e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
( Peer-Reviewed, Open Access, Fully Refereed International Journal )
Volume:05/Issue:01/January-2023 Impact Factor- 6.752 www.irjmets.com

# RPL PROTOCOL INFLUENCE IN IOT APPLICATIONS

**Poorana Senthilkumar S[*1], B. Subramani[*2]**

[*1]Assistant Professor, Computer Applications, Dr. N.G.P. Arts And Science College, And Research Scholar, Computer Science, SNMV College Of Arts And Science, Coimbatore, Tamil Nadu, India.

[*2]Research Supervisor, Principal, SNMV College Of Arts And Science, Coimbatore, Tamil Nadu, India.

DOI : https://www.doi.org/10.56726/IRJMETS32931

## ABSTRACT

The Real-time things and an Internet connection have proved to be an interesting paradigm that aims to solve countless applications problem in the last two decades. The Internet of Things (IoT) describes physical things that are connected to the Internet technology, next-generation applications in humans' daily life. The IoT applications are not single components; it contains several low-power sensors, actuators, and constrained resources. In 2012, the Internet Engineering Task Force (IETF) standardized RPL as the routing protocol for Low-Power and Lossy Networks (LLNs). The routing protocols are considered the pivotal requirements in the Wire Less Sensor Network (WSN). In the view of the IoT network configuration, routing is highly related to network performance. In addition to that, we are focusing on IoT applications, LLN Border Router (LBR) connection building with RPL protocol.

**Keywords:** IoT, LBR, RPL, DODAG, Traffic.

## I. INTRODUCTION

The Internet technology application has rapidly growing in last two digital eras and introducing uncountable applications in all the real-time fields. During this digital era many Internet based devices, services and protocols were founded and standardized. This new generation world-wide network and a large number of "things" pursue connect together. These things are includes sensors, radio frequency identification (RFID) tags, near devices or gadgets communications in the field of industry, transport, education, agriculture, healthcare, etc. The Wireless Sensor Networks(WSN) are part of the creation and growth of the IoT, these sensors are low-powered end devices with constrained resources to connect to the Internet. Developing these low-powered devices is a key part of the Internet applications, the IETF Working Group (WG) of Routing Over Low Power and Lossy Networks (ROLL) developed the IPv6 low-power wireless personal area network (6LoWPAN) standardized a routing protocol and named as Routing Protocol for Low –power and Lossy Networks (RPL)[1].

To implement the sensor node access into the Internet, uses the adaption layer that allows for Internet Protocol(IP) stack implementation for accessing the other devices in the network. The countless applications end-to-end connectivity is enabled in adaptation layer to implement routing protocol in the network layer. The RPL protocol was especially designed for LLNs to accomplishing IoT applications requirements with constrained resources and standardized it in RFC6550[2] .

The rest of the sections are organized as follows: section II, Provides an RPL protocol overview and Section III types of RPL traffic patterns. Section IV explains LLN Border Router (LBR), and discussed about IoT Applications in section V and section VI provided the conclusion of this article.

## II. RPL PROTOCOL OVERVIEW

The RPL protocol is a distance vector protocol designed for low-power devices, the 6LoWPAN adaption layer supports on the IEEE 802.15.4 standard. The ROLL-WG standardization is taking into account constrained resources in LLNs in the terms of energy, computation, memory and reliability[3]. In many cases the LLNs are does not have predefined network topologies, the RPL constructs network topology routes are optimized for traffic to or from one or more than one roots and that roots are act as sink(s) in the network topology. RPL forms loop free topology by using of Directed Acyclic Graph (DAG) and the topology partitioned one or more than Destination Oriented DAG(s) (DODAG). The following section describes list of elements are used for DAG formation in RPL.

**RPL Identifiers**

The following values are used by RPL for identify and maintain the topology:

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
( Peer-Reviewed, Open Access, Fully Refereed International Journal )
Volume:05/Issue:01/January-2023 Impact Factor- 6.752 www.irjmets.com

RPLInstanceID: RPL Instance is One or set of DODAGs, which are identified by RPLLInstanceID, single network have number of RPLInstanceIDs.

DODAGID: The combination of RPLInstanceID and DODAGID is a unique value are used to identify a particular DODAG in the RPL instance, moreover, RPL Instance have one or more DODAGs.

DODAGVersionNumber: In repair or reconstruction process in a DODAG root the version number is incrementing DODAGVersionNumber then combining with RPLInstanceID and DODAGID to identify the DODAG version.

Rank : The Rank is related to DODAG version and it defines the individual node rank to the DODAG root.

