VOL. 11, NO. 1, JANUARY 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

PRIORITY BASED DISTRIBUTED STORAGE AND SCHEDULING (PBDS) FOR MOBILE DATA GATHERING IN WSN

Palani U.[1], Alamelu Mangai V.[2] and Alamelu Nachiappan[3]
[1]Department of Electronics and Instrumentation Engineering, Annamlai University, Chidambaram, India
[2]Department of Electronics and Instrumentation Engineering, Annamlai University, Chidambaram, India
[3]Department of Electrical and Electronics Engineering, Pondicherry Engineering College, Puducherry, India
E-Mail: palani_uin@yahoo.com

ABSTRACT

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. In this paper, the priority based distributed scheduling (PBDS) for mobile data gathering in WSN is proposed. This proposed method involves of Three Modules such as Priority based data Storage, Data exchange Policy to avoid dropping and then distributed scheduling algorithm for data gathering is processed. At first 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. 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 last module distributed scheduling algorithm is to schedule the time slots according to which the data collector could gather the maximal amount of data within a limited period.

Keywords: mobile data, data drop, distributed scheduling, exchange policy, load, priority data.

INTRODUCTION

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, duty cycle scheduling, etc. [8]. Such types of sensor nodes could be deployed in home, military, science, and industry [9].

Mobile data gathering (MDG) in WSN

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]. The 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. Then data compression is taking place using compressive Network Coding approach.(CNC) [14]

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 try to assign slot, the slots collisions among nodes have been resolved locally. A few distributed scheduling algorithms have been proposed in which, the nodes in the network announce the slots which have not conflict with the slots of n-hop neighbours. The number of n-hop neighbours 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 neighbours, 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 neighbours 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].

LITERATURE SURVEY

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 neighbour'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 MDG 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.

PROPOSED SOLUTION

ARPN Journal of Engineering and Applied Sciences

Overview

The priority based districted scheduling for mobile data gathering in WSN consists of three Modules: Priority based data Storage, Data exchange Policy to avoid dropping and then Distributed scheduling algorithm for data gathering is processed.

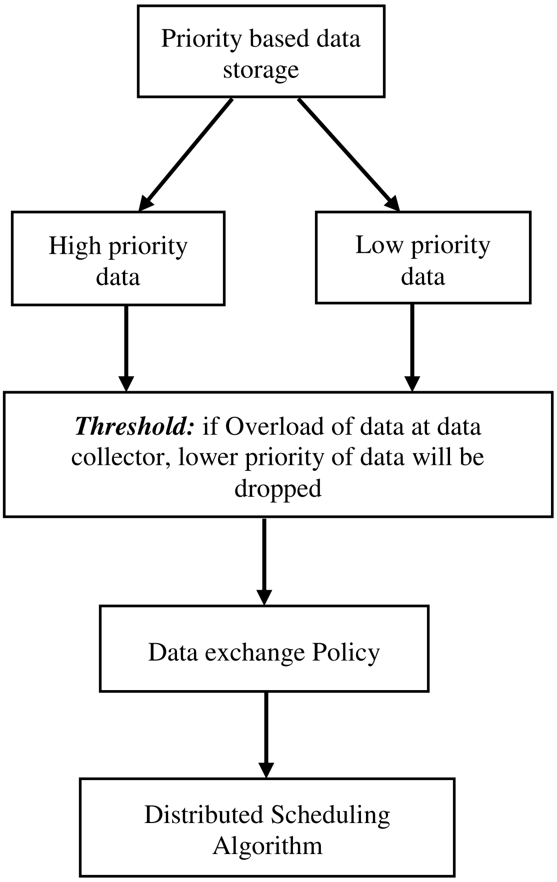

Figure-1. Block diagram of proposed approach.

- **Priority based data storage:** 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 [2].
- **Data exchange policy:** In order to avoid dropping of higher priority data, data can be exchanged between two mobile data collectors.
- **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 [1].

