Low Power RPL for Internet of Things (IoT)

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***Abstract*— Internet of Things (IoT) has the potential to improve the way we interact with things. IoT envisions the idea of universal connectivity of everything which is defined as the global network of uniquely identifiable and addressable smart things posing the capability to interact and communicate with other smart things. Every smart object consists of a microprocessor, transceiver module, a sensor and power source. Most of the times these systems have to deal with low power and lossy networks (LLNs), where nodes have limited memory, processing capability and power. However, stringent Quality of Service (QoS) is mandatory which is challenging to provide as the sensors are interconnected using lossy links. A routing protocol is needed as these devices can be scattered in an unplanned manner. For the unanticipated characteristics of LLNs, Internet Engineering Task Force (IETF) developed and standardized the Routing Protocol for LLNs (RPL) which is an IPv6 based routing protocol. RPL builds a tree-like topology which is based on few network metric optimization process using different Objective Functions (OF) to fulfill desired routing process. Our aim is to develop a new OF using the combination of Expected Transmission (ETX) and Received Signal Strength Indicator (RSSI) values to select best parent as well as routing path and to perform Transmission Power Control (TCP) to send packets to that parent.**

Keywords—RPL; OF; LLN; RSSI; ETX;

I. INTRODUCTION

A routing protocol makes the decision about how to forward packets to other nodes. There are two types of routing protocols which are known as Reactive and Proactive routing protocol. The reactive protocols provide routes whenever required. These types of protocols transmit control messages when needed by the path of data transfer. However, this increases the time required for finding the routes. On the other hand, the proactive routing protocols periodically exchange control messages to find and propagate the routes in the network as soon as they start. Nodes send both local control messages and messages across the entire network to get local neighborhoods' information and to share the topology related information among all the nodes in the network.

RPL is a proactive routing protocol which starts finding the routes as soon as the RPL network is initialized. [1]. RPL creates a tree-like topology with leaves at the edges and a root at the top. Unlike the tree topology, RPL offers extra links which is an important requirement in LLN [2].

For implementing RPL in practice, it is needed to specify the target application. To accomplish that target application, requirements have to be defined. Finally, the objective function should be designed based on the application specific requirements. Since our plan is to implement the proposed system in IoT-based applications, the main concern here should be power consumption. We have to design an OF which enables the network to be efficient regarding power consumption.

The objective function is a function of link metrics/node metrics which assigns a cost to each path. Link metric contains the information about the link connecting two nodes whereas node metric represents the attribute of a node. According to RFC6551, RPL routing only considers either reliability or energy consumption [3]. Most existing implementations of RPL use hop-count and ETX based OF. The hope-count based OF uses the node's attribute for routing where the OF selects parents and paths only based on the hop-count property of the node without considering the link quality. When OF utilizes the ETX metric, nodes are ranked based on their link quality towards the root [3]. The problem with hop-count based OF is it does not consider low power and lossy properties of the network. On the hand, ETX considers only link loss regardless of considering the transmission power needed to reduce loss level [4].

II. RELATED WORK

Alvi et al. proposed an enhanced version of RPL where main priority was to minimize carbon footprint emission and energy consumption while maintaining required QoS [5].

Marques et al. proposed an application-driven extension to RPL in [6] that allows the nodes to select parents with respect to the applications which helps to reduce the network energy consumption as it restricts radio communication activities.

In [7] Elnaz Rezaei proposed an adaptive transmission power control that minimizes the expected energy cost of transmitting packets. Here Received Signal Strength Indication (RSSI) is used to get the potential parent set of three. Nodes probe the potential parent set to determine best transmission power and best parent. In this algorithm, probing is done for all three members of potential parent set which can cause larger network convergence time.

In [8], Zhao et al. proposed an energy efficient region based routing protocol called ER-RPL. Unlike conventional RPL, this technique ensures both energy efficient packet delivery and reliability. Their work is simulation based and the quality of nodes such as battery life is not considered.

