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Analysis of Routing Protocol for Low-Power and Lossy Networks in IoT Real Time Applications

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Abstract

The wide-scaled sensing by Wireless Sensor Networks (WSN) has impacted several areas in the modern generation. It has offered the ability to measure, observe and understand the various physical factors from our environment. The rapid increase of WSN devices in an actuating-communicating network has led to the evolution of Internet of Things (IoT), where information is shared seamlessly across platforms by blending the sensors and actuators with our environment. These low cost WSN devices provide automation in medical and environmental monitoring. Evaluating the performance of these sensors using RPL enhances their use in real world applications. The realization of these RPL performances from different nodes focuses our study to utilize WSNs in our day-to-day applications. The effective sensor nodes (motes) for the appropriate environmental scenarios are analyzed, and we propose a collective view of the metrics for the same, for enhanced throughput in the given field of usage.

Keywords: RPL; Wireless Sensor Network (WSN); Internet of Things (IoT); Cooja simulator; Contiki;

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1. Introduction

Routing Protocol for Low Power and Lossy Networks (RPL) is an IPv6 routing protocol [1], which specifically for wireless networks is optimized, and designed by IETF over low power and lossy network (ROLL) [2] as a proposed standard. The motes (sensor nodes) in a WSN are capable of processing, gathering sensory information and communicating with other connected nodes in the network. For effective implementation of RPL in real time applications, the analysis of various performance metrics of the respective motes is essential.

In this paper, we have considered a Contiki test-bed to investigate the performance of IPv6 RPL. The performance metrics for two motes, Zolertia Z1 mote and WiSMote are analyzed for various environment based implementations of RPL. Zolertia Z1 mote is a low-power WSN module that serves as a general purpose development platform for WSN developers to test and deploy applications with the best trade-off between time of development and hardware flexibility [3]. WiSMote is a wireless sensor and an actuator module well adapted to WSN applications which has low consumption [4]. By simulation in Cooja (Contiki WSN simulator), we have achieved a pattern of performance metrics to analyze and differentiate the following environments, Smart building and Agriculture.

The rest of the paper is organized as follows. Section 2 deals with a Literature Review. Sections 3 and 4 showcase the Performance Analysis of metrics with the two motes, Zolertia Z1 and WiSMote, respectively. Finally, the paper is concluded in Section 5, followed by References.

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2. Literature Review

Low-Power and Lossy Networks (LLNs) comprise mainly of constrained nodes with limiting processing power and volatile energy. Traffic patterns are mostly not point-to-point, but mostly multipoint-to-point, or multipoint-to-multipoint. These lead to typically lower data rates leading to instability [5]. Contiki is an operating system which supports lossless and low-power monitoring of Internet of Things devices, and supports RPL. The topological assignment of nodes is based on multi-hop transmissions and it has been used in environment monitoring, health-care and other smart systems [6].

RPL is a dynamic routing protocol which is aimed at communication from a source node to a sink node with the increased complexity and overhead. There are several instances where a network can achieve only half of the throughput achieved than the corresponding lossless network, and hence packet retransmissions occur. Studies have shown that 50 to 80% of the energy for communication is wasted in overcoming packet collisions and environmental factors [7]. The path selection in RPL uses various factors which compute the best paths with the best routing metrics. RPL ensures advanced monitoring applications in several conditions.

The various validity threats, the internal and the external play a major role in making conclusions. The Simulation of lossy medium is emulated by using the Cooja feature Unit Disk Graph Model (UDGM). The real network of lossyness may not be accurately validated. Nevertheless, the simulation confirms the functionality and behaviour of RPL [8]. The main objective of analysis is to observe the impact of the various RPL parameters on its performance with respect to metrics like Latency, Energy Consumption, etc. These differences in behaviours are observed and they help in determining changes in factors affecting them.

3. Performance Analysis of Zolertia Z1 using RPL

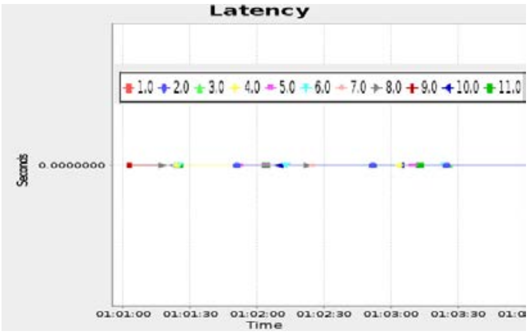


Fig. 3.1(a) - 1 sink, 10 senders (Latency)

