shortest path tree structure to all sensors in the subnet. Every sensor can transmit data along the path of the shortest path tree in its subnet. The operation is divided into rounds. In each round, SPTs are configured and aggregated data is transmitted from sensors to the cluster-head & the process is repeated. The subnet lifetime is expired if the residual energy of a sensor in the subnet is exhausted [14][15].

Algorithm 4:Data Transmission Phase

```
for each round do
    for each subnet do
Weight(I,j)=Esend(I,j)*max{Econsume(i),Econsume(j)}
        SPT=Dijkstra{Weight(i,j)}
        if Eresidual(k)<=0 then
            break
        Ni->Aj::{aggregated data}
        end if
    end for
end for
```

5. Route Repair Mechanism

The route created to send the data towards the sink node is unique and efficient since it maximizes the points of aggregation. Any failure in one of the node will cause disruption, preventing the delivery of aggregated data [16]. Possible causes of failure include low energy, physical destruction, and communication blockage. In the proposed work a piggybacked, ACK-based route repair mechanism is used, which consists of two parts: detection of failure node and selection of a new Node. When a node needs to forward data to the sink, it simply sends the data packet, sets a timeout, and waits for the ACK message. If the sender node receives ACK from the node within the pre-determined timeout, it will assume that the node is alive .If not, it considers the node as offline and another New node selected. For this, the sender chooses the neighbour with the lowest hop-to-tree level to be its new node; in case of a tie, it chooses the neighbour with the highest energy level. After this repair mechanism, a newly reconstructed path is created & proceeding with forwarding aggregated data towards sink [2][17].This mechanism also provides secured data aggregation[20].

V. Conclusion

Aggregation aware routing algorithms play an important role in event based WSN. The cluster-based algorithm along with data aggregation and in-network processing can achieve significant energy savings. The proposed approach, a cluster based routing protocol will consider the residual energy of nodes to extend the lifetime of sensor networks. These effects on prolonging the network lifetime while incurring acceptable levels of latency and without sacrificing quality. The approach can attain the energy and latency efficiency needed for wireless sensor networks. Furthermore new strategies can be added to control the waiting time for aggregator nodes based on two criteria: average distance of the cluster heads and spatial & semantics of event correlation.

References

[1] Vaibhav Pandey, Amarjeet kaur & Narottam Chand, "A review on data aggregation techniques in wireless sensor network", in Journal of Electronics & Electrical Engineering, ISSN:0976-8106 vol.1 issue 2010,pp 01-08.

[2] Leandro Villas, Azzedine Boukerche, Heitor S. Ramos, " A Lightweight and Reliable Routing Approach for in-Network aggregation in WSN", in Jounal of IEEE Tranactions on computer networks ,vol 38,Mar 2011,pp 393-422.

[3] Rajagopalan, Ramesh and Varshney, Pramod K., "Data aggregation techniques in sensor networks: A survey", (2006), Electrical Engineering and Computer Science. Paper22.

[4] Jamal N. Al-KarakiRazaUl-Mustafa Ahmed E. Kamal , "Data Aggregation and Routing In wireless sensor networks: optimal and heuristic algorithms" ,A survey IEEE wireless communications,vol 11,Dec 2004,pp 6-28.

[5] Woo-Sung Jung, Keun-Woo Lim, Young-BaeKo, "A Hybrid Approach for Clustering-based Data Aggregation in Wireless Sensor Networks", in IEEE transactions on networking,vol 11,pp2-16,Feb 1999.

[6] Sonam Palden Barfunga, PrativaRai, "Energy Efficient Cluster Based Routing Protocol for Wireless Sensor Networks", in International Conference on Computer and Communication Engineering (ICCCE 2012), 3-5 July 2012, Kuala Lumpur, Malaysia

[7] Arati Manjeshwar and Dharma P. Agrawal , **"**TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks", Center for Distributed and Mobile Computing, ECECS Department, University of Cincinnati, Cincinnati, OH 45221-0030,2001.

[8] Manjeshwar and D.P. Agarwal, "APTEEN: A Hybrid Protocol for Efficient Routing and Comprehensive Information Retrieval in Wireless Sensor Networks", in proceedings of Int'l. Parallel and Distributed Processing Symposium (IPDPS), Fort Lauderdale, USA, 2002, pp 195-202.

[9] S. Lindsey and C.S .Raghavendra ,"PEGASIS: Power- Efficient Gathering in Sensor Information Systems",in proceedings of IEEE ICC 2001, vol. 3, Jun 2001, pp.1125-1130

[10] Meenakshi Diwakar and Sushil Kumar ,"An Energy Efficient Level Based Clustering Routing Protocol for Wireless Sensor Networks", in International Journal Of Advanced Smart Sensor Network System, Vol 2, No.2, April 2012.

[11] P. Krishna N. H. Vaidya, M. Chatterjee, "Cluster-based Approach for Routing in Dynamic Networks", Department of Computer Science & Digital Equipment Corporation Texas A&M University,May 2004

[12] Mohammad Mostafizur Rahman Mozumdar, Nan Guofang, Francesco Gregoretti, "An Efficient Data Aggregation Algorithm for Cluster-based Sensor Network", Department of Electronics, Politecnico di Torino, Italy.Journal of Networks, Vol. 4, no. 7, September 2009.

[13] Uk-Pyo Han, Sang-Eon Park, Seung-Nam Kim, "An Enhanced Cluster Based Routing Algorithm for Wireless Sensor Networks" ,Computer Science Department, Kangwon National University, Chunchon, Korea, Vol. 40, Issue 8,pp. 102-114, Aug. 2002

[14] V. Akila, Dr. T. Sheela, Computer Science and Engineering, Bharath University, Chennai , "Overview of Data Aggregation Based Routing Protocols in Wireless Sensor Networks", in International Conference on Information Systems and Computing, Volume 3, Special Issue 1, January 2013

[15] Zhicheng Dai,Bingwen Wang ,Zhi Li,"An Energy Aware & Cluster Based Data Routing Algorithm for Wireless Sensor & Actor Network", in Information Technology Journal 8,1044-1048,2009

[16] Chris Karlof, David Wagner "Secure routing in wireless sensor networks: attacks and counter measures" ,University of California, Berkeley, CA 94720, USA, (2003) ,pp293–315

[17] B. Kumar, N. Vikram and M. Malla Reddy, "Secure Data Collection in Wireless Sensor Networks Using Random Routing Algorithms", in International Journal of Computer Science and Telecommunications ,Volume 2, Issue 4, July 2011.

[18] Harneet Kour,Baba Ghulam Shah Badshah University, Rajouri, "Hierarchical Routing Protocols In Wireless Sensor Networks", in International Journal of Information Technology and Knowledge ManagementDecember 2012, Volume 6, No. 1, pp. 47-52.

[19] Jin Wang, Jianwei Zhang, Jeong-Uk Kim ,**"**An Energy-based Clustering Algorithm for Wireless Sensor Networks", in Computer Networks, vol.38, no.4, pp.393-422, 2002.

[20] Sanjeev SETIA ,Sankardas ROY, "Secure Data Aggregation in Wireless Sensor Networks ",in Computer Science Department, George Mason University, USA,pp1361-1364, 2004.

[21] Eduardo F. Nakamura, Horacio A.B.F. de Oliveira, "On Demand Role Assignment for Event-Detection in Sensor Networks",Department of Computer Science, Federal University of Minas Gerais in 11th IEEE Symposium on Computers and Communications, 2006.