**RPL Instance**

The LLNs contains single or multiple RPL Instances and logically independent, act as a router in some applications. One or more DODAG roots are formed in a RPL Instance, provide paths to particular destination node via the DODAG roots or alternative route within a DODAG. The DODAG roots are operates independently or coordinate entire network.

In application scenario the RPL Instance are performs the following any one of the combinations:

(i) Single DODAG-single root: In this model a RPL Instance contains centralized single root in a DODAG for minimize latency applications for example, Home Automated applications

(ii) N DODAG(s) – N root(s) : In this model a RPL Instance has number of DODAG(s) with independent roots the each DODAG conations unique DODAGID for example, urban multiple data collection points application

(iii) Single DODAG – Virtual root : In this model DODAG roots capable of acting as logical interface to the sink of a single DODAG and coordinates LLN sinks with single DODAGID. The IPv6 Low-Power Wireless Personal Area Network (6LoWPAN) applications are supports this types for reliable communication.

(iv) Combination: Some kind of real time applications are suited to combination of the above three models for reliable network operation.

The following Figure 1. Presents a RPL Instance consist of three DODAGs with three DODAG roots. These DODAG roots uses a same RPL InstanceID.

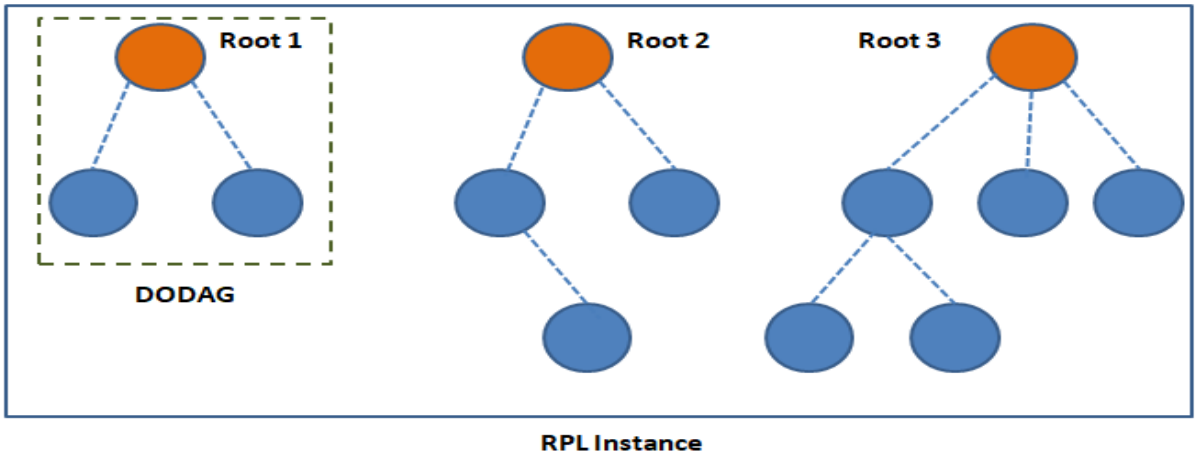



**Figure 1.** RPL Instance

The DODAG topology change or maintenance illustrated in Figure 2. The DODAG Version Number increment bring into new DODAG version from the existing DODAG and topology formed with new DODAG Version Number.

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
( Peer-Reviewed, Open Access, Fully Refereed International Journal )
Volume:05/Issue:01/January-2023 Impact Factor- 6.752 www.irjmets.com

