Efficient Data Transmission for ICT of Energy Systems

Zoya Pourmirza†
Newcastle University
Newcastle upon Tyne, UK
zoya.pourmirza@newcatle.ac.uk

Sara Walker
Newcastle University
Newcastle upon Tyne, UK
sara.walker@newcatle.ac.uk

1 Introduction

Smart energy systems are an integration of ICT and energy systems. Energy efficiency consumption has been identified as one of the major challenges for ICT of energy systems. Additionally, the exponential increase of the number of monitoring devices in the energy system will lead to an explosion in the data volume. Currently systems are not well prepared to exchange such volumes of data, and there are concerns about associated increased energy consumption of data transmission. Hence, we investigated efficient data transmission techniques and developed data compression techniques, with compression ratios of 76%-99%, to ease this limitation.

2 Efficient Data Transmission Techniques

We have classified the data transmission techniques in energy system into three categories (Figure 1). The first category is used when sensors transmit their data after receiving requests from the sink. The second category is when sensors send data indicating that a threshold condition is violated. The third category is when sensors collect data and broadcast them continuously. In this research, we have investigated the third category, because we sometimes need to monitor data collected from the grid energy system continuously without interruption. Energy efficient radio communication can be accomplished through different means, such as; duty cycling, optimizing the routing algorithm, optimizing the network topology, and in-network processing. Duty cycling can be achieved through scheduling the sleep/wakeup program of sensors. Optimizing the routing algorithm can be accomplished by developing a multi-hop routing algorithm that can identify the next optimal hop to route the message to the sink. Optimizing the network topology can be achieved through managing the communication distance. Finally, in-network processing can be classified in two classes. The first class is for data aggregation techniques implemented in conjunction with wireless sensor network (WSN) routing protocols. The second class of in-network processing methods is called data reduction, which is performed by implementing data reduction algorithms to reduce the communication cost by minimizing the size of transmitted data. The technique used in this research, to offer energy efficiency to the communication network, belongs purely to the second class of in-network processing, is the data reduction method. Data reduction itself can be classified into data aggregation, data fusion, and in-network data compression. Data aggregation is useful when the goal is to reduce the communication overhead and cost, by utilizing one of the aggregation functions such as Min, Max, Sum, and Average. Data fusion will combine various unreliable data to eliminate the related noise and produce a more accurate signal. Data compression will process raw data into a condensed structure compared to its original format.

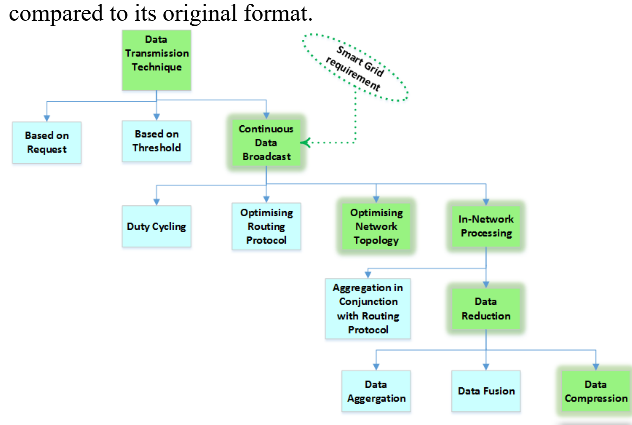

Figure 1: Efficient data transmission

3 Developed Data Compression Algorithm

A technique utilized in our research to offer communication energy efficiency for ICT of energy system is to develop a data reduction algorithm. We investigated the pattern of energy data, and then developed two novel data compression algorithms. The first algorithm, called DRACO-1, discards the redundant bits by applying XOR on each two consecutive measured values and transmits the changing bits only. The changed bits are a small portion of the binary representation which will be converted to digit-based representation before transmission. The difference between the DRACO-1 and DRACO-2 is that on the transmitter side, after applying XOR and converting the binary representation back to digit-based representation, if any consecutive values are the same, DRACO-2 will only send one instance of that value together with the number of repetitions times. Although DRACO-2 is not as stable as DRACO-1, it is very helpful in compressing high volumes of data with strong correlations (e.g. frequency and voltage) and in these cases it can perform better than DRACO-1.

4 Conclusion

The developed data compression algorithms are envisaged to provide benefits for energy systems in terms of: 1- transmission cost, we could reduce cost by reducing the number of transmitted bit, 2- communication energy efficiency, by reducing the number of transmitted bits we could reduce the energy consumption of wireless data transmission, and finally 3- data storage, we could save storage cost if we could can store smaller volumes of data.