Low Delay and High Throughput Data Collection in Wireless Sensor Networks with Mobile Sinks

A.Rehash Rushmi Pavitra[1], Dr.E.Srie Vidhya Janani[2]
[1]PG Scholar, [2]Assistant Professor,
Department of Computer Science and Engineering,
Anna University Regional Campus,
Madurai, India.

Abstract — Wireless Sensor Networks enabled with Mobile Sinks (WSN-MSs) are observed to be a sensible cost effective replacement towards the implementation of traditional wireless sensing framework. Data collection seems to be a task of highest importance in WSN-MSs. When data collected from the sensor nodes are broadcasted to the MSs an increased delay with a minimum throughput is experienced which in turn leads to high implementation complexity. Subsequently, this necessitates a light weighted routing and scheduling technique called Opportunistic Backpressure Collection (OBC). WSN enabled with MSs is simulated with high-powered networked queuing methods. The technique attempts to reduce the queue length. The approach seems to ensure low delay and high throughput thereby outperforming in large scale sensor networks. In large scale sensor networks OBC achieves an optimum index behavior in terms of end-to-end delay and energy efficiency in comparison to other techniques. The experimental results conform to maximize data collection in WSN-MSs complementing towards the performance of Large Scale WSNs.

Index Terms — Wireless Sensor Networks, Sensor Data Collection, Queueing Systems, Mobile Sink.

———————————————————— ◆ ————————————————————

1 INTRODUCTION

WSNs consist of large number of sensor nodes that are established into a large scale sensing area without a predesigned structure. The sensor nodes aim is to collect the data at standard interval, then turn around the data into digital signal and ultimately send the signal to the sink or base node [10]. Sensor node is also capable of identifying their neighbor nodes to form a network. These networks well suits real time applications as Acoustic detection, Forest fire detection, Environmental monitoring, Military surveillance, Inventory tracking, Medical monitoring, Process monitoring and Smart spaces etc [9]. Many applications necessitate the use of MSs as required in military applications. One of the major issues in MS enabled WSNs is data collection.

In WSNs data collection techniques are classified into three categories- data collection using static sink method, data collection using mobility based approach and data collection using MSs [8]. Sensor node throughput, transmission delay and packet loss rate are the factors of prime focus in data collection.

The static sinks used for collecting data leads to energy hole problem and major delay of per-hop packet transmission in WSNs.
Further, the remote communication greatly reduces the network lifetime due to higher energy consumption rates. In-

————————————————————

- *A. Rehash Rushmi Pavitra is with the Department of Computer Science and Engineering, Anna University Regional Campus, Madurai, India. E-mail: rushmiips@mail.com*
- *Dr. E. Srie Vidhya Janani, Assistant Professor, Department of Computer Science and Engineering, Anna University Regional Campus, Madurai, India. E-mail: esrievidhya@mail.com*

In a WSN-MS, some techniques require the estimation of routes of the sink, which obtains major overheads and be affected from prediction errors or may not even be available in large scale networks. Particularly, the proposed Opportunistic Backpressure Collection (OBC) a collective dynamic multi-path routing and scheduling protocol for WSN-MS. OBC is lightweight, easy to implement and can support massive number of fast moving sinks [1].

2 RELATED WORK

Routing Technique	Network Structure	Packet Loss Rate	E2E Delay	Through-put
DT-MSM	Flat	-	High	-
HTDC	Hierar-chical	-	High	Low
QBDCS	Location	Less	-	High
MASP	Location	-	Low	Low
HYBRID WSN	Flat	-	High	-

Table 1: Comparison Table

The survey infers that the previous literature have mainly addressed the issues of static wireless networks. Therefore, the OBC algorithm is combined with CA-ETX and backpressure

stead the MSs move across the network to collect data. The collected data can be made available to users using wireless internet connection. Path between node and sink is multi-hop.

routing to improve the delay and throughput performance of data collection in WSN-MSs.

