An Optimized Approach to Manage Energy Depletion in Routing Protocol for Low-Power and Lossy Networks (RPL)

Amarjeet Kaur[1], Vikas Khatri[2]
[1] M.Tech Student,
[2] Assistant Professor,
Department of Computer Science & Engineering,
Maharishi Ved Vyas Engineering College, Jagadhri, Yamunanagar.

ABSTRACT

The planned work targets to realize load balancing by letting every node to allocate the scalar data and multimedia data among parent nodes, in order to increase packet transfer rate and to decrease the end-to-end delay by estimating the remaining battery status and buffer usage of bottleneck parent nodes. Depending on current buffer usage and the data extents to be delivered by parent node, the required memory banks can be activated. Our proposal will greatly alleviate the packet loss problem, thereby achieving significant reduction in end-to-end delay for packet transfer.

Keywords: Routing Protocol for Low-Power and Lossy Networks, Objective Function, Queue Operation, Load Balancing Index,

1. INTRODUCTION

Wireless Sensor Networks are a basic portion of sensible environments like sensible homes, buildings, and cities [1]. Sensible environments trust upon the detected data from the important world. WSNs contain specialized parts that ensure sensing, procedure, and communicative capabilities for watching distributed locations [5]. Routing Protocol for Low-Power and Lossy Networks (RPL) [1] is extensively considered to aid routing among sensor nodes. Usually a backbone set-up of intermediate nodes is deployed, and is probable to be fixed in nature. RPL practices a hierarchical routing method for the static backbone network. Key characteristic of movement is an extremely dynamic topography and face recurrent interruptions with neighboring nodes. Frequent disconnections take place due to dynamic topography, packets directed to a movable node can be directed to edges (parents) even afterward the movable node is currently out of range of these parents [2].Load Imbalance of RPL network lead to problems such as bottle neck, energy hole, early node death and poor net-work performance. Such complications can disturb the RPL network badly if the affected nodes are single hop to the sink or root. Therefore, capable load balancing procedures are needed to be devised to prevent these issues [5]. A percentage of the network may be divided due to load imbalance, as the energy of the burdened chosen parent node will drain much quicker than other applicant parents. The battery weakening of that burdened parent node may disturb the network consistency negatively. This difficult drawback is quiet an open problem [2]. Early node death, energy depletion, buffer occupancy are results of load imbalance. Hence, load balancing procedures need to speak these problems so that RPL network has improved node and network life time [6].

The succeeding section of the article discusses related work briefly, Section 3 presents algorithms for the proposed system and Section 4 concludes the paper with future work.

