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A Priority-Based Message Response Time Aware Job Scheduling Model for the Internet of Things (IoT)

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ABSTRACT

The Internet of Things is seen as the progressive version of internet involving the transmission of information between things/objects with the aim of context-aware processing. The IoT can be anything ranging from home appliances, vehicles, almost anything networked and fitted with sensors, actuators or embedded computers. The IoT aims to make the internet sensory while maintaining a minimum quality of service (QoS) guarantee. In such an environment, job scheduling becomes very important, ensuring the minimum response time for message transfer. This work proposes an SCM based scheduling model for the IoT with the aim of minimization of the response time to optimize the scheduling performance of the underlying network and minimize the execution costs. After being serviced by a given node with its queue acting as a server for the message, appropriate next node for message forwarding is selected offering the least response time until the message reaches the destination. The effect of message scheduling to account for both the prioritized and non-prioritized message delivery has been studied.

KEYWORDS

Internet of things (IoT), Service Time, Supply Chain Management (SCM), Response Time, Waiting Time, Queue Length

1. INTRODUCTION

Nowadays, there is a change in the Internet concept from a set of connected devices to be a set of connected surrounding daily life objects such as TVs, Lamps, transportations, medical devices, and sensors. The effective interaction between these heterogeneous objects through the Internet leads to the Internet of Things (IoT). Each object in IoT is called a 'thing' that should be defined using the unique address. The radio-frequency identification (RFID) is used to achieve communication between things. Furthermore, many intelligent web applications are used to manage the IoT systems. The new IoT applications depend on the promotion of wireless sensor networks (WSNs) and inspire experts and engineering equally with the potential to achieve smart proactive actions. These IoT applications contain the big amount of devices, which are connected with different requirements and technologies.

IoT can even be seen as a loosely coupled network of networks connecting things/objects surrounding us. Each constituent in IoT is called a 'thing' and should be defined using unique addressing e.g. Uniform Resource Name (URN). The radio-frequency identification (RFID) is used to achieve communication between things. IoT is different from the internet in the sense that the internet connects machines to machines or web pages to web pages. In contrast, using the internet,

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IoT can connect machines as well as anything or everything surrounding us using sensors referred to as objects. This brings into the picture the use of RFID technology either reactively or proactively. There is a definite amalgamation of distributed computing with the IoT under the cloud-based condition. Therefore, Cloud computing provides efficient resource utilization and along with IoT can allow users to scale up to solve larger science problems. The cloud-based IoT model is quite suitable for the current applications being Service Oriented. (Hwang, Dongarra, & Fox, 2012; Sundmaeker, Guillemin, Friess, & Woelfflé, 2010; Uckelmann, Harrison, & Michahelles, 2011; Jayayardhana et al., 2013; Atzori et al., 2010; Zanella, Bui, Castellani et al., 2014; Guo, Zhang, & Wang, 2011; Vermesan, Friess, & Friess, 2011; Dennis & Dominik, 2010; Rao et al., 2012)

The IoT applications generate data through sensing, collect the data for analysis and send this data to the administrator nodes or even a cloud at the backdrop for data analytics and other possible actions. The routing protocols for the same works in two ways. The first way is to improve data transmission and scalability. The second way is to minimize energy consumption. Even though it faces the challenges like the unreliability of low-power nodes, limited resources and data should be transmitted through low delay and loss rate as the minimum Quality of Service (QoS). IoT produces an enormous amount of data, but this data is collected by network nodes under different network topology. This heterogeneity restricts the TCP/IP to be the best policy demanding proper resource allocation both for computing and data routing.

Owing to the above-mentioned constraints, different people based on their perception and requirements making it an NP-Complete problem can view IoT differently. The different job scheduling methodologies reported are either heuristic or metaheuristic based. Heuristic-based methodologies are more helpful when we look for local optima while metaheuristic approaches try to explore the solution space further to attain global optima. Despite the fact that, metaheuristic approaches look very engaging, a large number of parameters to be tuned on account of IoT limits the utilization (www.airclearenergy.com, n.d.; Evans, 2011; Vermesanovidiu et al., n.d.; Aggarwal, Ashish, & Sheth, 2013; Abdullah & Yang, 2013; Sumit & Zahid, 2017).

The resource management problem can be addressed by selecting a suitable job scheduling technique for performance optimization. This should involve the resource attributes, job attributes and even dynamic network conditions for appropriate scheduling decisions considering desired QoS parameters. One such QoS parameter, the end-to-end delay, which decides the system response time for the ever-changing IoT network, needs to be minimized. This is important so that data delivery of within minimum possible time being the focus of the current work (Rao et al., 2012; Abdullah & Yang, 2013; Sumit & Zahid, 2017; Sumit & Zahid, 2017).

Supply Chain Management (SCM) is responsible for planning and execution of the objective of monitoring goods and services from one place to the other in the best possible time with the tracking information being updated at every moment. IoT, on the other hand, refers to the network of wired or wireless objects working under some control. Thus, there is a definite synergy between SCM and IoT which can be explored for designing efficient message delivery systems or data routing strategies for IoT. SCM ensures tracking and recordkeeping of the movement of goods in the chain starting from the supplier to the end retailer or customer. In IoT terms, it translates as the transfer of messages from the source node to the destination node (Cloud). SCM thus serves the purpose of efficiency improvement with timely delivery of goods and services. With these advantages, the organization (IoT world) benefits both structurally (QoS) and financially (computational cost) and that too with customer satisfaction. The movement of goods at every step is timestamped for effective monitoring and rerouting, if necessary (Tu, 2016; Machado & Shah, 2016; Tadejko, 2015; Cortes et al., 2015; Bhaskar & Lallement, 2008; Sumit & Zahid, 2018).

The proposed work presents an SCM based scheduling model with the objective of minimizing the response time of the job/message forwarding on the IoT architecture. The work proposes a greedy scheduling heuristic using the layered network approach for ensuring efficient response time or the end-to-end delays between the IoT constituents. The greedy approach used in the work ensures that