

# DoE to Minimize the Energy Consumption of RPL Routing Protocol in IoT for Supporting Green Wireless Communication

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**Abstract :-** *IoT being an emerging technology where billions of devices are expected to be added in mere future. With increasing devices, the carbon footprint increases gradually and have its impact on environment. In order to reduce the carbon footprint, it is necessary to make devices energy efficient and to achieve this, we make use of network size and mobility parameter as additional factor along with random topology in RPL protocol to understand the energy consumption and throughput. In this paper, we made an attempt to minimize the energy consumption of RPL, enhancing the network lifetime and supporting green wireless communication. Taguchi method was used to verify and validate the factor that influencing the performance metrics and it is noted that the network size is the most influencing factor for Energy consumption. we evaluated the performance of RPL under different network sizes along with mobility. To this end, different scenarios like Both Sender and sink mobility, sender mobility and sink mobility are implemented with network size of 10,20,30,40,50 using the Cooja simulator. Our simulation results show that RPL performance and de facto values of RPL are greatly influenced by the number of nodes, and mobility. Throughput of the nodes in different scenarios is calculated and it is observed that the throughput of smaller networks is increased by 2.82% when compared to larger network. The energy consumption is reduced to 22.11% in case of smaller networks.*

**Key Words:** RPL, Green Wireless Communication, Mobility, Energy, Taguchi method.

## 1. INTRODUCTION

Low-Energy and Lossy network (LNN) is commonly deployed in Internet of Things. RPL (Routing Protocol for Low-Energy and Lossy Networks) is a proactive protocol based on distance vectors and operates on IEEE 802.15.4, optimized for multi-hop and many-to-one communication, but also supports one-to-one messages. IoT consists of a considerable amount of devices, also known as motes, with sensory capacity and wireless connectivity deployed in a wide geographical area. Devices in IoT face limitations in terms of energy, memory and processing. Low-Energy and Lossy-Network (LLN) are usually composed of static nodes, but the increase demand for mobility in mobile robotic and dynamic environment raises the question how the routing protocol for Low-Energy and Lossy-Networks such as (RPL) would perform in where a mobile sink is deployed. RPL is an IPv6 Routing Protocol for Low Energy and Lossy Networks

that uses an optimized route for transmitting traffic from or to a central collector node called a root or sink node. The main concept of RPL is that the nodes are able to self-organize themselves by forming a tree topology with a root at the top (sink). There are redundant links in the topology that uses up and down directions depending on the network traffic pattern. Upwards traffic to the sink can be described as multipoint-to-point, downwards as point-to-multipoint and point-to-point traffic between nodes. Given that RPL forms a tree topology with redundant paths and multihop infrastructure it can be adapted to support mobile nodes. The protocol constructs a hierarchical tree like topology also called Directed Acyclic Graph (DAG) with the aim of minimizing the path cost to the DAG root. Each sender node has a preferred parent, which acts as a gateway for that node and also determines the default path. Green wireless communication always aims to achieve energy efficient communication. The rest of paper is structured as follows. Section II: Related work, Section III: Performance evaluation, Section IV: Results and Discussion on the RPL performances, and finally the Conclusion and Future work are given in Section V.

## 2. RELATED WORK

Many research studies had been carried out on evaluating the performance of RPL in different simulation frameworks, scenarios and its applications, network simulator and performance evaluation metrics. Some compared the protocols such as CoAP, 6LoWPAN, RPL using Contiki operating system cooja simulator based on some criteria such as transmission ranges, interference ranges, transmission success ratios, radio duty cycle, average inter-packet time etc. Some studies evaluated RPL using energy efficiency over virtual distance as the core routing mechanism. Some more studies have given an insight of the advances in green wireless communication especially in grid communication with renewable energies being implemented. Studies on energy with objective functions were discussed. In some cases the types of motes were used to evaluate the performance. Some studies have considered Taguchi method but with different simulators like OMNET++. But of all the discussions, there is no methodology of determining the factors that influence performance metrics and evaluating rpl under different scenarios to achieve green RPL. Green RPL was previously implemented by making the nodes energy efficiency using solar energy and evaluated the performance.

