# Routing in Intermittently Powered IoT Networks

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***Abstract*—Internet of Things (IoT) applications have evolved rapidly in the past few years with applications in various domains such as smart cities. Energy harvesting techniques help to extend the lifetime of these devices. These devices can only work intermittently during power cycles when energy is available, but this is not taken into account by routing protocols. This paper evaluates the standard routing protocol RPL in an intermittent energy harvesting scenario for an IoT network and concludes that RPL is unsuitable due to the large number of lost packets caused by the unavailability of the intermittent node.**

***Index Terms*—IoT, Energy, Intermittent, Routing, RPL**

## I. Introduction

Energy has become one of the most significant challenges in IoT networks, because of its direct impact on the lifetime of such networks [1]. Since IoT devices are mostly battery-powered, the network lifetime is limited as a result of the constrained battery energy. Additionally, batteries pose a threat to the sustainability of IoT devices due to their high cost and associated environmental hazards [2]. Energy harvesting techniques have been studied as a potential alternative due to their low maintenance requirements, ability to operate under challenging conditions, and ability to eliminate the need for energy storage in non-conventional ways [3].

There are different ways to handle the dynamics of ambient energy harvesting. Energy neutral operation uses energy storage and duty cycling to regulate ambient energy harvesting dynamics, while intermittent computing accepts frequent and unpredictable power interruptions. The primary advantage of intermittent operation is that it reduces costs and, with minimal environmental impact, can provide maintenance-free operation and a theoretically limitless lifespan [4].

Routing in IoT networks is one of the research challenges that require additional study because the majority of the currently used routing algorithms mostly assume continuous energy; therefore, it is necessary to develop techniques that account for the unpredictability and scarcity of environmental energy. This paper explores and evaluates the packet delivery of the standard RPL protocol for intermittent IoT networks to address the challenges of communication over multihop intermittent networks.

## II. Methodology and Simulation Setup

The Omnet++ v5.6 was used to simulate the suitability of RPL for networked intermittent devices. Nodes are modeled to simulate harvesting solar energy charging a small capacitor (except the sink node which operates with unlimited energy). All nodes transmit packets to the sink. The network consists of 5×5 grid of intermittent nodes and a Sink node in the center, within four hops. Where the majority of the nodes exist in the middle ( Second and third hop). Each node is set to a random packet generation interval between 30 to 50 seconds, with a random initial capacity of the stored energy in order to creat a more realistic scenario. Different levels of energy harvesting are tested between 0.05 to 3 mW which is the approximate harvest energy in an indoor office with a small solar panel.

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## III. Results and Conclusions

The results in Fig.1 indicate that higher harvesting rates increase the number of successfully received packets. However, the intermittency of the nodes causes the unavailability of the parents which leads to an increase in the number of lost packets because of the re-transmissions.

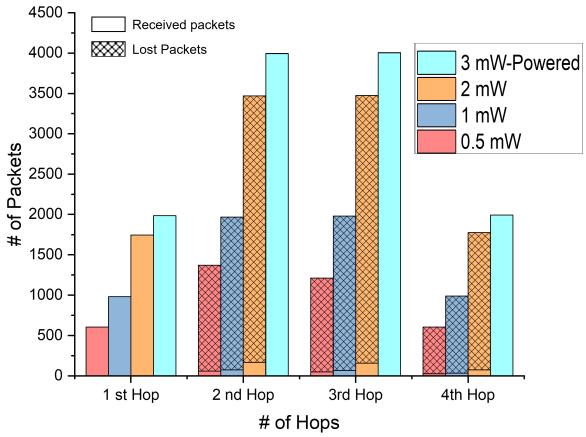


Fig. 1. Successfully received packet and Lost packets of RPL protocol for each number of hops in different power of energy harvesting rate

This paper examined the impact of the RPL protocol on intermittent multihop networks and concludes that intermittent devices perform poorly with RPL. Future research will focus on enhancing routing protocols in intermittent IoT networks.

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