Polling based Mobile Data Gathering and weightage based Data Storage Algorithm for Wireless Sensor Networks

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Abstract

In this paper, polling based mobile data gathering and the priority based data storage algorithm for wireless sensor networks (WSN) is proposed. 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. Then, priority based data storage module is processed where the data is classified as high and low priority based on the deadline and urgency. The high priority data is buffered near the polling points. When there is overload of data at the mobile data collector, the lower priority of data will be dropped. By simulation results, it has been shown that the proposed algorithm minimizes the data losses and reduces energy consumption.

1. Introduction

Wireless Sensor Networks (WSNs) is a self-organized, distributed, sensing and data propagation networks formed by a large number of sensor nodes. Nodes are resource constrained tiny autonomous devices. It is used for sensing, data processing and communicating components environmentally distributed to sense environmental conditions in their immediate surroundings. Batteries are used as an energy resource. Sensor nodes generate data and operate in a multi-hop fashion to relay data from other nodes. It has a task to perform systematic collection of data and transmit gathered data to a distant base station (BS). [1] [2]. WSNs undertake intensive data collection during the sensing period right from the beginning. The limited energy storage of tiny sensors in a WSN harshly restricts transmitting the acquired data, which in turn disturbs the connectivity of the network due to premature death of several sensors [4]. As data collection becomes an issue in WSN, data aggregation technique is required to reduce the energy consumption [5].

Sink mobility in WSNs provides energy conservation by balancing energy consumption of each sensor node and reduces latency during data collection. It can also reduce the possibility of “routing hotspots” caused by fixed sinks due to the nearby heavy data flow [6, 7, 8].

Mobile sinks face some challenging issues like seamless data collection and energy conservation. The frequent variation of the sink location causes loss of data reports from the sensor nodes as the existing path become invalid on moving the sink. Communication paths or routing trees should be exhaustively rebuilt to overcome this. The frequent updates of the routing tree results in large energy consumption and significant delays for restarting communication [9]. As the sinks collect data from the nodes within a certain range, a protocol should have policies for sleeping and waking up the sensor nodes to save energy [9].

This paper proposes a polling-based mobile data gathering and priority based data storage (PMDGPDS) algorithm for WSN.

2. Related Works

Miao Zhao et al [10] 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

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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.

Arun K. Kumar et al [11] 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 [12] 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 [13] 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

This paper proposes a polling-based mobile data gathering and priority based data storage algorithms for WSN.

In polling-based mobile data gathering, a subset of sensors will be selected as polling points that buffer locally aggregated data and upload the data to the mobile collector when it arrives. It uses the centralized algorithm [15] that places the pooling points (PPs) on the shortest path trees rooted at the sensors closest to the data sink.

In Priority based data Storage, data is classified as high and low priority based on the deadline and urgency. The high priority data is buffered near the polling points. When there is overload of data at the mobile data collector, the lower priority of data will be dropped [14].

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 [15]:

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 $E' \subseteq E$.

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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 SPTs 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 T';
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 subtree rooted at *w* from T'. Corresponding sensors on the removed subtree 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 Priority based Distributed Data Storage (PDDS)

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 we can consider that each node i knows its distance to the sink $D_S(i)$ and to the neighbor nodes $D_N(i)$. 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 goal of PDDS is to achieve the following

- Dropping of packets in {SPP} should be minimized.
- If dropping of packets is unavoidable, those with lower priorities should be dropped first.
- To facilitate mobile mules to collect data, packets with higher priorities should be stored in PPs with high buffer size which are closer to the sink [14].

Each u ∈ {SPP}, Let P_u denote the packet at u,
$Pr(P_u)$ denote the priority of P_u.
BS_u denote the buffer space of u.

Then PDDS has to satisfy the following properties:

P1. For each node v∈{SPP}, such that $BS_u > BS_v$ and $D_S(u) < D_S(v)$, then
$Pr(P_u) > Pr(P_v)$
P2. For each node v∈{SPP}, such that $BS_u < BS_v$ and $D_S(u) > D_S(v)$, then
$Pr(P_u) < Pr(P_v)$

The properties P1 and P2 imply that nodes which are closer to the sink and having high buffer space should contain high priority packet and vice versa.

For each node u∈ {SPP},

Let MaxPost(u) be the packet with maximum priority of all neighbors v of u such that $BS_u > BS_v$ and $D_S(u) < D_S(v)$.

Let MinPre(u) be the packet with minimum priority of all neighbors v of u such that
$BS_u < BS_v$ and $D_S(u) > D_S(v)$.

Let MaxEqual(u) be the packet with maximum priority of all neighbors v of u such that
$BS_u = BS_v$ and $D_S(u) = D_S(v)$.