2. RELATED WORK

Hyung-Sin Kim et al. examine the load assessment and congestion problem of RPL. Congestion is the main cause for packet harms in dense traffic, and a severe load balancing problem occurs in RPL in footings of routing parent selection. Proposes an effective queue operation based RPL (QO-RPL) that considerably enhances packet transfer performance as compared to the normal RPL [1]. **Mamoun Qasem et al.** propose a comprehensive Objective Function (OF) which equilibriums the volume of children of the parental nodes to dodge the congestion difficulty and safeguard node lifespan maximization [2]. **Jad Nassar et al.** A metric based on Multiobjective criterion which uses the end-to-end delay and the residual battery in the mobile nodes together through the excellence of the link quality is proposed. Spontaneously adjusts to adopt different traffic flow categories, providing a QoS variation grounded on the dissimilar smart network submissions necessities [3]. **Licai Zhu et al.** Adaptive procedure for multipath traffic loading grounded on RPL is proposed. Its basic notion is to allocate traffic through multipath adaptively agreeing to network's actual situation. It can escape the arrival of traffic jam by balancing the nodes' energy, which ensures the network energy to be stable and dropping the end-to-end delay [4]. **A. Sebastian et al.** present a novel routing metric load balancing index for RPL, which exploits load assessment features of RPL nodes to choose further load well-adjusted parents and paths [5]. **A. Sebastian et al.** network performance and path optimization are affected by load balancing problem. In this article, investigation of present load balancing systems for RPL is achieved. Author also lists out various challenges in RPL with reference to load difference and load balancing metrics [6]. **Belghachi Mohamed and Feham Mohamed** [7] present a metric which uses the remaining power and the communication interval as direction-finding in the subsequent step choice procedure for the RPL protocol. An objective function built on (ACO) for this metric is projected, and then associate the outcomes of tests recognized with the RPL built on ETX. **Weisheng Tang et al.** [8] propose a congestion prevention multipath direction-finding procedure which practices many routing metrics established on RPL, named CA-RPL. A direction-finding metric is proposed for RPL that reduced the average delay neighboring the DAG root, and the weight of all paths is calculated through four metrics. **JeongGil Ko and Andreas Terzis** [9] present the ideals projected by operating teams, and outline however the investigation community sharply contributes during this course by effective their strategy and providing open basis implementations. **Harith Kharrufa, Hayder Al-Kashoash** [10] designed an additional self-motivated Objective-Function to advance the packet transfer rate and energy intake while maintaining low packet overhead. **Tripathi** [11] presented a greedy process to solve load balancing problem. Load unevenness issue is considered for every stage of the routing to identify nodes that are susceptible to bottleneck. This arrangement targets to stability the routing tree and decreases the load inequity factor. The procedure chooses a parent for a node from three designated parents by itself. The root node executes the procedure and tries to choose parents which reduces load imbalance factor. This is completed periodically, keeping the tree as well-adjusted as promising throughout the network lifetime. **Kulkarni** [12] suggested a technique for load balancing, DODAG root identifies the count of nodes in each subtree. Each node which wants to connect the DODAG gets alert of the DODAG's node count and joins a DODAG with the lowermost number of nodes.

3. PROPOSED WORK

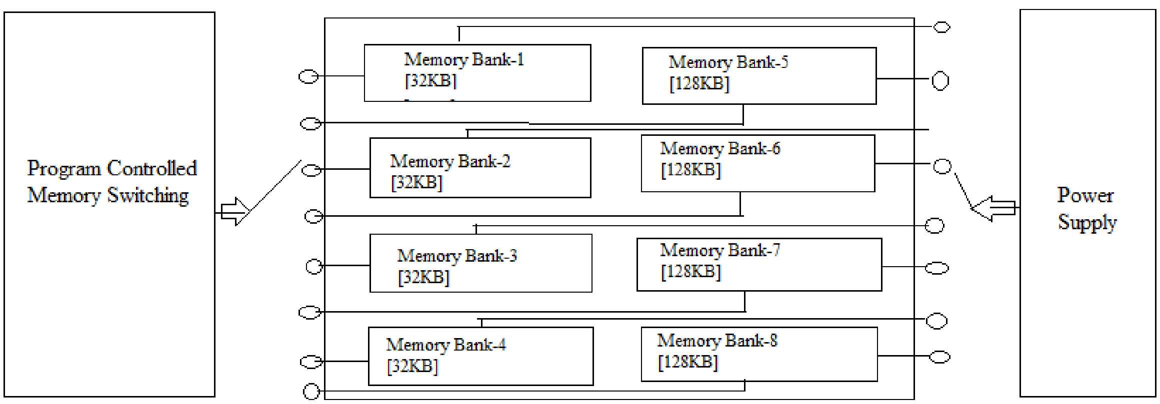

Figure 3.1: Memory Bank Architecture of node

There is always a difference in the traffic movement in wireless sensor network applications, at specific time the traffic flow is more whereas at some stage the traffic movement is less. In the RPL routing protocol strategy process, type of traffic passing through parent nodes was not considered in the parent choice process. An optimized approach to manage energy depletion is to distribute the memory into a number of chunks and then power only the share of the memory essential for data storage. This section presents a Multipath Traffic distribution method based on RPL. We will deploy heterogeneous sensors (scalar sensors, audio and video) that communicate directly in a certain schedule with a set of parent nodes and send data to it. We realize the entire network's energy balance by distributing scalar data and multimedia data in order to increase packet transfer rate to reduce the end-to-end delay by estimating the battery status and buffer usage of bottleneck parent nodes in the network. Depending on current buffer usage and the data extents to be delivered by parent node, the memory banks are supplied power which leads to reduced congestion.

