Volume-5, Issue-1, January -2016 • ISSN No 2277 - 8160

Research Paper | Engineering

Hierarchy Based Distributed Scheduling Algorithm for Mobile Data Gathering in WSN

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ABSTRACT

In this paper, priority based distributed scheduling algorithm for mobile data gathering in Wireless sensor networks (WSN) is proposed. This proposed method involves data exchange policy to avoid dropping and then distributed scheduling algorithm for data gathering. Initially, the centralized algorithm places the polling points (PPs) on the shortest path. These polling points (PP) buffer locally aggregated data and upload the data to the mobile data collector when it arrives. The data is classified as high and low priority based on the deadline and urgency. At the second module, data exchange policy is processed and it is used in order to avoid dropping of higher priority data, data can be exchanged between two mobile data collectors. Finally in the distributed scheduling algorithm, the time slots are scheduled according to which the data collector could gather the maximal amount of data within a limited period. By simulation results, we show that the proposed algorithm minimizes the data losses and reduces energy consumption.

KEYWORDS : Data exchange, Polling Points, higher priority, local buffer.

1. INTRODUCTION

1.1 Wireless Sensor Network (WSN)

Wireless Sensor Network (WSN) is deployed to monitor the physical environment, process sensing information and report to the sink through wireless communications. Sensor nodes are typically resource-constrained micro-electronic devices. This necessitates effective solutions in various aspects of WSNs, such as routing, medium access control (MAC), duty cycle scheduling, etc. [8]. Such types of sensor nodes could be deployed in home, military, science, and industry [9].

1.2 Mobile data gathering (MDG) in WSN

Recent years there have been a lot of applications in Wireless Sensor Networks (WSNs), ranging from

monitoring to event detection and target tracking. For all these applications, data gathering is one of the primary operations carried out in WSNs. Traditionally, the network is assumed to be dense so that there are end-to-end multi-hop paths within the network, along which the generated data could be routed to the base station. This assumption, however, does not always hold in the scenarios of real network deployments. For example, as the WSN is often deployed in harsh environments, the signal is susceptible to external interference and leads to disconnected and portioned network; and if the network is sparse or the nodes are mobile, the paths to the sink might not always be available. So recently there is a research trend that adopts mobile elements for the message transmission and data gathering in mobile sensor networks [10] [11]

1.3 Distributed scheduling for MDG in WSN

Recently, two types of TDMA scheduling algorithms have been proposed: centralized scheduling and distributed scheduling. In contrast, distributed scheduling does not need to construct conflict graph for WSNs. When node tries to assign slot, the slots collisions among nodes have been resolved locally. A few distributed scheduling algorithms have been proposed for WSNs. In these algorithms, the nodes in the network announce the slots which have not conflict with the slots of n-hop neighbors. The number of n-hop neighbors is depends on the interference model. In general, the algorithm uses the protocol interference model. However, as the protocol interference model only considers the two-hop neighbors, the slot collision among nodes cannot be avoided due to the irregular wireless interference. In order to improve the performance of algorithm, nodes need to propagate to more hop neighbors to avoid the slot collision, resulting in considerable communication and energy cost. Furthermore, the control packet used during slot assignment maybe lost due to wireless communication collision. Therefore, these algorithms cannot guarantee the good performance of data collection and energy efficiency [12].

2. Related Works

Arun A Somasundara et al [1] have introduced a scheduling problem, where the mobile element needs to visit the nodes so that none of their buffers overflow. Wireless networks have historically considered support for mobile elements as an extra overhead. However, recent research has provided means by which network can take advantage of mobile elements. Particularly, in the case of wireless sensor networks, mobile elements are deliberately built into the system to improve the lifetime of the network and act as mechanical carriers of data. The mobile element, which was controlled, visits the nodes to collect their data before their buffers are full. It may happen that the sensor nodes are sampling at different rates, in which case some nodes need to be visited more frequently than others. The problem of scheduling the mobile element in the network was defined, so that there was no data loss due to buffer overflow.