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 numbers 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 neighbouring 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 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 treet_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 treet_v.

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

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

 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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 neighbour 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.

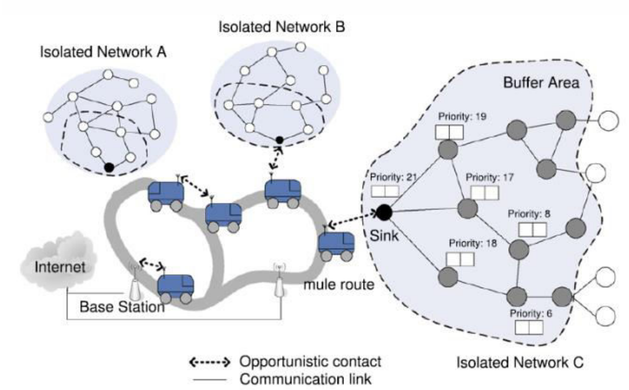

Figure-2. Selection of lower and higher priority during overload condition.

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 is closer to the sink [11].

Each u $\in$ {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 $v \in$ {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 $v \in$ {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 $\in$ {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

The above rules are triggered when a node changes its packet or when its neighbours change their packets. The steps involves in PDDS are given in Algorithm-2.

Algorithm 2: SPT-DCA
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

Data exchange policy

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-Base Station (BS) is processed as follows. At First, for WSN-to-mule communications, since packets in Buffered Area (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 3

Step 1:

Based on the current utility of the package, the packets are sorted by each mule considering whether copy packets from itself to another.

Step 2:

The packet *p* selected by mule *u* which has highest utility and not been considered.

Step 3:

Similarly the packet *q* selected by *v* which has highest utility and not been considered.

Then u and v are computed as

$E(u \rightarrow v, p, t) - E(u, p, t)$ and

$E(v \rightarrow u, q, t) - E(v, q, t)$

Step 4:

If higher benefit is obtained by copying *p* then *u* copies *p* to *v* else, *v* copies *q* to *u*.

Step 5:

The copied packets are mentioned as "considered"

Repeat the step 2 if u and v are still in communication range of each other

Else stop

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 neighbouring 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

$$Y = \sum_{x_i \in X} \rho(x_i) = \sum_{x_i \in X} \mu_i B(s) \quad (1)$$

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:

$$\forall (x_i, [a_i, g_i]) \in \Psi, [a_i, g_i] \subseteq SD(x_i), g_i - a_i \geq T_{slot}, a_0 \leq a_i < g_i < a_i < a_{i+1} \leq e_{k+1} \quad (2)$$

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

$SD(x_i)$ One of the key stationary duration of x_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].

SIMULATION PARAMETERS

Network Simulator-2 is used [13] to simulate the proposed Priority Based Distributed Scheduling (PBDS) protocol. IEEE 802.11 is used for WSNs as the MAC layer protocol. It has the functionality to notify the network layer about link breakage. The simulation settings and parameters are summarized in Table-1.

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	Two Ray Ground
Antenna	Omni Antenna
Initial Energy	25.1J
Transmission Power	0.660
Receiving Power	0.395

Performance metrics and analysis

The Comparison is made between the Adaptive Data Gathering (ADG) [10] algorithms with the proposed PBDS protocol. The performance of the new protocol mainly is evaluated according to the following parameters.

- Average Packet Delivery Ratio
- Average end-to-end delay
- Packet Drop

Case-1: Based on rate (Range-250m)

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

The CBR traffic rate is varied from 100kb to 500 with the transmission range of 250 and the above performance metrics are evolved.

