Abstract Reporting and Reformation Schemes for Wireless Sensor Networks

Hock Guan Goh[1,2], Soung Yue Liew[2], Kae Hsiang Kwong[1,3], Craig Michie[1], and Ivan Andonovic[1]

[1] Centre of Intelligent Dynamic Communications, Department of Electronic and Electrical Engineering, Faculty of Engineering, University of Strathclyde, Royal College Building, 204 George Street, Glasgow, G1 1XW, United Kingdom
[2] Department of Computer and Communication Technology, Faculty of Information and Communication Technology, University of Tunku Abdul Rahman, Jalan Universiti, Bandar Barat, 31900 Kampar, Perak, Malaysia
[3] MIMOS Berhad, Wireless Network and Protocol Research, Technology Park Malaysia, 57000 Bukit Jalil, Kuala Lumpur, Malaysia
{gohhg,syliew}@utar.edu.my,
{kwong,c.michie,i.andonovic}@eee.strath.ac.uk

Abstract. Energy resource constraints inherent in wireless sensor network deployments limit the amount of data that can be transported to a destination sink. An alternative strategy that could be invoked to address this issue is to only report the data sample when there is significant change in the sensed data from sensor nodes, and reconstruct the unreported data at the base station without compromising the needs of the application. It is shown that judicious reporting of data significantly reduces the number of packets that are transmitted. In this paper, a mechanism that adopts these principles, referred to as Abstract Reporting and Reformation (ARR), is proposed and demonstrated.

Keywords: Abstract Reporting and Reformation, Data Aggregation, Wireless Sensor Networks.

1 Introduction

The aggregation of physical sensing data poses significant challenges in the deployment of a Wireless Sensor Network (WSN) [1]. By its nature, a WSN comprises low cost, small form factor devices providing limited storage and processing resources and able to establish dynamic multi-hop routes. Since large scale deployments are typically battery powered, inefficient management of networked data will result in the rapid exhaust of that scant resource. Consequently the transportation of significant volumes of data is difficult, and this drives the development of efficient methods for data aggregation. Techniques such as the Tiny Aggregation (TAG) [2] and Data Aggregation and Dilution by Modulus Addressing (DADMA) [3] are used to reduce the number of packets transported through a network.

P. Sénac, M. Ott, and A. Seneviratne (Eds.): ICWCA 2011, LNICST 72, pp. 69–74, 2012.

In this paper, a mechanism that only reports the data sample when there is significant change in the sensed data from sensor nodes, and reforms the data at the destination sink is proposed and demonstrated. Such mechanism is referred to as Abstract Reporting and Reformation (ARR).

2 Data Filter and Data Recovery Schemes

In practice, configuring the sampling rate for data capture directly by the user control is non trivial. Thus to circumvent this, the approach adopted is to apply some intelligence at the sensor node that governs the reporting of a processed stream of original data without compromising the application. In this example, the amount of data to be reported is reduced by only transporting modified, abstracted samples only when the difference between the current and the previous reported data samples exceeds a pre-defined threshold. The threshold is set according to the equation below;

$$th_n = a + (n-1)s \tag{1}$$

where *a* is a value assigned based on the degree of sensor sensitivity, *s* is the sensor sensitivity value obtained from its datasheet and *n* is a variable incremented by 1 after each threshold comparison until it reaches a maximum value of 10. After a data sample is reported, *n* is reset to 0. Assume that the previous reported sample has a value of x_0 and after *i*-1 unreported sampling rounds, the current reading of the sensed data is x_i. The following algorithm is applied to determine whether or not to report this data sample;

```
increase i by 1
n ← min(i, n_max)
th_n ← a + (n - 1) × s
if |x_i - x_0| ≥ th_n, then
  report the values of i and x_i
  x_0 ← x_i
  i reset to 0
```

When the abstracted data reaches the sink, the unreported data is recovered using a simple recovery mechanism. This scheme fills the unreported data with the previous updated data until there is new reported data.

3 Results

A sensor network device, MICAz [4] with a temperature sensor was configured to sample sensor readings every second and report the sampled data to a base station at the same rate. The network was tested under three sensor data patterns designated as burst (from t = 1 to t = 200), slowly incremented and decremented (from t = 201 to t = 400) and random (from t = 401 to t = 600) (Fig. 1, Full sensor readings). Three types of ARR with threshold parameter a = 0.05, 0.1 and 0.2 were applied to full sensor readings. Since ARR only reports abstracted data, a significant reduction in the number of packets transported through the network is achieved (Fig. 1).