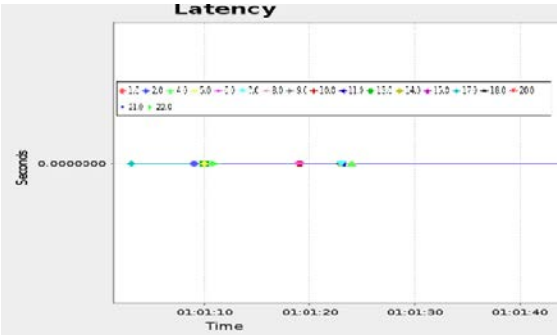
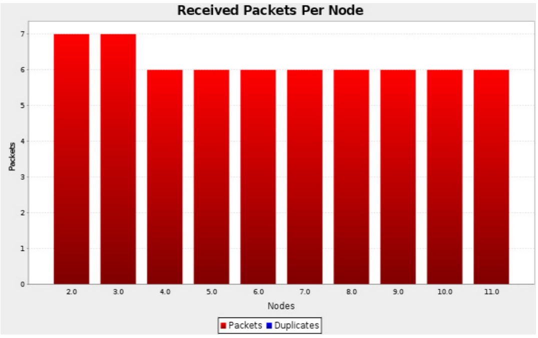


Fig. 3.1(b) - 2 sinks, 20 senders (Latency)



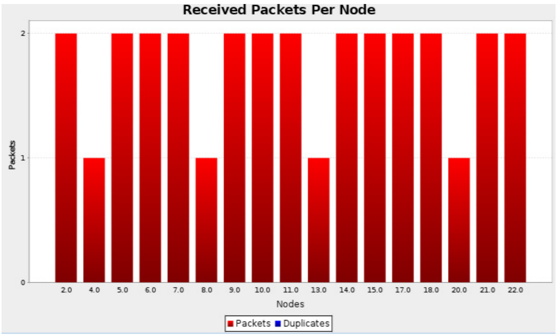


Fig. 3.2(a) - 1 sink, 10 senders (Packets per node)

Fig. 3.2(b) - 2 sinks, 20 senders (Packets per node)

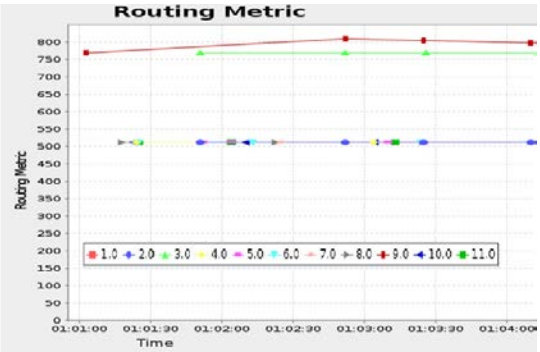


Fig. 3.3(a) - 1 sink, 10 senders (Routing Metric)

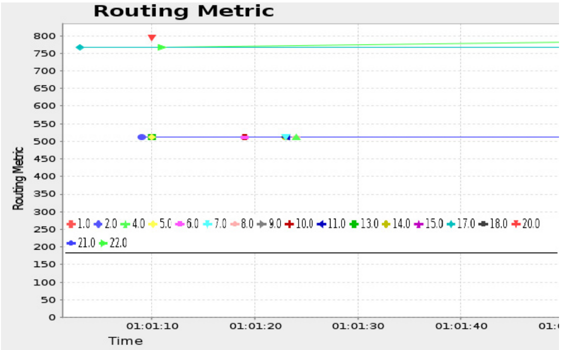


Fig. 3.3(b) - 2 sinks, 20 senders (Routing Metric)

4. Performance Analysis of WiSMote using RPL

Fig. 4.1(a) - 1 sink, 10 senders (Latency)

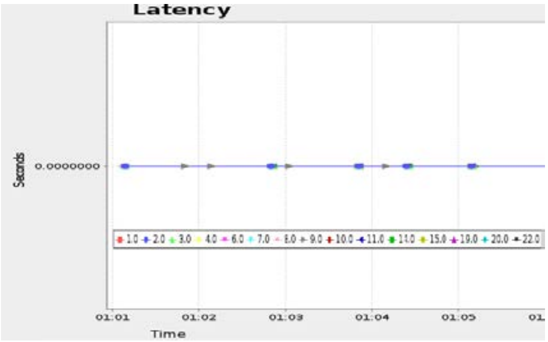


Fig. 4.1(b) - 2 sinks, 20 senders (Latency)

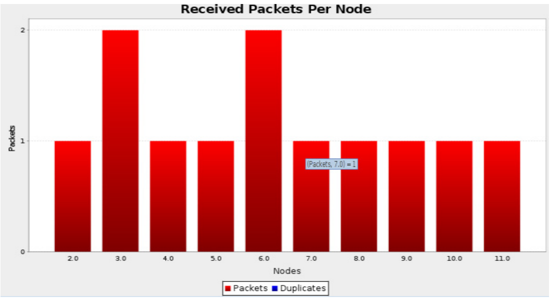


Fig. 4.2(a) - 1 sink, 10 senders (Packets per node)