Algorithm Battery Status Computation of Parent Node

Battery status is divided into 3 categories:

For each selected parent node

If (Battery Status < 10%)

Then Set B_weight = 0.1

End if

If (10% <=Battery Status <75%)

Then Set B_weight = 0.3

End if

If (Battery Status >=75%)

Then Set B_weight = 0.6

End if

End for

Algorithm Self-Buffer Management of Parent Nodes

Analyze traffic type

If parent node is idle

Then

Serve the packets

Else

For each selected parent node

Case 1: if (traffic type is normal and B_weight = 0.3)

If (Buffer usage >=90%)

Set Memory_Bank_Size = 32K

Then compute the amount of memory needed by the parent node based on the normal traffic flow. Activate required no. of memory banks

End if

Case 2: if (traffic type is multimedia and B_weight = 0.6)

If (Buffer usage >=90%)

Set Memory_Bank_Size = 128 KB

Then compute the amount of memory needed by the parent node based on the multimedia traffic flow. Activate required no. of memory banks

End if

End if

Compute Total Energy Consumption = $E_{arrival} + k^* E_{buffer} + E_{transmit}$

Where $E_{arrival:}$ Packet arrival energy

k: Active memory banks

E_{buffer}: Energy for queuing or Storing in buffer

$E_{transmitt}$: Packet transmit energy

4. RESULTS AND DISCUSSION

The proposed self-buffer management scheme for RPL is tested under Contiki OS-COOJA simulator. The simulation parameters are shown in table 4.1

Table 4.1: Simulation Parameters

Parameter	Value
Channel type	Wireless channel
Number of nodes	25, 50, 75, 100, 125, 150
Area (deployment)	1000*1000M
Initial energy	50 joules.
MAC type	802.11
Antenna model	Omni Direction Antenna

Propagation model	Random waypoint
Transmission power	10.35E-3 Watts
Receiving power	5.25E-3 Watts
Queue type	Priority queue
Simulation time	1200 S
Routing Protocol	RPL
Idle power	700E-5 Watts
Sleep power	2.5E-9 Watts

Table 4.2: Packet Delivery Ratio

Network Size	PDR% (Memory Bank Disable)	PDR% (Memory Bank Enable)
25	94.41	100
50	91.67	100
75	86.22	100
100	82.15	100
125	76.79	98.21
150	72.83	98.01