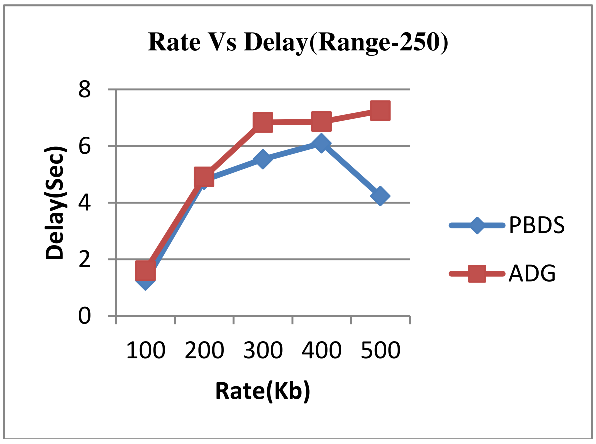

Figure-3. Rate vs delay.

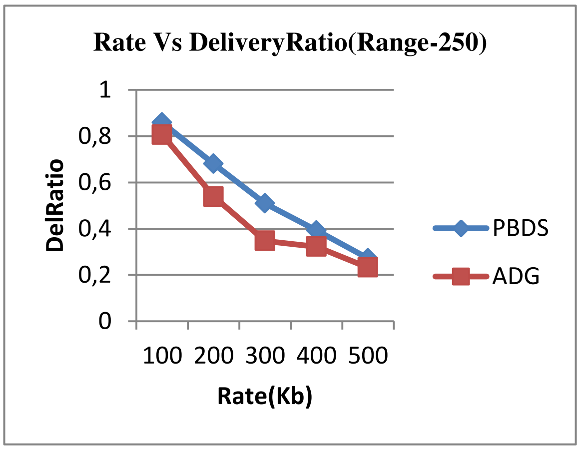

Figure-4. Rate vs delivery ratio.

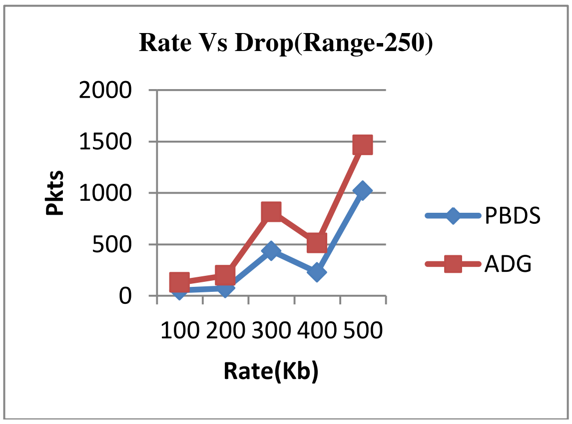

Figure-5. Rate vs drop.

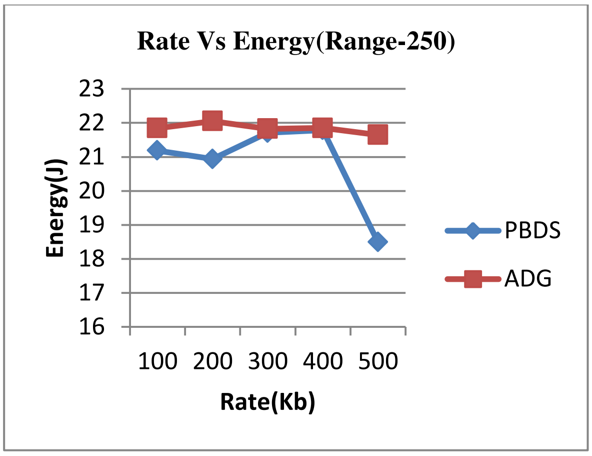

Figure-6. Rate vs energy consumption.

Figures 3 to 6 show the results of delay, delivery ratio, packet drop and energy consumption by varying the rate from100Kb to 500Kb for the CBR traffic in PBDS and ADG protocols. When comparing the performance of the two protocols, it infers that PBDS outperforms ADG by 19% in terms of delay, 18% in terms of delivery ratio, 51% in terms of packet drop, and 5% in terms of energy consumption.