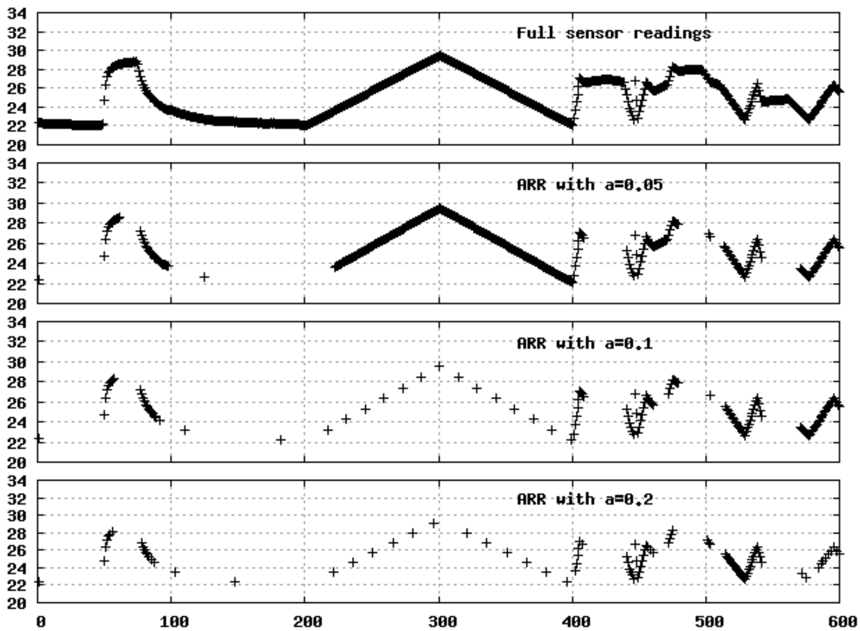

Fig. 1. Full sensor readings (1-200 burst data, 201-400 slowly incremented and decremented data, 401-600 random data), data reported using ARR with a = 0.05, data reported using ARR with a = 0.1 and data reported using ARR with a = 0.2. x-axis represents timeline and y-axis represents temperature in degree Celsius.

Fig. 2 shows the total number of transmitted packets with the assumption that one packet is required for each sensor reading. On average, ARR reduces the number of packet being transmitted by up to 50%.

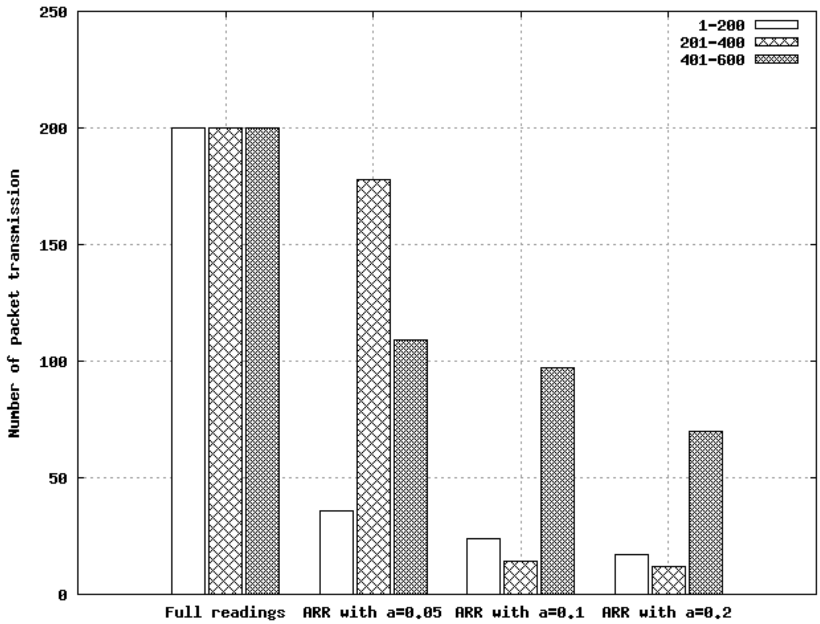

Fig. 2. Number of packets transmitted for full sensor readings and sensor data using ARR with a = 0.05, 0.1 and 0.2.