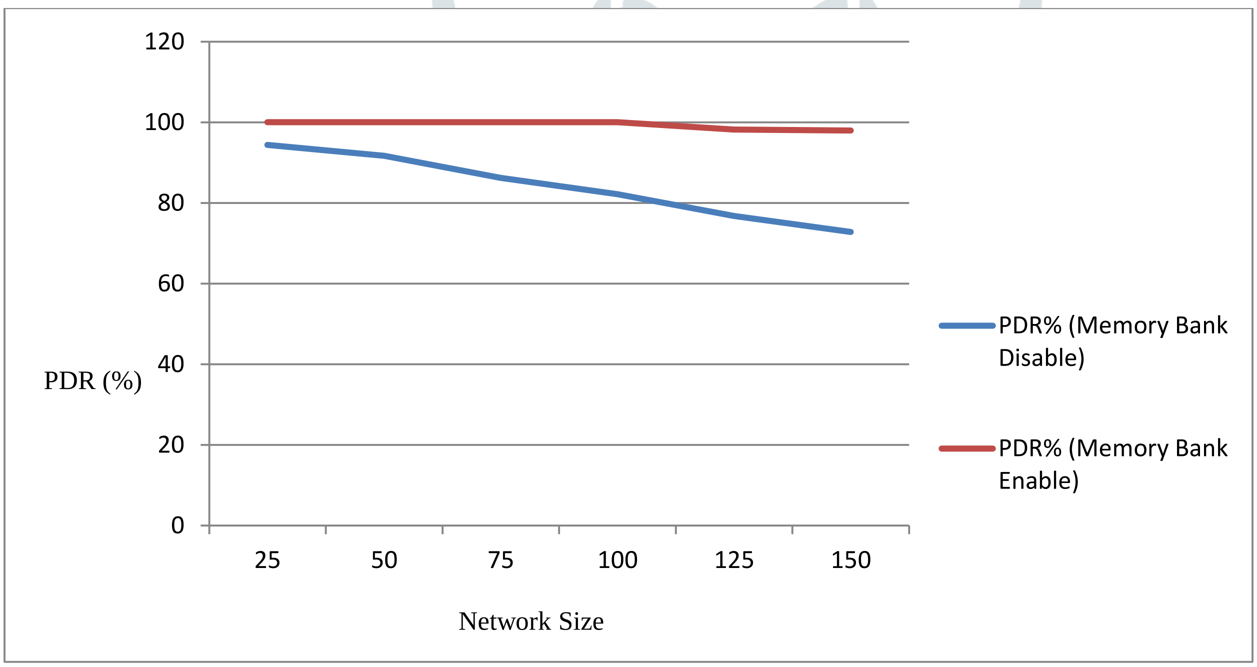

Figure 4.1: Packet Delivery Ratio

Packet Delivery Ratio detected in the simulation is shown in figure 4.1. The results are compared for standard RPL and proposed with memory bank. The PDR is 98.01 to 100.00% when memory bank is enabled which is good. On the other hand, PDR for standard RPL has low value (72.83% to 94.41%).

Table 4.3: Throughput

Network Size	Throughput (Kbps) (Memory Bank Disable)	Throughput (Kbps) (Memory Bank Enable)
25	5.9070	6.2565
50	4.0915	4.4635
75	3.0250	3.5085
100	2.5240	3.0725
125	2.1460	2.7945
150	1.8320	2.5155

