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Survey on RPL enhancements: a focus on topology, security and mobility

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Abstract

A few years ago, the IPv6 Routing Protocol for Low-power and Lossy Networks (RPL) was proposed by IETF as the routing standard designed for classes of networks in which both nodes and their interconnects are constrained. Since then, great attention has been paid by the scientific and industrial communities for the protocol evaluation and improvement. Indeed, depending on applications scenarios, constraints related to the target environments or other requirements, many adaptations and improvements can be made. So, since the initial release of the standard, several implementations were proposed, some targeting specific optimization goals whereas others would optimize several criteria while building the routing topology. They include, but are not limited to, extending the network lifetime, maximizing throughput at the sink node, avoiding the less secured nodes, considering nodes or sink mobility. Sometimes, to consider the Quality of Service (QoS), it is necessary to consider several of those criteria at the same time. This paper reviews recent works on RPL and highlights major contributions to its improvement, especially those related to topology optimization, security and mobility. We aim to provide an insight into relevant efforts around the protocol, draw some lessons and give useful guidelines for future developments.

Keywords: RPL, Low-power and Lossy Networks, topology optimization, mobility, security, Routing Protocol, Internet of Things

1. Introduction

Low-power and Lossy Networks (LLNs) are classes of networks where nodes are largely resources constrained. They have limited processing power, work with a scarce memory and mainly operate on batteries or rely on an energy scavenging unit. Those nodes are interconnected by lossy links that support only low data rates and their state is usually unstable with low packet delivery rates. An LLN supports a wide range of application domains. Those include home (e.g. lighting, remote video surveillance, window shades, alarm systems, healthcare appliances) and building automation (e.g. HVAC [1] systems, fire, physical security devices, lift control) scenarios. Sensors and actuators are remotely monitored and controlled to provide a safe and comfortable environment [1]. The use of these networks with nodes placed outdoor in an urban environment is widespread. For instance, their application in smart cities allows them to measure and report data related to meteorology (temperature, humidity, pressure, UV index, wind direction and strength) or pollution, and manage urban devices such as street or traffic lights. Also, in smart grids they enable the remote monitoring of electric, gas and water smart meters through a city-wide distributed network [2]. This allows to the identification of peak loads and match energy production to household demands in smart grids systems [3]. In the industrial field, LLNs enable users to increase the amount of information collected and the number of control endpoints (fuses, pumps, luminaries, HVAC status) that can be remotely managed. As a result, they improve the productivity and the safety of plants while increasing the efficiency of the workers.

These networks are primarily part of the Internet of Things (IoT) paradigm [4]. In the latter, various physical entities are connected to the virtual world and receive their orders from the Internet [5]. Use cases related to urban, industrial, home and building automation applications mentioned above, have specific requirements formally expressed in Internet standard documents [6–9]. These requirements are different from those of traditional wired or wireless ad hoc networks. They concern, but are not limited to traffic flow characterization, scalability, latency, network dynamicity, manageability, stability, convergence time and support to mobility.

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