3 IMPLEMENTATION OF PROPOSED SCHEME

To develop a large scale WSN the factor that affects the high throughput data collection in WSN-MSs is to be focused. The opportunistic data collection is influenced by the factors of throughput-optimal, latency, communication channel etc. On the other hand, throughput and packet loss rate performance are observed to have a higher influence on the large scale sensor networks. When data is to be transmitted from WSN to the MSs there will be an increase in delay, which makes the lifespan of the sensor network to reduce phenomenally. To overcome this a light weighted routing technique called Opportunistic Backpressure Collection is exploited. In WSN-MSs a sink moving across the sensing area would suffer from heavy communication overheads because of large numbers of moving sinks. In such cases OBC is easy to implement, requires no mobility prediction and can support a large number of fast moving sinks.
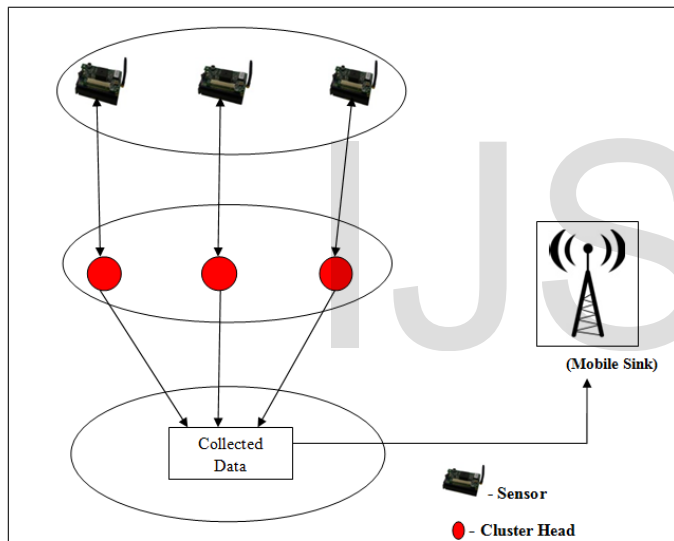

Figure 1: Representative scenario for data collection in WSN-MSs

Sensors group together to form a cluster, where CH is chosen in a random fashion. Sensors elect themselves to be CHs with a certain probability. These CHs broadcast their status to other sensors in the network. Once all the nodes are organized into clusters, each CH creates a schedule for the nodes in its cluster [7]. LEACH protocol organizes the nodes by themselves. Regular nodes in cluster send data to (CH). CH aggregates the data and sends to Base Station (MS). Sensor node should select a random number between the interval 0 & 1. If the generated random number is less than threshold then the node becomes a CH for current round. Threshold is obtained by using the following formula:

$$T(n) = \{P/1-P * (r \bmod 1/P)\}, \text{ if } n \in G \rightarrow (1)$$

Where, p is the desired percentage of clusters; r denotes the current round; G denotes set of nodes that have not been CHs

in the last 1/p rounds. CH collects data and sends acknowledgment to the MS. The sink moves towards the CH and collects data and sends to the base station.

3.1 OBC Algorithm

The phases for data collection in WSN-MSs are: weight calculation, scheduling, routing and forwarding and queue update. Each phase has briefly described below.

3.1.1 Weight Calculation

Step 1: $Q_x(t)$, $Q_y(t)$ are the queue length, each sensor node x calculates the weight w for each of its current neighbor nodes y.

Step 2: MS is initialized with a non-zero value.

```
1: Input: Qx(t), Qy(t) are the queue length;
2: Each senor node X → weight W (neighbor node);
3: Set the MS as non-zero value;
4: If 0 < φ^min ≤ φx ≤ φ^max < α;
5: End;
```

3.1.2 Scheduling

The Longest Queue First (LQF) scheduling algorithm involves the following steps:

Step 1: Estimate weight w for each link to neighbor nodes.

Step 2: Find a neighbor node with maximum link weight.

Step 3: After receiving a pairing request and reply from neighbor node, link is selected as a paired link, and send information to all other neighbors.

Step 5: Receiving a message from neighbor node, node excludes from its neighbors group.

Step 6: If node is in a paired link, no further action is taken. Otherwise, it will repeat steps 2 – 5. Only paired links are allowed to forward.

```
1: Valuating weight W for each node;
2: Searching for its maximum link weight;
3: if x reaches is maximum link weight then
4: Sending request ↔ response
5: x and y are naming paired link;
6: else
7: Go to find maximum link weight;
8: End;
```

3.1.3 Routing and Forwarding

Step 1: When the forwarding queue is non-empty, weights are estimated for every neighbor.

Step 2: If all w ≤ 0, there exists no neighbor and the node waits thereby re-computing weights.