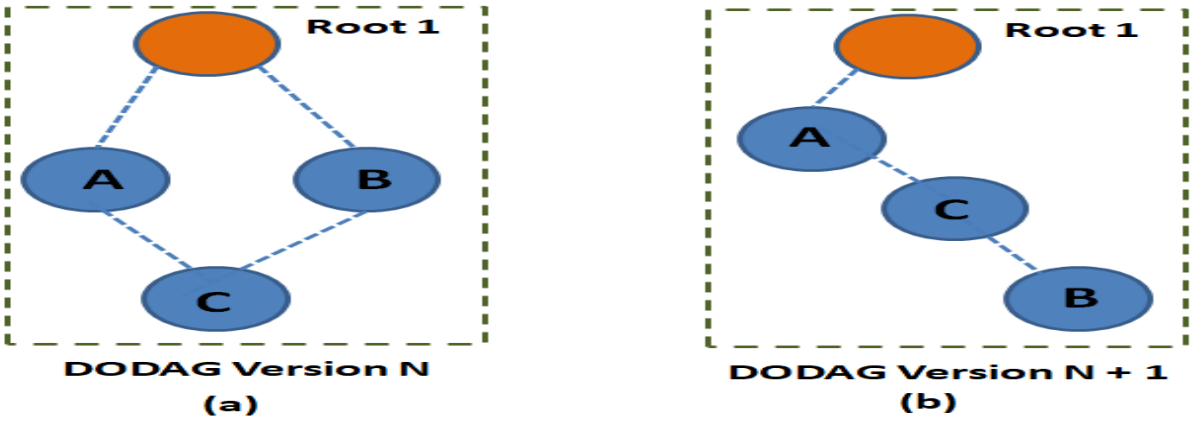



**Figure 2.** DODAG Version

RPL Instance formation and reconstructed the existing topology into new one with incrementing the DODAG version number.

**Control Message**

A high-level overview of construct the DODAG, the RPL uses a new Internet Control Message Protocol Version 6 (ICMPv6) with type of 155. These control messages are identified by the code filed. If node receives unknown code field, the message discards from the current process.

The RPL control messages consist of two components, among the three first one is ICMPv6 header, it takes three fields (i) type (ii) Code and (iii) checksum, the second component is base that includes the message content and options. The control packets are identified by type and code fields. The figure 3. represents the RPL message components of bit code, message type and messages are predominantly used in RPL protocol and control message code on respective types.

**DODAG Information Solicitation (DIS)** : The DIS message used to obtain a DODAG Information Object (DIO) on the RPL Instance for neighbor discovery. The DIS messages are multicast, these messages are solicited to neighbor nodes to create the new DODAG or join the existing one. This Router Solicitation is followed by IPv6 neighbor discovery specification.

**DODAG Information Object (DIO):** The DIO messages hold the relevant information regarding the node to obtain the rank and allow discovering the RPL Instance. Responsibility for selecting the parent node and identify the path to the sink node. The DIO messages are broadcast periodically across the RPL Instance to maintain the DODAG.

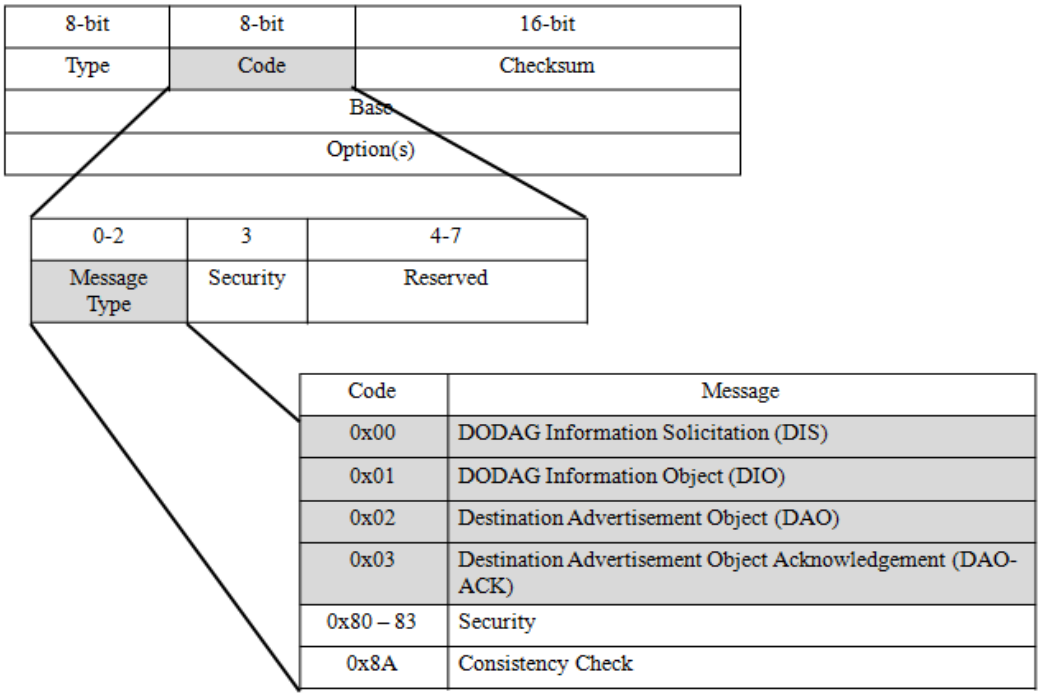
**Destination Advertisement Object (DAO):** The message of DAO is utilized to propagate and deliver reversed route data from the destination upward along the DODAG. The DAO message is unicast by the present or child node to the selected parent. After completing the DAO message process route will be established from the child node to the DODAG root.

