International Journal of Internet of Things 2022, 10(1): 22-31
DOI: 10.5923/j.ijit.20221001.02

A Combined Metric Objective Function for RPL Load Balancing in Internet of Things

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Abstract In an IoT-oriented intelligent world, everything around us is interconnected and integrated. The IoT ecosystem comprises a network of constrained devices called Low-Power Lossy Networks, where RPL (IPv6 Routing Protocol over Low power lossy networks) is recognized as the standard routing protocol for these networks. Though RPL projects several distinctive features, Load Balancing is identified as one of the significant inadequacies unaddressed by this protocol. In this paper, a novel Combined Metric Objective Function (COM-OF) is proposed that considers a combination of significant metrics to design a load-balanced DODAG, that distributes the traffic load equally amongst the different nodes within the network and maximizes the network lifetime. The metrics of our interest incorporates the expected lifetime of the node, the child count, the energy consumption, and link reliability for the nodes. The performance of COM-OF is compared with the standard RPL objective functions OF0 and MRHOF using the Cooja simulator of Contiki OS. The results prove that COM-OF exhibits enhanced performance than OF0 and MRHOF with 33% reduction in power consumption, 97% packet delivery ratio, up to 45% improvement in network lifetime and 36% reduction in the average number of child nodes.

Keywords Internet of Things, Load balancing, Low power Lossy Networks, Objective Function, RPL

1. Introduction

IoT envisages the idea of worldwide connectivity. Here we can connect a network of dedicated devices or objects called “things” that are entrenched with sensors, actuators, software and, electronics to the Internet so that they can gather and exchange real-world data without human intervention. Post data collection, the sensors share their data through other IoT devices or the gateway, which is later analyzed locally or in the cloud. It is anticipated that the volume of data created by IoT will reach a massive total of 79.4 zettabytes, with around 75 billion devices connected by 2025 [1]. IoT has shaped multiple opportunities to link the natural world with computer-aided systems leading to automation in numerous fields and empowering innovative applications. When combined with the latest technologies like 5G, IoT helps improve the operational efficiency of organizations with minimal cost and enhanced decision-making and user experience.

IoT typically deals with a distinct category of a network of embedded devices termed Low-power Lossy Networks (LLNs), where both the routers and interconnects are constrained [2]. The routers are constrained in resources like low memory, battery power, bandwidth, and processing power. The interconnects are constrained, providing low data rates, stability, and high loss rates. LLNs support point-to-point, point-to-multipoint, and multipoint-to-point traffic flow between thousands of nodes.

These constrained devices can be connected to the IPv6 network using the 6LoWPAN (IPv6 over Low-power Wireless Personal Area Network) standard. Here, an adaptation layer is compressed between the IP and 802.15.4 standard protocol layers in the protocol stack [3]. This adaptation layer compresses and fragments the IP protocol stack 1280 octets MTU (Maximum Transmission Unit) into packets of 127 bytes, attuned to the 802.15.4 standard. It also lets routing protocols be implemented at the network layer to provide end-to-end connectivity for various applications [4].

Routing data for these heterogeneous low power lossy networks is a unique unresolved challenge due to the intrinsic properties of IoT like inadequate resources, fluctuating link quality, and regular topological changes. Therefore, routing protocols that can acclimate to these low-power lossy links play a vital role in reliable end-to-end data delivery. Here we look for reliable routing protocols that can handle critical and massive data generated by the tremendous traffic of numerous IoT applications.

Unfortunately, with the evolution of the Internet and IoT, conventional routing protocols like OSPF, OLSR, AODV, or DSR cannot lodge in IoT, overcoming the limitations of LLNs. Therefore, IPv6 Routing Protocol for Low power and Lossy Networks (RPL) was developed as the routing protocol used in 6LoWPAN for LLNs and was standardized

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Received: Apr. 14, 2022; Accepted: May 6, 2022; Published: May 12, 2022
Published online at http://journal.sapub.org/ijit