Step 3: The path X and Y is scheduled. With W>0, packet transmission occurs.

```
1: Valuating weight W for each node;
2: Searching for its maximum link weight;
3: if x reaches is maximum link weight then
4: Sending request ↔ response
5: x and y are naming paired link;
6: else
7: Go to find maximum link weight;
8: End;
```

3.1.4 Queue Update

Step 1: Each sensor node maintains a queue to store the sensor data received from other sensor nodes and updates its queue length.
Step 2: Finally, total incoming and outgoing sensor data at slot is estimated.

4 SIMULATION

In this section, we evaluate the performance of OBC, in terms of throughput, delay and packet loss rate. Simulation Settings: We compared OBC with the classic backpressure routing [8] and scheduling algorithm (BP). There are 200 sensor nodes 4 MS, are randomly deployed in a 600m * 600m area. The standard MS speed is 5 m/s. The simulation parameters are indexed in Table 2.

Parameters	No of Nodes	Network Size	MAC Layer	Packet Size	T_{sink}	$T_{neighbor}$
Values	200	600 X 600	CSMA+ LQF	34 Bytes	250 ms	50 ms

Table 2: Simulation Parameters

4.1 SIMULATION METRICS

Packet Loss Rate: Measures the percentage of total number of lost packets out of total number of transmitted data packets. (PLR = Lost Packets/Transmitted data packets × 100)
End-to-End Delay: This metric measurse the average time it takes to forward a data from the source to the destination. If the value is high then it means the protocol performance is not good due to the network congestion. (Average delay = $\sum (T_R - T_S)$ / Number of packets) where, T_R = Receive time, T_S = Send time.
Throughput: Measures the total data traffic in bits/sec successfully received and forwarded to the higher layer. Throughput denotes protocols successful deliveries for a time.
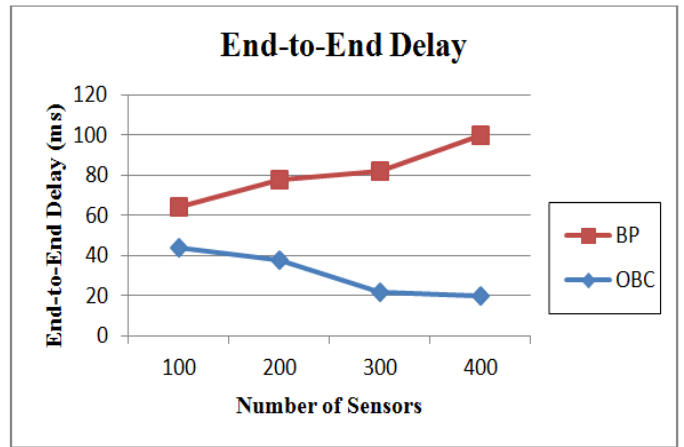

Figure 3: End-to-End Delay

The performance of Opportunistic Data Collection (OBC) is compared with the Backpressure Algorithm (BP) (Figure 3). The experiments attempt to measure E2E delay by the number of sensors. It reduces the delay of data packets that were transmitted through opportunistic multi-hop paths. OBC is found to outperform BP.
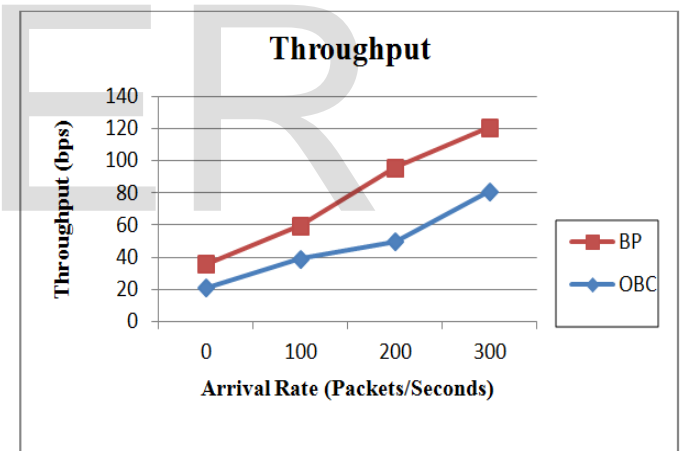