**Destination Advertisement Object Acknowledgement (DAO-ACK) :** The DAO-ACK is sent by DAO received parent or DODAG root. This unicast message is a reply received by the DAO sender node, which ensures the completion status. If the status value of 0 indicates acceptance, the remaining values as rejected and alternative parent selection will be chosen.

## III. RPL TRAFFIC FLOW

The terms of traffic flow defines the amount of packets moving across a LLNs network, in this case, the RPL admits three types that types are discussed in this section. Multipoint–to-Point (MP2P) Traffic: The child nodes send data packets to the root by upward flow. The flow of MP2P are providing connectivity to the LLN Border Router (LBR).or private Internet Protocol(IP) network.

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
( Peer-Reviewed, Open Access, Fully Refereed International Journal )
Volume:05/Issue:01/January-2023 Impact Factor- 6.752 www.irjmets.com




| Code | Message |
|---|---|
| 0x00 | DODAG Information Solicitation (DIS) |
| 0x01 | DODAG Information Object (DIO) |
| 0x02 | Destination Advertisement Object (DAO) |
| 0x03 | Destination Advertisement Object Acknowledgement (DAO-ACK) |
| 0x80 – 83 | Security |
| 0x8A | Consistency Check |

**Figure 3.** Control Message components

The destinations will be reached by DODAG roots. Point-to-Multipoint (P2MP) Traffic: In this multicast flow, the parent or root sends data packets to other nodes. The provision of advertisement follows down routes to the destination. On the topology changes upward and downward flow will be required for non-root nodes of a DODAG. The destination advertisement will be updated in the routing table.

Point-to-Point (P2P) Traffic: The P2P is one-to-one communication that supports upward and downward flows, the source node sends forward the messages through non-root nodes until reaching the destination. This traffic pattern is mostly used in constrained applications where the nodes are working under a nonessential of the stored route [4].

## IV. LLN BORDER ROUTER (LBR)

The Internet of Things (IoT) defines a set of real-time objects that are connected to the Internet and accessed the objects anywhere at any any-time. In this scenario, the RPL protocol intends is to connect to the Internet by using IPv6. The RPL DODAG nodes communicate with the Internet through a Border Router and this is a central point in the network [5]. Multiple IoT application services for various purposes real-time network there are thousands of LLN nodes are required to connect to the Internet. The LBR behaves as an interface from RPL Instance to private Wide Area Network (WAN) or the public Internet[6]. Figure 4, depicted the connection process to Internet service by LBR, the prominent choice of data center point and security service.

LBR supports bi-directional communication, formerly the nodes select routes toward an LBR, and RPL nodes form the DODAG under the RPL Instance. LBR depends on two types mode-of-operation (MOP) for routing either ‘storing mode’ (table-driven routing) or ‘non-storing mode’ (source routing). In storing-mode, all node stores the routing information for all successor nodes in its sub-tree. If the MOP is in non-storing-mode, only the DODAG root node stores that information for all nodes in its network. In this case, the basic idea is for the root node or LBR to process and store the information[7].

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
( Peer-Reviewed, Open Access, Fully Refereed International Journal )
Volume:05/Issue:01/January-2023 Impact Factor- 6.752 www.irjmets.com