ZhangBing Zhou et al [2] have proposed a popularity-based caching strategy for optimizing periodic query processing. Specifically, the network region was divided using a cell-based manner, where each grid cell was abstracted as an elementary unit for the caching purpose. Fresh sensory data are cached in the memory of the sink node. The popularity of grid cells are calculated leveraging the queries conducted in recent time slots, which reflects the possibility that grid cells may be covered by the queries forthcoming. Prefetching may be performed for grid cells with a higher degree of popularity when missed in the cache. These cached sensory data are used for facilitating the query answering afterwards. Moreover, the approach can reduce the communication cost significantly and increase the network capability.

Miao Zhao et al [3] have proposed a three-layer framework for mobile data collection in wireless sensor networks, which includes the sensor layer, cluster head layer, and mobile collector layer. The framework employs distributed load balanced clustering and dual data uploading, which was referred to as LBC-DDU. The objective was to achieve good scalability, long network lifetime and low data collection latency. At the sensor layer, a distributed load balanced clustering (LBC) algorithm was used for sensors to self-organize themselves into clusters. The algorithm generates multiple cluster heads in each cluster to balance the work load and facilitate dual data uploading. At the cluster head layer, the inter-cluster transmission range was carefully chosen to guarantee the connectivity among the clusters. Multiple cluster heads within a cluster cooperate with each other to perform energy-saving inter-cluster communications.

Xinjiang Sun et al [4] have proposed a distributed width-controllable braided multipath routing (WC-BMR) based on local neighbor's information for data collections in wireless sensor networks. By only attaching a little information to data packets, the transmission direction can be restricted near the main route. Heterogeneous widths, namely, different widths on different hops from the source to the sink can also be supported to adapt to the dynamic and heterogeneous wireless links. Additionally, a kind of less cooperative topology in the WC-BMR was found, which brings no or less reliability gain. Furthermore, a modified cooperative WC-BMR with the detection algorithm for LC-Topology was used to maintain the high reliability and efficiency, which allows parents nodes to choose the best main route locally and dynamically. Moreover, the approach can achieve higher reliability and efficiency, as well as keep lower delay under various network settings.

Arun K. Kumar et al [5] have proposed a model of mobile data collection that reduces the data latency significantly. In a wireless sensor network, battery power was a limited resource on the sensor nodes. Hence, the amount of power consumption by the nodes determines the node and network lifetime. One way to reduce power consumed was to use a special mobile data collector (MDC) for data gathering, instead of multi-hop data transmission to the sink. The MDC collects the data from the nodes and transfers it to the sink. Using a combination of a new touring strategy based on clustering and a data collection mechanism based on wireless communication, the delay can be reduced significantly without compromising on the advantages of MDC based approach.

Songtao Guo et al [6] have proposed a framework of joint Wireless Energy Replenishment and anchor-point based Mobile Data Gathering in WSNs by considering various sources of energy consumption and time-varying nature of energy replenishment. The anchor point selection strategy and the sequence to visit the anchor points was determined. The WerMDG problem was formulated into a network utility maximization problem which was constrained by flow, energy balance, link and battery capacity and the bounded sojourn time of the mobile collector. Furthermore, a distributed algorithm was used that composed of cross-layer data control, scheduling and routing sub algorithms for each sensor node and sojourn time allocation sub algorithm for the mobile collector at different anchor points.

Shuai et al [7] have proposed a data collection scheme, called the Maximum Amount Shortest Path (MASP) that increases network throughput as well as conserves energy by optimizing the assignment of sensor nodes. MASP was formulated as an integer linear programming problem and then solved with the help of a genetic algorithm. A two-phase communication protocol based on zone partition was designed to implement the MASP scheme. Moreover, a practical distributed approximate algorithm was developed to solve the MASP problem.

3. Proposed Solution

3.1 Overview

The priority based distributed scheduling algorithm for mobile data gathering in WSN consists of 3 Modules:

- Selection of polling points
- Data exchange Policy to avoid dropping
- Distributed scheduling

3.2 Selection of Polling Points (PP)

Among the sensor nodes, to find the optimal polling points (PP) the relay routing paths and the tour of the mobile collector are considered. If the mobile collector is available then the data collection is partitioned in two ways:

First: - The sensors which are selected as PPs are efficiently distributed and are close to the data sink.