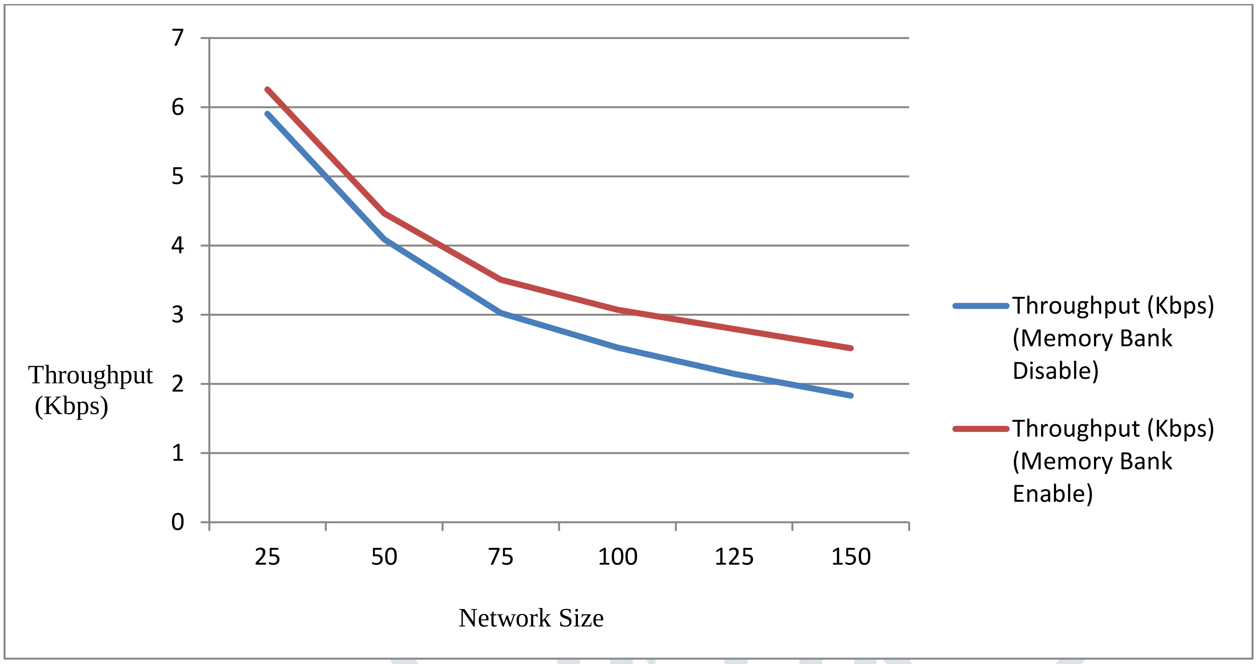

Figure 4.2: Throughput (Kbps)

Throughput measured in the simulation is shown in figure 4.2. The results are compared for standard RPL and proposed with memory bank. Throughput always remain high when memory bank is enabled which is good.

Table 4.4: Average End-to-End Delay

Network Size	Average End-to-End Delay (ms) (Memory Bank Disable)	Average End-to-End Delay (ms) (Memory Bank Enable)
25	0.02851	0.001592
50	0.01954	0.001635
75	0.03440	0.001492
100	0.04386	0.001557
125	0.067847	0.001605
150	0.07581	0.001624

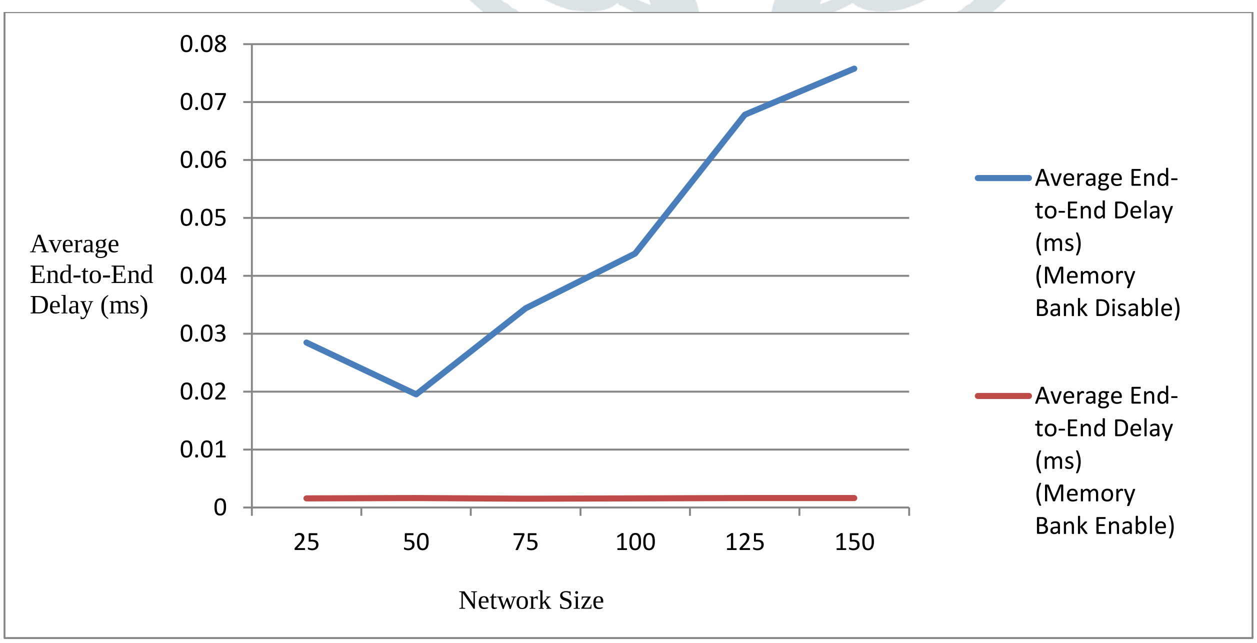

Figure 4.3: Average End-to-End Delay (ms)