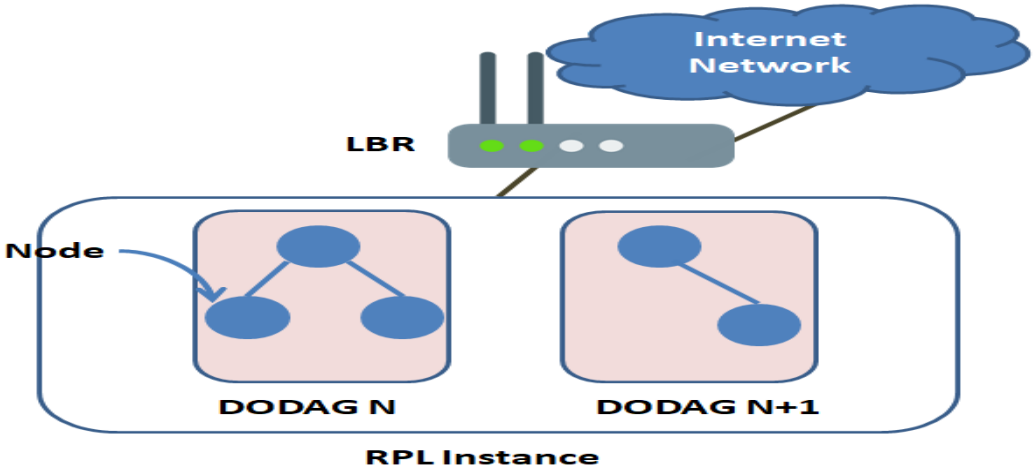



**Figure 4.** RPL Instance, LBR and Internet

## V. IOT APPLICATIONS

The information technologies development all the areas that go with IoT applications. Moreover, highly not possible to list out all the applications, however in this section covers some of the general applications and summarized process. The IoT applications are automated, countless that can be classified nature of the application area. The common classification of IoT applications are home automation, healthcare, transport, environment monitoring, military, industry applications, etc. All this applications fundamental idea is Wireless Sensor Network (WSN) and RPL protocol also used. This section highlights constant IoT applications basic requirements. According to the nature of IoT applications, the RPL provides possible routing to solve the real-time application requirements.

**Home Automation**

The home utilities are connected with each other either by private or public network and the network covered area is around 10 meters to 50 meters in the WSN. For example automatic sliding window, smoke alarm and automatic lighting.

**Healthcare Applications**

The healthcare automation applications, the nodes (application devices) are attached in the human body. The key factor of this applications are security, high responsive, energy, mobility and reliability. In real-time challenge is data transmission at the time of emergency situation and mobile node. In patient health monitoring applications, the patient data collected upon regular interval and the usual habits are monitoring of a person with location. This medical application are used to help the attainder, another difficulty in patient is remembering the regular medicine. In more significant applications, to detection emergency is the consistency and responsiveness of the health care applications is valuable in the human life. The GTM-RPL is providing the low cost with reliable data delivery and fitting with high flexibility in various health care applications [8].

**Transport**

The smart transport is as a part of smart cities, the data collects from the road side fixed sensors and on-road vehicles. These collected information are used like finding the traffic, road condition, prevention of congestions, counting the vehicle and identifying the emergencies, control the traffic ,in forest road animal crossing zone and assist the driver. The road side fixed sensor implementations are not an issue in RPL. On the other part of on-vehicle sensor implementation is possible by using of mobile nodes contribution. However, RPL and Vehicle ad-hoc networks ( VANET) are combined and selecting the parent method is implemented with potential energy consumption [9].

**Environment Monitoring**

These applications are not a single term which includes smart cities, smart agriculture, etc and these applications are working area that covers a wide area. To form this environment monitoring applications fundamental requirements are scalability, mobility, and energy consumption. For example, we are considering

only the smart agriculture application, the scattered sensor nodes are fixed around the yield area. The sensor nodes collect the data about temperature, humidity, and weather entity, this data is used to support the decision making and activate the automated action-based collected entity values. Sensors nodes can also monitor the plants and detect the diseases, this process supports avoiding the spreading of diseases to the next level. [10] . Other types of applications are classified as smart environment applications, which include water level monitoring, wild animal supervising, and temperature-based applications and the RPL supports these all applications by using either a fixed node or mobility node.

**Military**

The military application has required a high level of security and confidentiality, it is often a challenge to develop this field application. The country border monitoring, soldiers' status monitoring, surveillance data collection, war zone monitoring and hazardous data collection applications are mandatory applications in the field of the military. The security and attacks of the node are strongly required on these deployed applications The security and attacks of the node are strongly required on these deployed applications. In this part, [11] the RPL routing enhanced algorithm selects a routing path over a mobile node with a trust value and ensures against Denial of Service (DoS) and Sybil identity attacks based on trust value and average Received Signal Strength Indicator(RSSI).

**Industry**

Industrial applications have automates the plant with efficient control and safety as well as improve the productivity of the system. Plant-production monitoring and management applications are a prominent requirement, it requires real-time processing or offline post-processing of the collected data. An industry system monitoring system applications data transmit signal, temperature, pressure, speed level and so on, in some scenarios the transmission delay acceptable ratio one to several minutes reliability is required. On the other hand, delayed reporting is needed within a few seconds (Emergency stop). However, the industry setup causes high link quality and different topology changes, this network configuration is also resource-constrained. The Multi-Instance-RPL (MI-RPL) and Objective Function (OF) computed the suitable path selection in industrial low-power and lossy Networks under different traffic patterns [12].