Second: - The number of PPs are smallest under the constraint of the relay hop bound.

Considering these factors the shortest path tree based data collection algorithm (SPT-DCA) with its pseudo code listed is given in Algorithm 1. This algorithm will iteratively choose the PP among the sensors on a shortest path tree (SPT) depending upon the sensor which is near to the root that can connect the remote sensors on the tree.

SPT-DCA will build a SPT which covers every sensor in the network. Let us consider the sensor network as a graph G(V,E), where V=S represents all the sensors in the network, and E is the set of edges connecting any two neighboring sensors. For the single SPT the operation of algorithm is as given below.

Consider SPT denoted by $T' = (V', E')$ with $V' \subseteq V$ and $E' \subseteq E$.

Algorithm 1: SPT-DCA

Input: A sensor network G(V,E), the relay hop bound d, and the static data sink π.

Output: A set of PPs *P*

Construct SPT for *G* that cover all the vertices in *V* ;

Step 1: For each SPT $T'=(V',E')$, when T' is not empty find the farthest leaf vertex *v* on ;

Step 2: If *v* is not a PP then assign parent(*v*) to *u* and assign *u* to *v*.

Step 3: If *u* is not the root of T' then Update T' by removing all the child vertices of u and the pertinent edges.

Step 4: If *u* is the root of T' then all the sensors on T' are affiliated with t_u and T' is set to be empty.

Step 5: If *v* is a PP then

Remove *v* from current T' if d = 1
Assign parent(*v*) to *w* and *w* to *v* if d ≠ 1

Step 6: If *w* is not the root of T' then remove the sub-tree rooted at *w* from T' . Corresponding sensors on the removed sub-tree are affiliated with *v* on the geometric tree t_v. If *w* is the root of T' then sensors on T' that are not selected as PPs are affiliated with *v* on the geometric tree t_v.

Find an approximate shortest tour *U* visiting π and all the PPs in *P*;

3.3 Data Exchange Policy

The set of PPs denoted by {SPP} in buffer area is considered as a distributed storage system to store the sensing data for the WSN. Thus all sensor nodes used to forward their packets towards nodes in {SPP} at any time. The data packets are classified as high and low priority based on the deadline and urgency.

The data exchange policy contains the following steps in order to avoid dropping of higher priority data, data can be exchanged between two mobile data collectors. Thus WSN-to-mule, mule-to-mule, and mule-to-BS is processed as follows. At First, for WSN-to-mule communications, since packets in BA are already in-order by using our priority based data storage process. Thus when a mule arrives at the sink of a WSN, the sink will try to transmit as many packets in BA to the mule as possible until it loses the contact with the mule. Once the sink makes sure the reception of a packet by the mule, it can drop the packet so as to make a space for subsequent packets. The following algorithm will show the data exchange policy [11].

Algorithm-2

1. Based on the current utility of the package, the packets are sorted by each mule considering whether copy packets from itself to another
2. The packet *p* selected by mule *u* which has highest utility and not been considered.
3. Similarly the packet *q* selected by *v* which has highest utility and not been considered.

Then u and v are computed as

$$E(u \rightarrow v, p, t) - E(u, p, t) \quad \text{and}$$
$$E(v \rightarrow u, q, t) - E(v, q, t) \quad (1)$$

4. If higher benefit is obtained by copying *p* then
u copies *p* to *v*
Else
v copies *q* to *u*.
End if

5. The copied packets are mentioned as "considered"

6. If u and v are still in communication range of each other

Repeat step 2
Else
Stop
End if

3.4 Distributed Scheduling Algorithm

A distributed scheduling algorithm is designed to schedule the time slots according to which the data collector could gather the maximal amount of data within a limited period. Once proxy nodes gather the sensed data from their neighboring nodes, these data should be collected by the mobile collector when they are in contact. Usually there are more than one proxy nodes, and MC has to arrange its visiting order and time slots so that it could gather the maximal amount of data within the limited period. The scheduling could also be viewed as the Proxy node Time Slot Allocation (PTSA) problem.

