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# Experimental Performance Evaluation of RPL Protocol for IPv6 Sensor Networks

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## ABSTRACT

In this article, the authors propose a new approach to meet various QoS requirements from different kinds of traffic; thus, maximizing network utilization, while improving its performance. The authors design an objective function based on ant colony optimization (ACO). The authors use the delay, energy, packet loss, and memory as the routing metric of the nodes in the preferred parent selection process for the RPL protocol to build the DODAG structure. After, the authors implement it in an experimental testbed deployed in real scenarios, and then the authors compare the results with RPL based on ETX.

## KEYWORDS

IoT, LLNs, Performance Evaluation, QoS, RPL Routing Protocols, Test Beds

## 1. INTRODUCTION

Low power and Lossy Networks (LLNs) are networks of embedded devices, such as sensors, that have limited power, memory, and processing capability (Hatem, Safa, & El-Hajj, 2017). These low-cost devices are often battery operated and can only handle limited amounts of data. Due to the embedded nature of these devices, they are subjected to a high variance of environmental factors, interference, and noise. Network protocols must be designed to operate effectively in what is referred to as a "lossy" environment where transmitted messages are often lost (Maria, 2010). The growing importance of LLN becomes apparent when you look at how LLN networks will be used. Applications include the Internet of Things (IoT), Machine to Machine (M2M) communications, and Smart City (Adjih, Baccelli, Fleury & al., 2015). In other words, the number of devices that connect these networks will be in the tens of billions. Using IP as the core network protocol for LLN has distinct benefits (Afanasyev, O'Rourke, Hu & Kusy, 2010). Most important is that it enables these devices to connect to the Internet. LLNs are underpinning the evolution to the Internet of Things. Many applications require the sensor network paradigm to be rethought in view of the need for mechanisms to deliver content with a certain level of quality of service (QoS). Since the need to minimize the energy consumption has driven most of the research in sensor networks so far, there is a need to create mechanisms to efficiently deliver application-level QoS, and to map these requirements to network-layer metrics such as latency or delay. The ROLL working group has proposed several drafts tightening the design of the RPL protocol. However, there are still several issues that are left open for further investigation.

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Although RPL is still in its early days, several research works have tackled some of these open issues. We propose a new approach to meet various QoS requirements from different kinds of traffic, thus maximizing network utilization, while improving its performance. The remainder of this paper is organized as follows: In section II, the RPL specification is introduced, including related message format and main operations. Section III presents the design of the proposed objective function. Section IV presents experimental evaluation of the proposed approach and then we compare the results of experiments performed with the RPL based on ETX. Finally, it ends with a conclusion and future work.

## 2. RPL SPECIFICATION

RPL is a distance vector routing protocol for the LLNs which describes a method of construction of a logical topology called DODAG (Destination Oriented Directed Acyclic Graph) (Mardini, Ebrahim & Al-Rudaini, 2017) which use an objective function and a set of metrics and constraints seen Figure 1. The objective function is based on a combination of metrics and constraints to calculate the "better acceptable path" (Zhao, Kumar, Chong, & Rongxing, 2017). The RPL messages generation is based on a timer. Additionally, nodes

**Figure 1. Creation of Upward Routes in RPL. (a) Step 1: Initial DIO Propagation, (b) Step 2: Route Establishment & DIO Propagation, (c) Step 3: Route Establishment & DIO Propagation, (d) Step 4: Resulting DODAG.**