Case-2: Based on rate (Range-300m)

The CBR traffic rate is varied from 100kb to 500 with the transmission range of 300 and the above performance metrics are evolved.

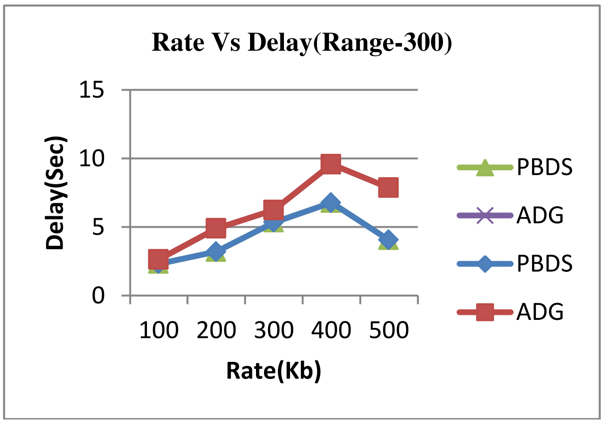

Figure-7. Rate vs delay.

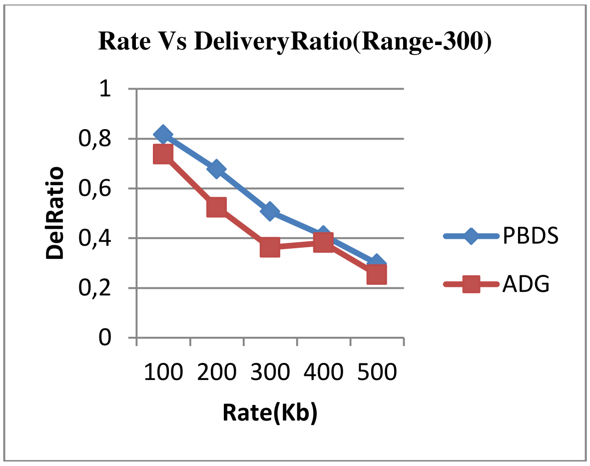

Figure-8. Rate vs delivery ratio.

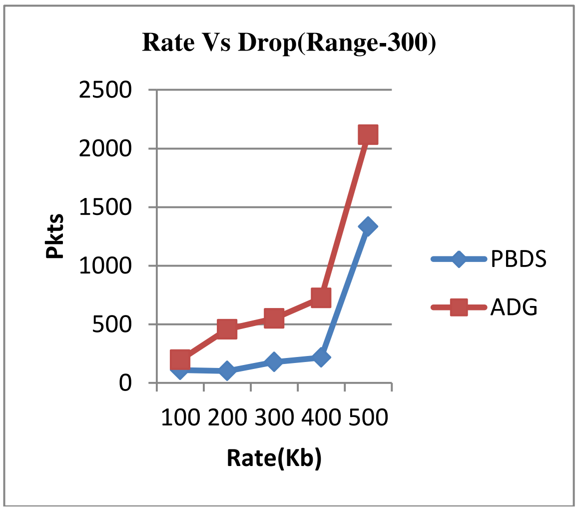

Figure-9. Rate vs drop.

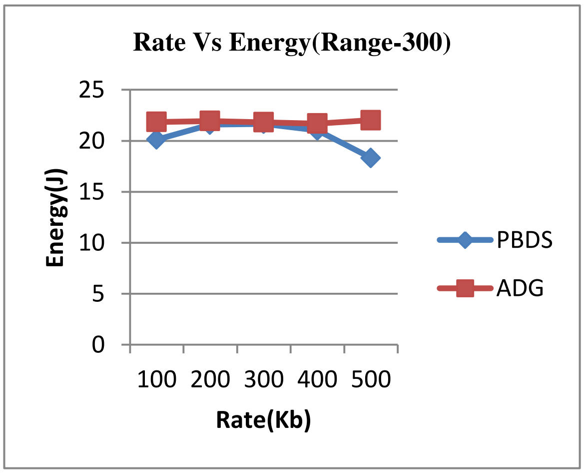

Figure-10. Rate vs energy consumption.