At first expected amount of gathered data is estimated using the following equation

$$Y = \sum_{x_i \in X} \rho(x_i) = \sum_{x_i \in X} \mu_i B(s) \qquad (2)$$

Where,

$\rho(x_i)$ Expected amount of data stored at a proxy node

μ_i Number of distinct contacts of x_i

$B(s)$ Amount of data a node might have in data gathering around *s*

Thus when a scheduler is compatible that the collector would visit each of the nodes one by one with in the gathering period of data during the following condition:

$$\forall (x_i,[a_i,g_i]) \in \Psi, [a_i,g_i] \subseteq SD(x_i), g_i - a_i \geq T_{slot}, a_0 \leq a_i < g_i < a_i < a_{i+1} \leq e_{k+1} \qquad (3)$$

Visiting during time range

$x_i, [a_i, g_i]$ Visiting x_i during time range a_i, g_i

T_{slot} Minimal data gathering duration of a slot

Because the mobile collector could move fast, here we assume the time duration moving from one proxy node to the next is negligible compared with the period of data gathering round and data is picked by the data collector [1].

4. Simulation Results

4.1 Simulation Parameters

We use NS-2 [13] to simulate our proposed Priority Based Distributed Scheduling (PBDS) protocol. We use the IEEE 802.11 for WSNs as the MAC layer protocol. It has the functionality to notify the network layer about link breakage. In our simulation, the packet sending rate is varied as 100, 200,300,400 and 500Kb. The area size is 500 meter x 500 meter square region for 50 seconds simulation time. The simulated traffic is Constant Bit Rate (CBR).

Simulation settings and parameters are summarized in the following table

Table 1: Simulation parameters

No. of Nodes	100
Area	500 X 500m
MAC	802.11
Simulation Time	50 sec
Traffic Source	CBR
Rate	100, 200, 300,400 and 500Kb
Propagation	TwoRayGround
Antenna	OmniAntenna
Initial Energy	25.1J
Transmission Power	0.660
Receiving Power	0.395

4.2 Performance Metrics

We evaluate performance of the new protocol mainly according to the following parameters. We compare the Adaptive Data Gathering (ADG) [10] algorithm with our proposed PBDSA.

Average Packet Delivery Ratio: It is the ratio of the number of packets received successfully and the total number of packets transmitted.

Average end-to-end delay: The end-to-end-delay is averaged over all surviving data packets from the sources to the destinations.

Packet Drop: It is the number of packets dropped during the data transmission

4.3 Results & Analysis

The data sending rate is varied as 100,200,300,400 and 500Kb.

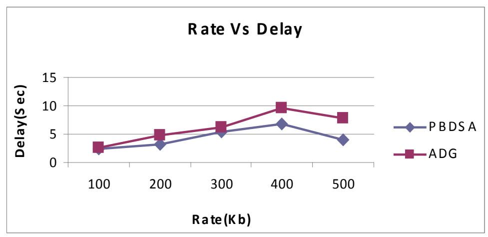

Fig 1: Rate Vs Delay

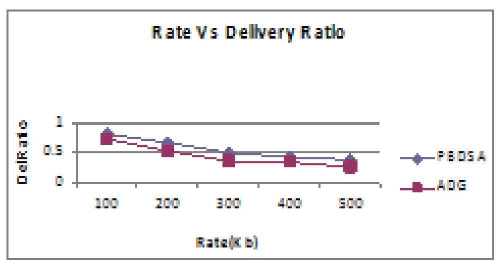

Fig 2: Rate Vs Delivery Ratio

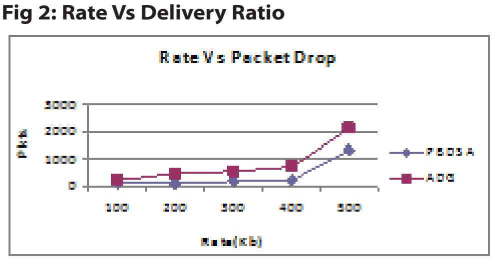

Fig 3: Rate Vs Drop

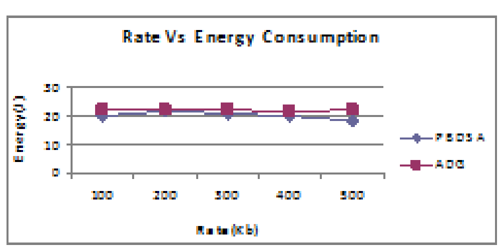

Fig 4: Rate Vs Energy Consumption

Figures 1 to 4 show the results of delay, delivery ratio, packet drop and energy consumption by varying the rate from100Kb to 500Kb for PBDSA and ADG. When comparing the performance of the two protocols, we infer that PBDSA outperforms ADG by 27% in terms of delay, 17% in terms of delivery ratio, 59% in terms of packet drop, and 6% in terms of energy consumption.