Figure 4: Throughput

In Figure 4, the X-axis denotes the arrival rate and Y-axis denotes the throughput. Throughput is equal to the aggregated arrival rate before the threshold is exceeded. It is clear that by increasing the number of flows, a higher aggregated throughput can be achieved when the arrival rate is low, since the aggregated arrival rate is proportional to the number of flows.
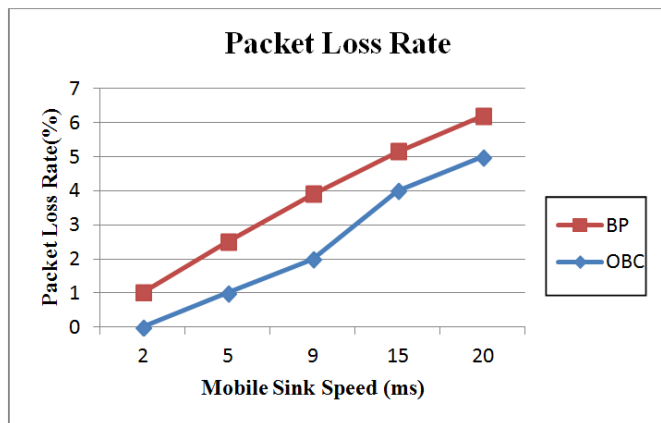
Figure 5: Packet Loss Rate

The performance of OBC against BP in terms of MS speed and packet loss rate is plotted in Figure 5. When a sensor node communicates remotely to a base-station packet loss rate seems to be exponentially high. When a sensor node transmits a data packet to a MS, distance over which packet travels reduces thereby reducing the packet loss rate. Subsequently, with the MS supported communication pattern queue length reduces. This in turn allows OBC to achieve an optimum packet loss rate.

5 CONCLUSION

The work concludes with the Opportunistic Backpressure Collection algorithm, which infers that sensor nodes with higher Link Quality have a better probability to receive more packets than those with lower Link Quality. However, data packets are continuously forwarded to sensor nodes with small CA-ETX values, which significantly moderate routing loops, resulting in much smaller E2E delay and energy costs. Furthermore, sensor nodes with small CA-ETX values have suitable data to transmit to MSs. This maximizes the utilization of its opportunistic contacts with MSs and therefore reduces the average queue length. OBC achieves approximately 60%, 60%, and 80% performance improvements in terms of E2E delay, throughput, and packet loss rate respectively. The experimental results conform to maximum data collection in WSN-MS thereby outperforming in Large Scale WSNs.

REFERENCES

[1] Shusen Yang, Usman Adeel, Yad Tahir, and Julie A. McCann, "Practical Opportunistic Data Collection in Wireless Sensor Networks with Mobile Sinks" in *IEEE Transactions on Mobile Computing*, 2016,pp.67-79.

[2] YoungSang Yun, Ye Xia, "Maximizing the Lifetime of Wireless Sensor Networks with Mobile Sink in Delay-Tolerant Applications", *IEEE Transactions on Mobile Computing*, Vol. 9, No. 9, Sep 2010.

[3] Harshavardhan Sabbineni, Krishnendu Chakrabarty, "Datacollection in Event-DrivenWireless Sensor Networks with Mobile Sinks", *International Journal of Distributed Sensor Networks*, Vol.10, No.12, Jul 2010.

[4] Long Cheng, Yimin Chen, Canfeng Chen and Jian Ma, "Query-Based Data Collection in Wireless Sensor Networks with Mobile Sinks", *NationalNatural Science Foundation of China (NSFC)*, pp.21-24, Jul 2009.

[5] 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, APR 2011.

[6] Biao Ren, Jian Ma and Canfeng Chen, "The Hybrid Mobile Wireless Sensor Networks for Data Gathering", *ACM Sensys*, pp. 3-6, Jul 2006.

[7] Sudhanshu Tyagi, Neeraj Kumar b, "A systematic review on clustering and routing techniques based upon LEACH protocol for wireless sensor networks", *Journal of Network and Computer Applications*, 2013.

[8] Michael J. Neely, Spring, "Notes on Backpressure Routing", *Stochastic Network Optimization*, 2011.

[9] Shivendra Dubey, Chetan Agrawal, "A Survey of Data Collection Techniques in Wireless Sensor Network", *International Journal of Advances in Engineering & Technology*, Sep 2013.

[10] A.Rajeswari, Dr.R.Manavalan, "Data Collection Methods in Wireless Sensor Network: A Study", *International Journal for Research in Applied Science and Engineering Technology*, Vol. 2, Sep 2014.