Load balancing and congestion problem of RPL is investigated in [9]. This article presents a simple and effective Queue Utilization based RPL (QU-RPL) which improves load balancing and packet delivery performance. QU_RPL is designed for each node to select its parent node considering the queue utilization of its neighbor nodes as well as their hop distances to an LLN border router. However, energy-efficient routing is not considered here.

III. PROJECT DESIGN

In our algorithm, we will use ETX values to get the preferred parent set of three. Among these three, the best parent will be chosen based on ETX and RSSI. The system will first pick a parent for which ETX is the least, and it will check whether it's RSSI is above the threshold or not. If the RSSI is above the threshold our task will be choosing the power of transmission by using transmission power control (TPC) algorithm of [6] for transmitting packet to that parent. If RSSI value drops below the threshold the whole process will be repeated excluding that particular parent. After that, our goal is to design a feedback system for the battery of each node which can inform the network when its power is bellow the threshold.

We will perform simulations on Cooja (emulator) at first. After getting convincing output, we will implement the proposed system in an IoT platform using Z1 modules.

Primary results:

Some simulations were done on Cooja for Z1 mote using ETX and hop-count based Objective Function (OF). Fig. 1 shows the network window of Cooja where one UDP-sink (User Datagram Protocol-sink) (green) and ten senders (orange) were used. Fig. 2 and 3 tells us about the power consumption details of each sender node for Hop-count and ETX based OF.

The average radio transmission and listen power for hop-count based OF are 0.166 mW and 0.315 mW respectively. On the other hand, radio transmission and listen power for ETX based OF are 0.208 mW and 0.357 mW.

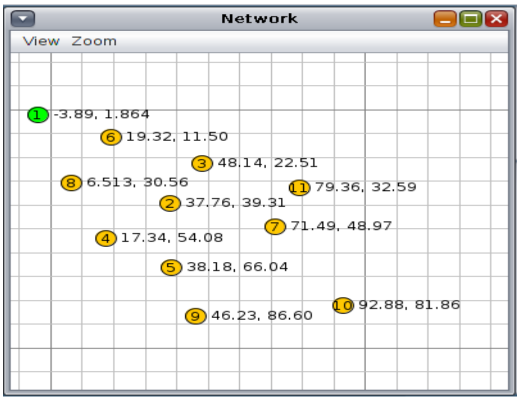

Fig. 1. Network window of the emulator Cooja for udp-sink (green) and udp-sender (yellow) nodes.

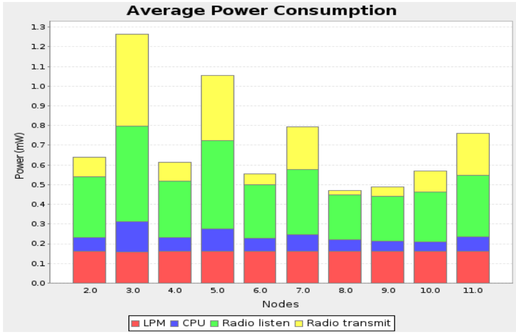

Fig. 2: Average power consumption for all the nodes of the network of Fig. 1 (Hop-count)

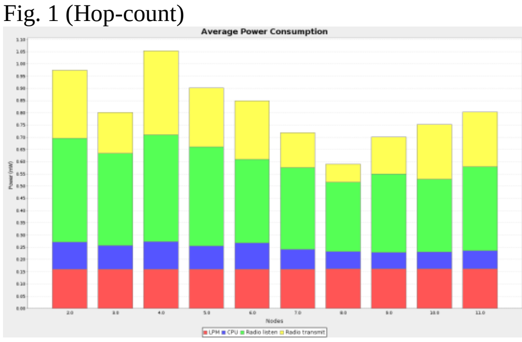

Fig. 3: Average power consumption for all the nodes of the network of Fig. 1 (ETX)

IV. CONCLUSION

Our expectation is to obtain an energy efficient system for IoT. Here nodes will consume lesser power which ensures the longevity of the network. Furthermore, the new OF will make sure higher throughput of the network. However, for our proposed OF, network convergence time can be more compared to normal ETX based network.

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