5. Conclusion

In this paper, priority based distributed scheduling algorithm for mobile data gathering in WSN is processed. The data is categorized as high and low priority based on the deadline and urgency. Moreover, when there is overload of data at the mobile data collector, the lower priority of data will be dropped. Then the data exchange policy is processed in which data can be exchanged between two mobile data collectors. Distributed scheduling algorithm is used to schedule the time slots according to which the data collector could gather the maximal amount of data within a limited period. By simulation results, it has been shown that the proposed algorithm minimizes the data losses and reduces energy consumption.

REFERENCES

[1] Arun A Somasundara, Aditya Ramamoorthy and Mani B Srivastava, "Mobile Element Scheduling for Efficient Data Collection in Wireless Sensor Networks with Dynamic Deadlines", Proceedings of the 25th IEEE International Real-Time Systems Symposium, 2004. [2] ZhangBing Zhou, Deng Zhao, Xiaoling Xu, Chu Du and Huilin Sun, "Periodic Query Optimization Leveraging Popularity-Based Caching in Wireless Sensor Networks for Industrial IOT Applications", Mobile network applications, 2014. [3] Miao Zhao, Yuanyuan Yang, Fellow and Cong Wang, "Mobile Data Gathering with Load Balanced Clustering and Dual Data Uploading in Wireless Sensor Networks", IEEE Transactions on Mobile Computing, 2013. [4] Xinjiang Sun, Hao Chen, Xiaobei Wu, Xinjie Yin and Wenzhan Song, "Opportunistic Communications based on Distributed Width-controllable Braided Multipath Routing in Wireless Sensor Networks", Adhoc networks, 2015. [5] Arun K. Kumar, Krishna M. Sivalingam and Adithya Kumar, "On reducing delay in mobile data collection based wireless sensor networks", Wireless Networks, No.19, pp.285–299, 2013. [6] Songtao Guo, Cong Wang and Yuanyuan Yang, "Joint Mobile Data Gathering and Energy Provisioning in Wireless Rechargeable Sensor Networks", IEEE Transactions on Mobile Computing, 2013. [7] Shuai Gao, Hongke Zhang and Sajal K. Das, "Efficient Data Collection in Wireless Sensor Networks with Path-Constrained Mobile Sinks", IEEE Transactions on mobile computing, vol. 10, No. 5, APRIL 2011. [8] Xing Zhang, Jingsha He and Qian Wei, "Energy-Efficient Routing for Mobility Scenarios in Wireless Sensor Networks," In Proceedings of the Third International Symposium on Electronic Commerce and Security Workshops, 2010 [9] Kai Li and Kien A. Hua, "Mobility-assisted Distributed Sensor Clustering for Energy efficient Wireless Sensor Networks," Ad Hoc and Sensor Networking Symposium, 2013 [10] Yongxuan Lai, Jinshan Xie, Ziyu Lin, Tian Wang and Minghong Liao, "Adaptive Data Gathering in Mobile Sensor Networks UsingSpeedy Mobile Elements", Sensors 2015 [11] Yu-Chee Tseng, Fang-Jing Wu, Wan-Ting Lai, "Opportunistic data collection for disconnected wireless sensornetworks by mobile mules, Ad Hoc Networks, pp.1150–1164, 2013 [12] Bo Zeng, Yabo Dong,"A Collaboration-based Distributed TDMAScheduling Algorithm for Data Collection inWireless Sensor Networks," Journal of Networks, Vol. 9, No. 9, 2014. [13] Network Simulator: http:///www.isi.edu/nsnam/ns