Average End-to-End delay measured in the simulation is shown in figure 4.3. The results are compared for standard RPL and proposed with memory bank. Average End-to-End delays always remains low when memory bank is enabled which is good.

Table 4.5: Consumed Energy

Network Size	Consumed Energy (j) (Memory Bank Disable)	Consumed Energy (j) (Memory Bank Enable)
25	207.773	209.228
50	416.608	418.395
75	624.567	627.320
100	833.148	835.891
125	1040.35	1044.06
150	1248.49	1252.01

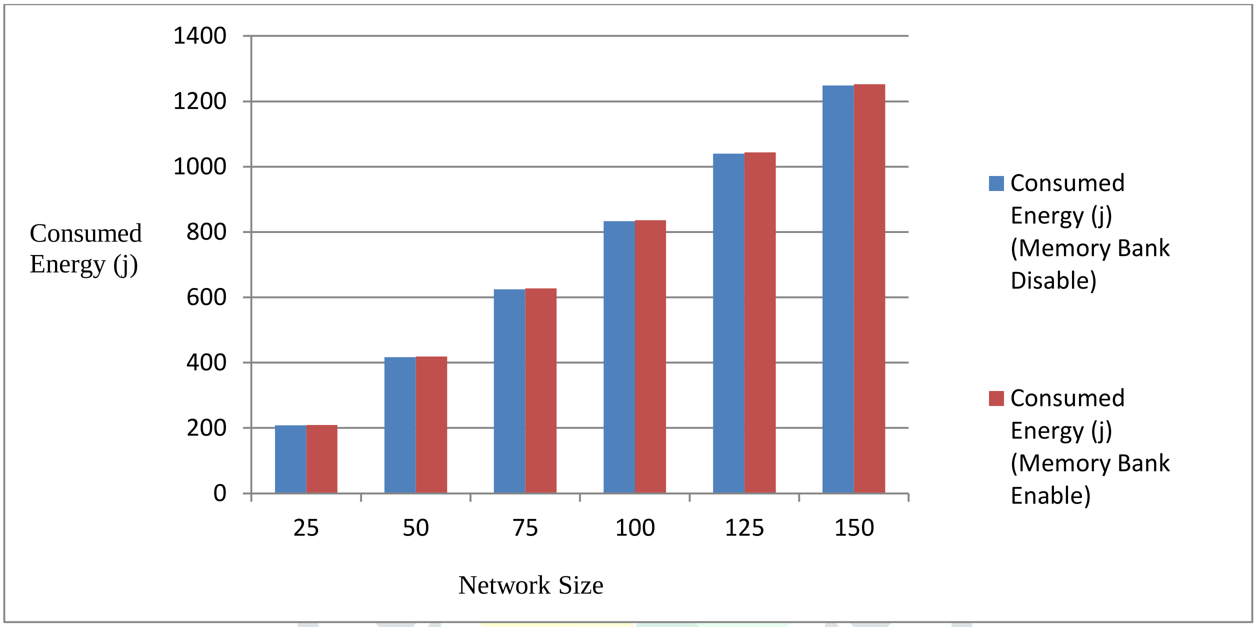

Figure 4.4: Consumed Energy

Energy consumption in the simulation is shown in figure 4.4. The results are compared for standard RPL and proposed with memory bank. It is observed that the energy consumption of Self-buffer management scheme at parent nodes is somewhat higher compared to standard RPL.

