Amplitude range data validation in Internet of Things (IoT) sensor

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Abstract. Internet of Things (IoT) has been widely used for collecting data wirelessly for many applications. Data is collected periodically through TCP/IP network to a collecting server for further usage. Data clean-up and validation are mainly performed in server to ensure valid data for processing. Since validation is performed in server, data sent by IoT node may contain error and invalid data. Since power availability in sensor is an issue, error data transmission has some disadvantages; power lost in data collection and data transmission. This paper experimentally applied a simple maximum minimum amplitude data validation to omit invalid data in sensor. The method requires small processing power and is proven to conserve 23.54% of total power.

1. Introduction

Internet of Things (IoT) enables sensors to be connected to TCP/IP network and treated as active internet users that send data periodically or sporadically. Those sensors are programmed to monitor many processes or circumstances depending upon the applications. IoT applications range from environmental, building, animal and industrial monitoring. In order to support IoT implementations, frameworks have been proposed by many researchers and vendors to enable integrated sensor services [1]. IoT framework enables collaborations of distributed sensors and collaborate intelligent system to wireless sensor [2]. It is projected that there has been more than seven trillion devices installed around the world [3].

IoT can be integrated to existing sensor networks such as radio identification network (RFID), wireless sensor networks (WSNs), supervisory control and data acquisition (SCADA) and other networks. This enables IoT to convey any device, any service, anywhere and anytime [4]. The IoT architecture includes edge sensors, network edge, and sink. Sink node may forward data to higher speed computer or cloud which requires middleware to accomplish the task [5].

Among the components, sensor edge has the lowest processing capabilities or even power availability. Some edge sensors are designed to disappear when power is drained [6]. Therefore some energy-saving and energy-harvesting method applied in edge sensors [7]. The work on energy harvesting can be seen in [8, 9], while survey on energy efficient method is found in [10, 11].

Other emerging problem is the irregularity of radio link that potentially causes disturbances and interferences to the transmitted data [12][17][18]. The quality of the transmitted data surely influences the applications [13]. Even its importance for application performances, study on this matter is still limited. On the other hand, data quality implementations are mainly performed in database level. Some issues related to data quality covers accuracy, currency, and completeness [14]. Quality guarantee is generally performed in database which is more stable and well defined. There is few work found on real-time data validation, implemented during data generations. Meanwhile, pervasive system performances depend on data acquisition and energy consumption. So this topic is still challenging.
Those energy-saving and energy-harvesting to conserve energy in edge sensor may not be optimal if sensor sends erroneous and invalid data that waste hardware resources and energy. Erroneous data can be caused by environmental disturbances, middleware imperfection as well as integrity matters [15] that reduce accuracy and reliability [19]. Some works have proposed machine learning methods to deal with the invalid data [3], although the method may be resource-absorbers for edge sensors [2]. Lower processing algorithm is exist [16] but worsen for short period data collection.

This paper proposes simple data validation based on maximum and minimum acceptable values that do not require additional processing power. Data is considered as valid if it is in the predetermined range of $X_{\text{min}}$ and $X_{\text{max}}$ as denoted by Equation 1.

$$X_n = \begin{cases} \text{Valid jika } X_{\text{min}} < X_n < X_{\text{max}} \\ \text{Invalid jika } X_n < X_{\text{min}} \text{ atau } X_n > X_{\text{max}} \end{cases}$$ [1]

2. Evaluation method
A simple IoT architecture with edge sensor made of ESP8266 module is devised to evaluate the proposed data validation. Network edge of 802.11 connects edge sensor to cloud. Cloud is located in the internet and accessible for OC to monitor. Figure 1a shows the designed system and Figure 1b shows the power consumption measurement circuit.

Since erroneous circumstances are difficult to find, random 5% error rates are simulated in sensor software to measure the effectiveness of the data validation in reducing power consumption. Voltage and current are measured for selected data sample.

3. Assessment results
Fig. 2 shows the sequence generated data that contains valid and invalid data. In order to plot invalid data, invalid data in form of non-readable data is plotted as zeros. As shown in Figure 2, zeros occurred frequently. To avoid confusion of invalid data caused by transmission interferences and sensor error, invalid data is also checked in sensor node.
Figure 2. IoT data with 5% interferences

Figure 3. Power consumption of non-validated transmission

Sensor power consumption is shown in Figure 3. Power consumption reached 3.5 mW at the most. By applying maximum minimum data validation is implemented to omit transmission of invalid data between that higher than 40°C and smaller than 10°C. As results, the transmitted data is almost homogeneity with only one data of 40°C (Figure 4a). There will be less data transmitted by edge sensor, which results lower power consumption as plotted in Figure 4b. The maximum power consumption is 3.2 mW.
(b) Validated data power consumption

Figure 4. Validated edge sensor

Average power consumption for each data transmission experiences increment about 0.05 mW (7.69%) as result of validation execution (Figure 5a). However, the total power consumption decreases more significantly about 21.9 mW or 23.54% (Figure 5b). Total power consumption occurred as results of decreasing number of transmission.

4. Conclusions

This paper has presented simple data validation technique that absorbed small amount additional power consumption in IoT edge sensor, but is able to reduce total power consumption 23.54%. This figure is significant that means almost a quarter in increasing sensor lifetime. The proposed data validation is able to omit invalid data that may add unnecessary processing time and power consumption in receiving end which is not evaluated in this paper. Both advantages denoted the importance of edge sensor data validation.

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