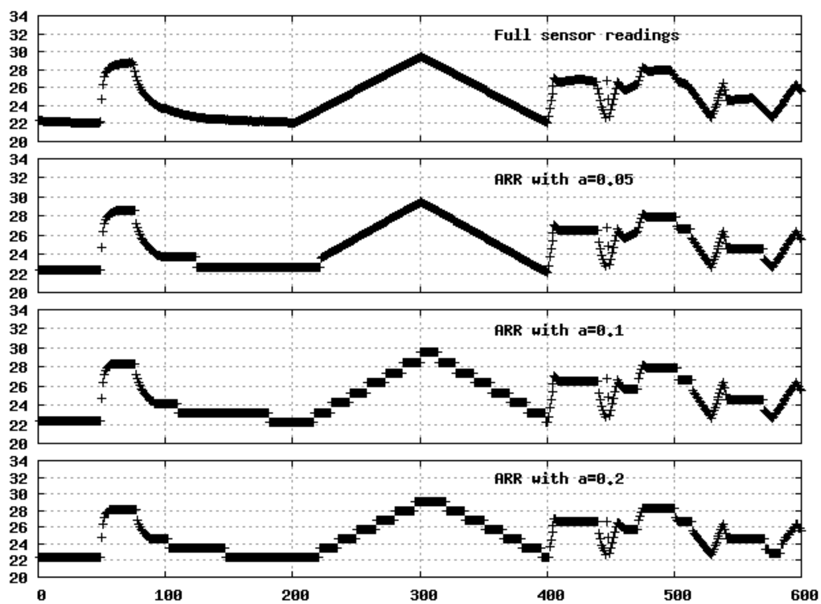

Fig. 3. Complete data after the data recovery scheme

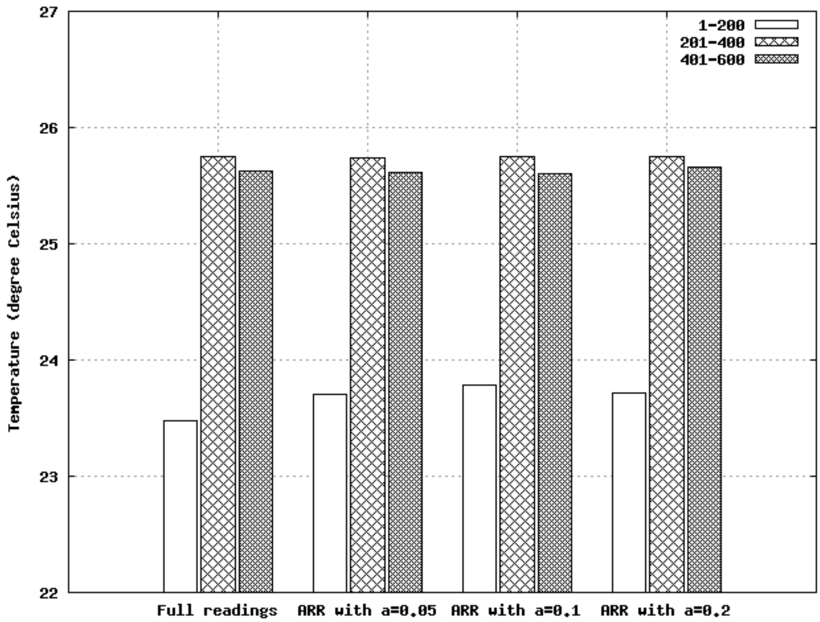

Fig. 4. Mean temperature for full sensor readings and sensor data using ARR with a = 0.05, 0.1 and 0.2

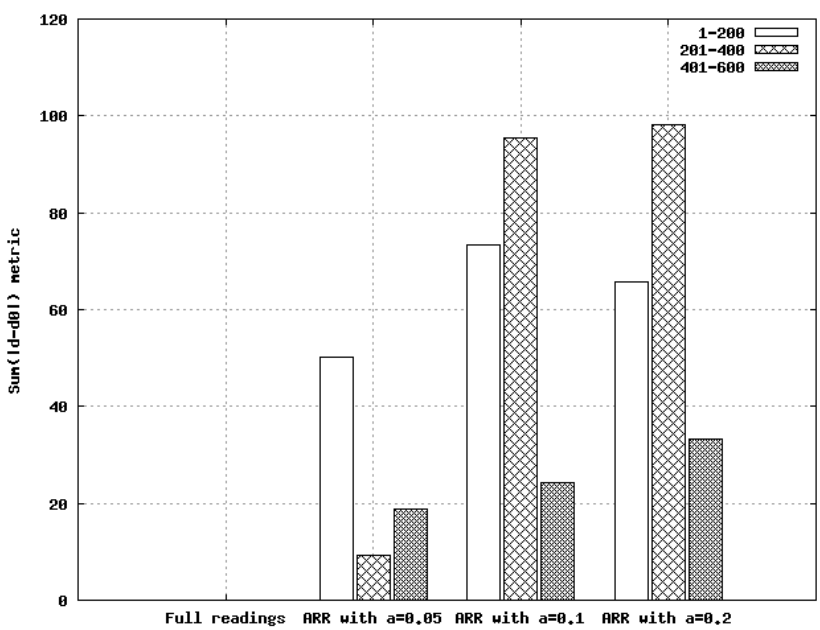

Fig. 5. The sum of differences for full sensor readings and sensor data using ARR with a = 0.05, 0.1 and 0.2.

At the sink, data were reformed using the data recovery scheme illustrated in Fig. 3. After the data is reformed, the means of the ARR recovered measurement data are less than 0.5 different compared to the means of the full sensor readings (Fig. 4).

In Fig. 5, the sum of differences for ARR recovered data and full sensor readings is on average <100. Equation 2 was used to evaluate the sum of differences where d is the recovered data and d_0 is the data originated from the full sensor readings;

$$sum\_d = \sum \left| d - d_0 \right| \tag{2}$$

4 Conclusions

Abstract reporting and reformation schemes provide an alternative solution for data aggregation in wireless sensor networks. In situations where energy is a constraint, this proposed method allows certain data to be collected and reformed. Results show that the proposed solution is able to reduce the number of packets transported through the network by 50% without appreciable loss of information. Since the power required to transmit data is by far the greatest burden on the power source, this approach can yield significant increases in the lifetime of batteries.

References

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