5. CONCLUSION AND FUTURE SCOPE

Network's transmission rate performance depends upon type of information broadcasted. Even identified complete information, choosing an enhanced load balancing procedure is still a challenging task. Packets being ready for transmission by a node are distributed among parent nodes according to battery status of each parent node. After calculating the buffer usage of each associated parent node, a heuristic procedure can be applied to modify memory architecture of parent node to reduce packet-drop in performance as against the normal architecture. The proposed scheme takes in to account remaining battery status and buffer usage of bottleneck parent nodes. The suggested scheme shows better outcomes. Load balancing optimization using machine learning or nature inspired algorithm is other challenges for the future work.

REFERENCES

[1] Hyung-Sin Kim, Jeongyeup Paek, Saewoong Bahk, "QU-RPL: Queue Utilization based RPL for Load Balancing in Large Scale Industrial Applications", 2015 12th Annual IEEE International Conference on Sensing, Communication, and Networking (SECON)

[2] Mamoun Qasem, Ahmed Yassin Al-Dubai, Imed Romdhani, Baraq Ghaleb, "Load Balancing Objective Function in RPL", https://www.researchgate.net/publication/313369944

[3] Jad Nassar, Nicolas Gouvy, Nathalie Mitton, "Towards Multi-instances QoS Efficient RPL for Smart Grids", Jad Nassar, Nicolas Gouvy, Nathalie Mitton. Towards Multi-instances QoS Efficient RPL for Smart Grids. PE-WASUN 2017 - 14th ACM International Symposium on Performance Evaluation of Wireless Ad Hoc, Sensor, and Ubiquitous Networks, Nov 2017, Miami, FL, United States. pp.85-92, PEWASUN '17 Proceedings of the 14th ACM Symposium on Performance Evaluation of Wireless Ad Hoc, Sensor

[4] Licai Zhu, Ruchuan Wang, Hao Yang, "Multi-path Data Distribution Mechanism Based on RPL for Energy Consumption and Time Delay", Preprints (www.preprints.org), 2017, 8, 124; doi:10.3390/info8040124

[5] A. Sebastian, S. Sivagurunathan, "Load Balancing Metric Based Routing Protocol for Low Power and Lossy Networks (lbRPL)", International Journal of Engineering & Technology, 7 (2.22) (2018) 39-44

[6] A. Sebastian, S. Sivagurunathan, "A Survey on Load Balancing Schemes in RPL based Internet of Things", IJSRNSC, Volume-6, Issue-3, June 2018

[7] Belghachi Mohamed and Feham Mohamed, "QoS Routing RPL for Low Power and Lossy Networks", Hindawi Publishing Corporation International Journal of Distributed Sensor Networks, Volume 2015, Article ID 971545, 10 pages

[8] Weisheng Tang, Xiaoyuan Ma, Jun Huang, and JianmingWei, "Toward Improved RPL: A Congestion Avoidance Multipath Routing Protocol with Time Factor for Wireless Sensor Networks", Hindawi Publishing Corporation Journal of Sensors, Volume 2016, Article ID 8128651, 11 pages

[9] JeongGil Ko and Andreas Terzis, "Connecting Low-Power and Lossy Networks to the Internet", IEEE Communications Magazine • April 2011

[10] Harith Kharrufa, Hayder Al-Kashoash, "Dynamic RPL for Multi-hop Routing in IoT Applications", EEE Proceedings of WONS 2017. 13th Annual Conference on Wireless On-demand Network Systems and Services (WONS)

[11] Tripathi J, De Oliveira JC. (2013) Quantifying load imbalance: A practical implementation for data collection in low power lossy networks. IEEE 47th Annual Conference on Information Sciences and Systems (CISS):1-6.

[12] Kulkarni P, Gormus S, Fan Z. (2012) Tree Balancing in Smart Grid Advanced Metering Infrastructure Mesh Networks. IEEE International Conference on Green Computing and Communications (GreenCom):109-115.