### 3. PERFORMANCE EVALUATION

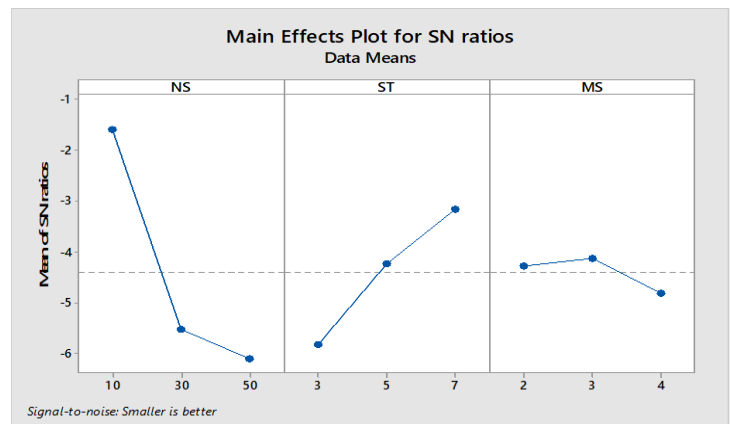
Taguchi method was used to understand the factor that effects the Energy consumption and then the potential of RPL protocol is assessed in terms of energy consumption and subsequently the throughput under mobility. Simulations were executed using cooja simulator. Cooja runs simulations using virtual motes running the contiki operating system. Cooja simulator does not support node mobility by default. Thus, the Cooja’s Mobility plugin must be enabled to allow information about mobility positions for each node to be included during the simulation. Simulations were conducted in 15 different scenarios with 10,20,30,40,50 nodes. Of all the cases one node is deployed as a sink and the others remained as senders. For all the simulations the parameters. Transmission ratio and Interference range remained same while the execution time was 10 minutes.

**Table -1: PARAMETERS FOR SIMULATION**

Parameter	Value
Number of nodes	10,20,30,40,50
Type of Mote	TMoteSky
Simulated Execution time	10 minutes
Seed	Random at each execution
Node Position	Random
Radio Medium	Unit Disk Graph Medium(UDGM)
Transmission range	50 meters
Interference range	100 meters
Success Transmission ratio	100%
Success Transmission ratio	100%
Mobility speed	4m/s
Mobility model	Random Waypoint model

### 4. RESULTS AND DISCUSSIONS

The exeperimental values were evaluated using Taguchi method and the experiment reveals that network size is more influencing factor of all the three factors (network size, simulation time, mobility).The results of taguchi method is shown below



**Chart -1: Main effects plot fo SN ratios**

$S = 0.2494$   $R-Sq = 99.7\%$   $R-Sq(adj) = 99.0\%$

Analysis of Variance for SN ratios

Source	DF	Seq SS	Adj SS	Adj MS	F	P
NS	2	36.3655	36.3655	18.1828	292.33	0.003
ST	2	10.9178	10.9178	5.4589	87.76	0.011
MS	2	0.7917	0.7917	0.3959	6.36	0.136
Residual Error	2	0.1244	0.1244	0.0622		
Total	8	48.1994				

Response Table for Signal to Noise Ratios

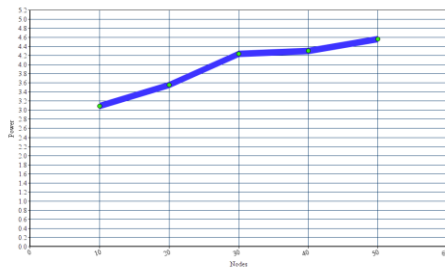
Smaller is better

Level	NS	ST	MS
1	-1.584	-5.831	-4.271
2	-5.518	-4.236	-4.128
3	-6.115	-3.149	-4.817
Delta	4.531	2.682	0.688
Rank	1	2	3

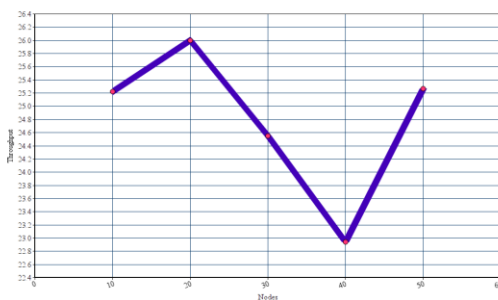
The Line graphs shown below are the reults obtained from the simulations performed for different network sizes under different mobilities.

Graphs for Energy consumption and throughput for different network size is shown below.

Chart 2 depicts the line graph for Energy consumption; which is less in scenarios where Network size is less and Energy consumption is more in a scenario where network size is larger.



**Chart 2. Variation of Energy consumption with network size**



**Chart 3. Variation of Throughput with network size**

Chart 3 depicts the throughput of the same scenarios where throughput increased in case of smaller networks compared to larger networks.

## 5. CONCLUSIONS

Our work conclude that Network size had greatly influenced the Energy consumption .We validated the factor that influenced the performance metric and simulated under different network sizes and mobilities. Sink mobility can reduce the Energy consumption to achieve higher energy efficiency and high throughput of the network of the WSN by selecting the mobility radius of the sink accordingly. The energy consumption is greatly reduced by 22.11% for a experimental time of 600 seconds with smaller networks of 20 nodes and this outcome greatly impacts when implemented in real time applications for wireless sensor networks. This reduction of Energy consumption can greatly contribute to Green Wireless Communication by reducing the carbon footprint. In the future, we plan to implement the results in testbed by using mobile smart devices and collect the carbon footprint from each device while communicating and analyze the results accordingly.

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