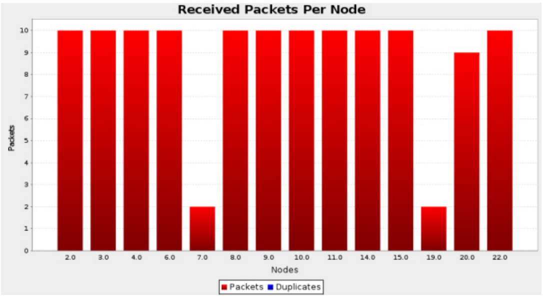


Fig. 4.2(b) - 2 sinks, 20 senders (Packets per node)

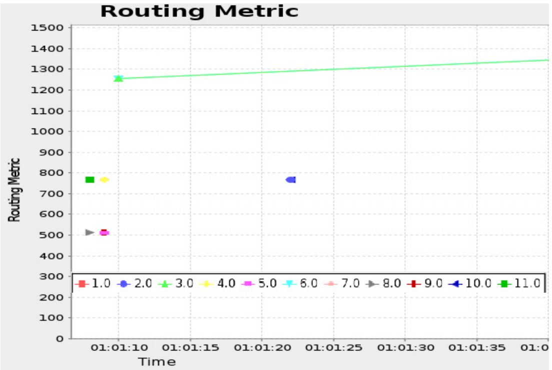


Fig. 3.3(a) - 1 sink, 10 senders (Routing Metric)

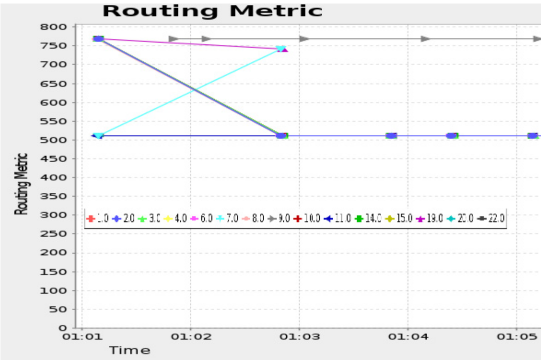


Fig. 3.3(b) - 2 sinks, 20 senders (Routing Metric)

The amount of time it takes, for a packet of data to move across a network connection (latency) has been observed for the 2 motes. Fig 3.1(a) and 3.1(b) show the latency graph for Z1 for two different scenarios (1 sink with 10 senders, and 2 sinks with 20 senders) and Fig 4.1(a) and Fig 4.1(b) show the latency graph for WiSMote for two different scenarios (1 sink with 10 senders, and 2 sinks with 20 senders), it is clearly observed that more packets are transmitted by Z1 mote than WiSMote in a particular time interval (0 - 4 sec).

Fig 3.2(a) and Fig 3.2(b) indicate the number of packets that have been received per node, it is observed that the average number of packets received per node in a 10 sender - 1 sink Zolertia Z1 scenario is 6 whereas, the average number of packets that have been received per node in 20 sender - 2 sink Z1 mote scenario is 2. The previously observed situation gets reversed in WiSMote. Fig 4.2(a) and Fig 4.2(b) show number of packets received per node in a 1 sink - 10 sender WiSMote scenario, it is observed that the average number of packets received is 1, whereas in a 2 sink - 20 sender WiSMote scenario, it is observed that the average number of packets received is 10.

The routing metric for the individual nodes of Zolertia Z1 and WiSMote have been depicted in Fig 3.3(a), Fig 3.3(b) respectively, it is observed that Z1 motes largely travel by 2 different paths which are considered to be optimal for them whereas the network traffic is directed across several paths in WiSMote.

5. Conclusion

The increase in number of devices with communicating–actuating capabilities is popularising Internet of Things (IoT) where blending of sensing and actuation functions takes place in the background and opens up a wide range of possibility for WSN based real-time application. Using RPL for analysis of WSN can enhance their functionality. This paper presents an overview of analysis of sensors using RPL where Zolertia Z1 and WiSMote were considered. The performance of each node of Zolertia Z1 and WiSMote in terms of Latency, Received packets per node, Routing metric has been investigated in detail using RPL. In our future works, we have planned to investigate in detail other network factors such as ETX, Beacon interval and Network hops. Zolertia Z1 is hence more suitable for Agriculture (larger field area), while WiSMote is more suitable for Smart Building (relatively smaller area).

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