Let MinEqual(u) be the packet with minimum priority of all neighbors v of u such that
$BS_u = BS_v$ and $D_S(u) = D_S(v)$.

Based on the properties P1 and P2 and the above category of packets, the following packet exchange rules are designed.

R1. When Pr(MaxPost(u)) > Pr(u), then node u exchanges packet with MaxPost(u)

R2. When Pr(u) > Pr(MinPre(u)), then node u exchanges packet with MinPre(u)

R3 a. When Pr(MaxEqual(u)) > Pr(MinPre(u)), then these two packets are exchanged

R3.b When Pr(MaxPost(u)) > Pr(MinEqual(u)), then these two packets are exchanged

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The above rules are triggered when a node changes its packet or when its neighbors change their packets. The steps involves in PDDS are given in Algorithm2.

Algorithm-2

1. If a packet P_u arrives at the node $u \in \{SPP\}$,
2. Check the priority of packet $Pr(P_u)$
3. If P1 or P2 is violated at u, then

Exchange the packet as per rules R1, R2 and R3.

Else

Store the packet at u

End if

4. Simulation Results

4.1 Simulation Parameters

We use NS-2 [17] to simulate our proposed Priority Based Distributed Scheduling (PBDS) protocol. We compare the Adaptive Data Gathering (ADG) [16] algorithm with our proposed PMDGPDS algorithm. The performance evaluated mainly according to the parameters. average packet delivery ratio, average end-to-end delay and packet drop.

The simulation settings and parameters are summarized in table 1

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 joules
Transmission Power	0.660
Receiving Power	0.395

Table 1: Simulation parameters

4.2 Results & Analysis

The simulation results are presented in the next section.

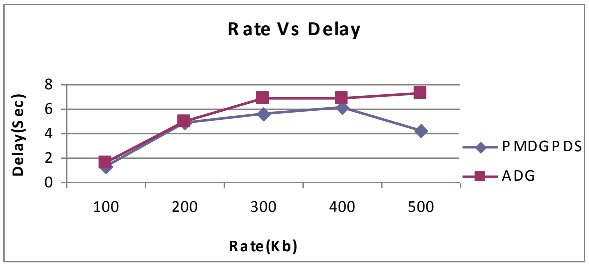

Fig 1: Rate Vs Delay

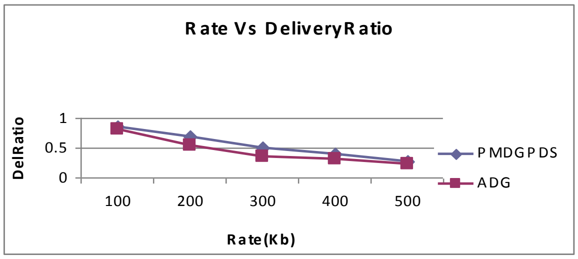

Fig 2: Rate Vs Delivery Ratio

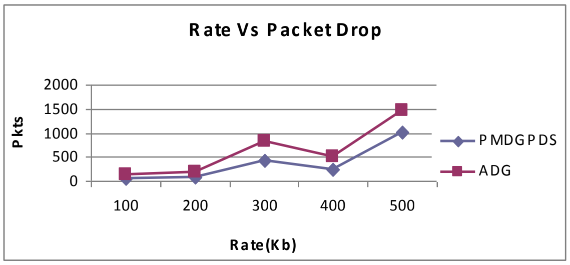

Fig 3: Rate Vs Drop

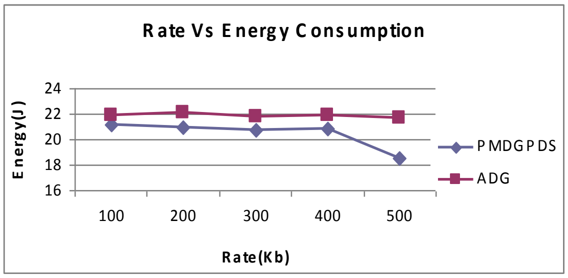

Fig 4: Rate Vs Energy

Figures 1 to 4 show the results of delay, delivery ratio, packet drop and energy consumption by varying the rate from100Kb to 500Kb for the CBR traffic in PMDGPDS and ADG protocols. When comparing the performance of the two protocols, we infer that PMDGPDS outperforms ADG by 19% in

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terms of delay, 18% in terms of delivery ratio, 51% in terms of packet drop, and 5% in terms of energy consumption

5. Conclusion

In this paper mobile data gathering in WSN is processed. The priority based data storage module is processed where 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 and it is used in order to avoid dropping of higher priority data, then the data can be exchanged between two mobile data collectors. At lastdistributed scheduling algorithm is used to schedule the time slots according to which thedata collector could gather the maximal amount of data within a limited period

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