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A Resource-Efficient Algorithm for Processing Various Sensor Data in Internet of Things Applications

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Abstract. The Internet of Things (IoT) technology is gaining vast popularity and it is expected to become ubiquitous in the near future. It envisions the idea of a fully connected network of smart objects, enabling cooperative and intelligent distributed functionalities. In this paper the challenge of processing large amounts of sensor data at network gateways with limited memory and computing power is described. A novel algorithm to efficiently process various heterogeneous data is introduced.

Keywords: internet of things; data processing; resource efficiency

1 Introduction

Internet of Things (IoT) technology is receiving growing attention from research, industry and government organizations [1]. The IoT paradigm consists in fully connected smart objects (such as sensors, smartphones, embedded systems), providing integrated services. The number of connected smart objects is growing impressively, expecting to exceed 26 billion by 2020. Thus, smart objects will soon generate large amounts of data traffic requiring appropriate management [2].

Two main approaches exist to handle potential large amount of sensor data generated by the different smart objects. In current IoT approaches, time-series sensor data generated from smart objects are transmitted to cloud servers which process the received data and make decisions for appropriate actions. However, as more and smarter objects are developed and possibly generate data for each and every event, transmitting the entire data to outside servers may not be practical. Furthermore, some of the actions may need to be confined within the corresponding IoT environment, such as a smart home. As an alternative, various sensor data can be locally processed at the network gateways and only the relevant information for the target application is transmitted to the outside server. The latter approach mandates a fast and limited-memory processing algorithm.

Additionally, the processing at gateway level of sensor data coming from multiple sources is further challenged by the following issues: (1) resource constraints of

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gateways: As can be seen in Table 1, due to the self-organizing nature of IoT networks, gateway functionalities could be assigned to devices with very limited memory and computing power capabilities, therefore incapable of performing standard data processing; (2) heterogeneity of data types: the IoT environment relies on a vast and heterogeneous set of objects, each possibly generating different data types; (3) variability of sensor data inter-arrival times: due to the different functionalities implemented, some smart objects may generate data with regular intervals, as opposite to devices generating data on event basis.

With the objective of overcoming the above identified challenges, in this paper we propose a fast and memory-efficient algorithm for processing various heterogeneous data, indispensable for resource-constrained devices.

Table 1. Device Specification Comparison

Device	CPU	Memory	Storage
iPhone (Mobile)	1.7Ghz	2GB	32GB – 128GB
Zolertia GWZ1 (Gateway)	500Mhz	256MB	2GB (CF Card)
Netgear Router	1.0Ghz	256MB	128MB
Sensor Devices	4 - 32Mhz	4 - 16KB	16 - 128KB

2 Proposed Algorithm

We propose a novel algorithm derived from the known RETE algorithm [3], a pattern-matching solution developed for implementing production rule systems, constituting the core engine of most of the rule engine systems. Our algorithm generates a set of memory nodes, called beta nodes, interconnected as an acyclic directed graph representing higher level rule sets for handling the data from the smart objects. Each memory node is set with a fixed size, based on the maximum number of stored data calculated based on the effective alive time of each sensor data.

To test the RETE-based sensor data processing algorithm, Zolertia Z1 Sensor node and gateway devices are chosen as test devices. Fig. 1 depicts our experimental environment containing multiple sensor motes and a gateway. Each of motes will send their sensing data using UDP communication. If any motes are too far from the gateway then they will send the data to nearby mote to forward to the gateway so that data can be guaranteed to be delivered to the gateway. There are two scenarios to test performance of our algorithm, uniform interval settings for all devices and different interval settings for each device. We have tested a processing performance of various sensor data. In general, proposed algorithm showed better performance than simple if-then-else statement. With large rule set (more than 30 rules) proposed algorithm outperformed simple if-then-else. Based on the simple experiment results, number of rules affects processing performance and optimizing rule set can increase processing time significantly.

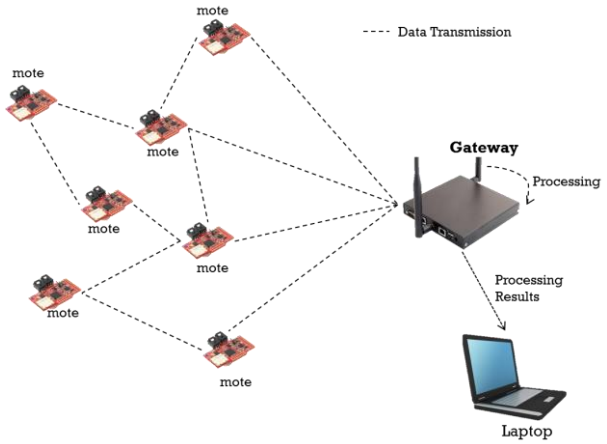

Fig. 1. Testbed for proposed algorithm

3 Future Work

In our future research, the proposed algorithm will be implemented in different IoT testbeds, consisting of resource-constrained gateways interconnected with multiple smart objects. A quantitative performance analysis of information processing for the proposed algorithm will be carried out for devices with different computational capabilities and using various synthesized and real data types.

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