Figures 7 to 10 show the results of delay, delivery ratio, packet drop and energy consumption by varying the rate from100Kb to 500Kb for the CBR traffic in PBDS and ADG protocols. When comparing the performance of the two protocols, it infer that PBDS 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.

CONCLUSIONS

In this work, the priority based data storage module is processed for 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 initiated 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 last 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.

REFERENCES

[1] Arun A Somasundara, Aditya Ramamoorthy and Mani B Srivastava. 2004. Mobile Element Scheduling for Efficient Data Collection in Wireless Sensor Networks with Dynamic Deadlines. Proceedings of the 25th IEEE International Real-Time Systems Symposium.

[2] Zhang Bing Zhou, Deng Zhao, Xiaoling Xu, Chu Du and Huilin Sun. 2014. Periodic Query Optimization Leveraging Popularity-Based Caching in Wireless Sensor Networks for Industrial IOT Applications. Mobile network applications.

[3] Miao Zhao, Yuanyuan Yang, Fellow and Cong Wang. 2013. Mobile Data Gathering with Load Balanced Clustering and Dual Data Uploading in Wireless Sensor Networks. IEEE Transactions on Mobile Computing.

[4] Xinjiang Sun, Hao Chen, Xiaobei Wu, Xinjie Yin and Wenzhan Song. 2015. Opportunistic Communications based on Distributed Width-controllable Braided Multipath Routing in Wireless Sensor Networks. IEEE Transactions on Industrial electronics.

[5] Arun K. Kumar, Krishna M. Sivalingam and Adithya Kumar. 2013. On reducing delay in mobile data collection based wireless sensor networks. Wireless Networks. 19: 285-299.

[6] Songtao Guo, Cong Wang and Yuanyuan Yang. 2013. Joint Mobile Data Gathering and Energy Provisioning in Wireless Rechargeable Sensor Networks. IEEE Transactions on Mobile Computing.

[7] Shuai Gao, Hongke Zhang and Sajal K. Das. 2011. Efficient Data Collection in Wireless Sensor Networks with Path-Constrained Mobile Sinks. IEEE Transactions on mobile computing. 10(5).

[8] Xing Zhang, Jingsha He and Qian Wei. 2010. Energy-Efficient Routing for Mobility Scenarios in Wireless Sensor Networks. Proceedings of the Third International Symposium on Electronic Commerce and Security Workshops.

[9] Kai Li and Kien A. Hua. 2013. Mobility-assisted Distributed Sensor Clustering for Energy efficient Wireless Sensor Networks. Ad Hoc and Sensor Networking Symposium.

[10] Yongxuan Lai, Jinshan Xie, Ziyu Lin, Tian Wang and Minghong Liao. 2015. Adaptive Data Gathering in Mobile Sensor Networks Using Speedy Mobile Elements. Sensors.

[11] Yu-Chee Tseng, Fang-Jing Wu, Wan-Ting Lai. 2013. Opportunistic data collection for disconnected wireless sensornetworks by mobile mules. Ad Hoc Networks. pp. 1150-1164.

[12] Bo Zeng, Yabo Dong. 2014. A Collaboration-based Distributed TDMAScheduling Algorithm for Data Collection in Wireless Sensor Networks. Journal of Networks. 9(9).

[13] Network Simulator: http:///www.isi.edu/nsnam/ns.

[14] Palani, U., Alamelu Mangai, V., & Nachiappan, A. (2014). Compressive network coding based mobile data gathering technique for wireless sensor networks. In IEEE International conference on Advanced Communication Control and Computing Technologies (ICACCCT'14) (pp951-957), Ramanathapuram. India.