## VI. CONCLUSION

The low-power sensors are constrained components and these sensor nodes need the provision for network establishment to solve the real-time IoT application requirements. The LBR is part of IoT network components, it acts as the connection layer between sensor nodes and Internet connected devices. This article is acknowledging the importance of RPL as the standard routing protocol for IoT applications. The effect of RPL DODAG control message, Instance provisions, and respectively IoT Applications connected through LBR. Moreover, the LBR is an Interface between RPL protocol and IoT applications. The RPL protocol is an optimum solution for routing and collecting the data from real-world applications depending upon the application requirements. This article focused on a few classes of IoT applications; it's not limited. Moreover, the potential of IoT applications with RPL protocol combinations is primary in the digital era.

## VII. REFERENCES

[1] D. Priyadarshi and A. Behura, “Analysis of Different IoT Protocols for Heterogeneous Devices and Cloud Platform,” in 2018 International Conference on Communication and Signal Processing (ICCSP), Apr. 2018, pp. 0868–0872. doi: 10.1109/ICCSP.2018.8524531.

[2] P. Senthilkumar S and S. B, “Enhanced Objective Function Etx Metric in Routing Protocol for Low-Power and Lossy Networks (RPL),” Int. J. Comput. Networks Appl., vol. 9, no. 4, p. 462, Aug. 2022, doi: 10.22247/ijcna/2022/214507.

[3] T. Winter et al., “RPL: IPv6 Routing Protocol for Low-Power and Lossy Networks,” Internet Engineering Task Force (IETF). Internet Engineering Task Force (IETF), pp. 1–157, 2012. [Online]. Available: https://tools.ietf.org/pdf/rfc6550.pdf

[4] J. V. V. Sobral, J. J. P. C. Rodrigues, R. A. L. Rabêlo, J. Al-Muhtadi, and V. Korotaev, “Routing Protocols for Low Power and Lossy Networks in Internet of Things Applications,” Sensors, vol. 19, no. 9, p. 2144, May 2019, doi: 10.3390/s19092144.

[5] B. Ghaleb et al., "A Survey of Limitations and Enhancements of the IPv6 Routing Protocol for Low-Power and Lossy Networks: A Focus on Core Operations," IEEE Commun. Surv. Tutorials, vol. 21, no. 2, pp. 1607–1635, 2019, doi: 10.1109/COMST.2018.2874356.

[6] H.-S. Kim, H. Kim, J. Paek, and S. Bahk, "Load Balancing Under Heavy Traffic in RPL Routing Protocol for Low Power and Lossy Networks," IEEE Trans. Mob. Comput., vol. 16, no. 4, pp. 964–979, Apr. 2017, doi: 10.1109/TMC.2016.2585107.

[7] H.-S. Kim, J. Ko, D. E. Culler, and J. Paek, "Challenging the IPv6 Routing Protocol for Low-Power and Lossy Networks (RPL): A Survey," IEEE Commun. Surv. Tutorials, vol. 19, no. 4, pp. 2502–2525, 2017, doi: 10.1109/COMST.2017.2751617.

[8] H. Kharrufa, H. Al-Kashoash, and A. H. Kemp, "A Game Theoretic Optimization of RPL for Mobile Internet of Things Applications," IEEE Sens. J., vol. 18, no. 6, pp. 2520–2530, 2018, doi: 10.1109/JSEN.2018.2794762.

[9] B. Tian et al., "Application of modified RPL under VANET-WSN communication architecture," Proc. - 2013 Int. Conf. Comput. Inf. Sci. ICCIS 2013, vol. 6158, pp. 1467–1470, 2013,
doi: 10.1109/ICCIS.2013.387.

[10] K. Fathallah, M. A. Abid, and N. Ben Hadj-Alouane, "PA-RPL: A Partition Aware IoT Routing Protocol for Precision Agriculture," 2018 14th Int. Wirel. Commun. Mob. Comput. Conf. IWCMC 2018, pp. 672–677, 2018, doi: 10.1109/IWCMC.2018.8450396.

[11] P. Thulasiraman and Y. Wang, "A Lightweight Trust-Based Security Architecture for RPL in Mobile IoT Networks," 2019 16th IEEE Annu. Consum. Commun. Netw. Conf. CCNC 2019, pp. 1–6, 2019, doi: 10.1109/CCNC.2019.8651846.

[12] M. M. Monowar and M. Basheri, "On Providing Differentiated Service Exploiting Multi-Instance RPL for Industrial Low-Power and Lossy Networks," Wirel. Commun. Mob. Comput., vol. 2020, pp. 1–12, Jan. 2020, doi: 10.1155/2020/1748647.