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# Analysing the impact of ICMP on the performance of RPL Routing Protocol for IoT

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Abstract

The Internet is a Best-Effort model; if IPv4 is replaced by IPv6, the number of connections available is greater than the existence. Drastic increase made a way for IOT existence is a QoS Model. ICMP, IGMP, ARP and RARP protocols plays a crucial role for conversion of Best effort model to QoS Model. Using the cooja simulator and the contiki operating system, we explore the impact of de-facto ICMP parameters on the performance of the routing protocol in RPL. Power consumed and PDR are analysed under different network conditions by modifying the ICMP parameters. Experimental analysis reveals that ICMP time intervals from 45 to 55 seconds provide the better performance in truncating the power utilization and in improving network Life Expectancy.

Keywords: IPv4, IPv6, IoT, Cooja, ICMP, RPL

## 1.Introduction

The world is moving toward ICT tools in which devices/things must be connected to the internet via wired or wireless connections. Internet plays a key role in establishing the global connectivity among devices, initially uses the IPv4. To accommodate the increasing number of connections there is a need for transformation from IPv4 to IPv6 a QoS Model[1,2]. With the introduction of IPv6, the number of connections available has increased, allowing things/devices (which may or may not contain computers) to have unique addresses and a more widespread presence, making IOT more desirable. WSN, the heart of IoT, has sensing and actuating capabilities with limited power and bandwidth, allowing for a range of low-power Personal Area Networks (PAN) such as Low PAN. Routing protocols play an important part in standard networks for improving performance, but in Low PAN, the Routing Protocol is given a little more weight.

RPL is an IETF-proposed best routing protocol for IPv6 for Personal Area Networks with Low Power[4]. Traditional routing protocols such as OSPF, AODV, and OLSR, which are well suited to dynamic network topologies, are not adaptable to IPv6 networks with limited energy, bandwidth, and computational capabilities[3].

RPL constructs a spanning tree using the Reactive routing methodology and an asymmetric approach. We're using a DAG (Directed Acyclic Graph) to go to our destination, which stands for Destination Oriented Directed Acyclic Graph (DODAG). Data is transferred from the source node (leaf node) to the destination node (root/sink node) using the DODAG technique. With the implementation of the objective function, the best path to explore the data can be found. In determining the optimum optimal path, the objective function is crucial. RPL is made up of two different objective functions. The Minimum Rank Hysteresis Objective Function (MHROF) employs the value ETX (estimation transmission count) on the route path to discover the best way to the root node, while the Zero Objective Function (OF0) uses the minimum hop count to determine the best path to the root node.

RPL constructs the DODAG using ICMPv6 control messages. The DODAG Information Object (DIO) is broadcasted across the network, stating whether it is a storing (or) non-storing node (Root node) and any new nodes interested in joining that node. A new child node requesting to join a DODAG is known as a DODAG information Solicitation (DIS). Advertisement for DODAG Based on the parameters of the Objective function, request from the current node, Object (DAO) a node in DODAG proceeded to displace to another Sub-DODAG. DODAG Acknowledgement to the child node from the parent node. The formation of the DODAG is aided by all of these control messages. Figure 1 depicts the control message flow.

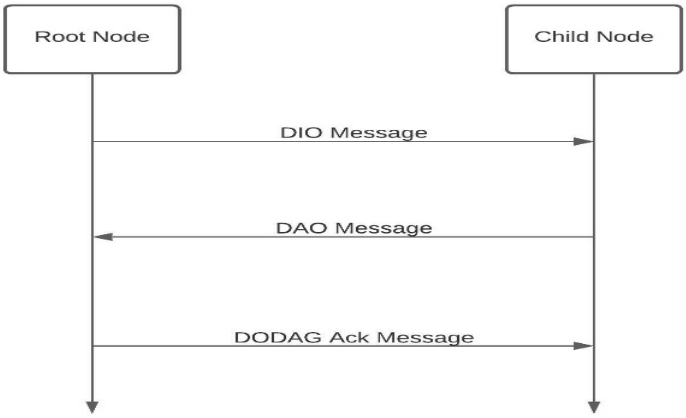



**Figure 1** RPL Message Flow Using ICMP

RPL routing with DO-DAG formation is highly influenced with control messages. A node in a network may fail then data needs to be re-routed, which creates chaos in the network and leads to the congestion in the network. Re-routing of the data happens only with the ICMPv6 control messages only. In this context performance parameters power utilization and PDR is to be analysed by varying the ICMP time intervals in with de-facto values.

The Structural organization of this paper is accompanied as; module 2, a brief study of the previous related works; module 3, a glimpse about the simulator with its performance metrics; module 4, simulation setup parameters; module 5, discussions related to the results; module 6, conclusion and the their future works.

**2. Literature Review**

Wail mardini et al [5] Considering both objective functions, performance parameters such as power and pdr of the RPL were studied. Changing the ICMP time intervals in relation to the Tx Ratio on power and pdr in relation to various network scenarios.

Hussien et al [6] By adjusting the Rx ratio in various network situations, we investigated the power and pdr of RPL based on the two objective functions in grid and random topologies.

A.S Joseph et al [7] They are RPL QoS metrics in the cooja simulator using the measure Wireshark, as specified. They're attempting to quantify power, pdr, throughput, convergence time, delay ETX, and overhead control.

L.Lassouaouni et al [8] indicated that they are attempting to compare the energy required by RPL in two scenarios: one with no packet loss and another with 40% packet loss.

G.Y.Liu et al [9] highlighted that keeping the least energy consumption is a crucial concern with the enormous growth of WSN and high data rates. They discussed OFDMA networks, MIMO techniques, and other topics related to communication in order to enhance energy efficiency.

X.Liu et al [10] In a network with multi-hop connectivity, a relative comparative analysis of routing protocols such as LOADng, geographical algorithms, and RPL was stated. The researchers looked at parameters like as power, pdr, ETX, and Link Quality Data, among others.

M.Zhao et al [11] In P2P, a route must be discovered between two peers while preserving throughput in order to achieve a trustworthy route, which is a time-consuming operation. They have presented an energy efficient –RPL based on region named ER-RPL in this study while keeping the reliability.

Kumar et al[12] Implementation of numerous trickling, m-trickle, i-trickle, and elastic trickle variants using the RPL and comparison of all variations with benchmark trickle algorithm based on power and packet delivery ratio.

Srikanth et al[13] implemented the design of experiments using the taguchi approach in recognizing the parameter, relatively greater influence for enhancing the power consumption and PDR in RPL protocol.

The previous related works reveals that power consumption and packet delivery ratio are two most influential factor for enhancing the Network Life Expectancy by minimizing the power utilization in the network. This paper articulates on analysis of these performance metrics in relation to the variation of ICMP intervals.

**3. Simulator Used**

Cooja-2.7, which operated on the Contiki OS, was a graphical-based wireless network simulator. The network consists of nodes with native c code incorporated in them, such as sky, Tmote, and Zoletria[14,15]. The simulator ran from the physical layer to the application layer, with a collect view for each that monitored all performance indicators. Figure 2 depicts a graphical representation of the Cooja environment.

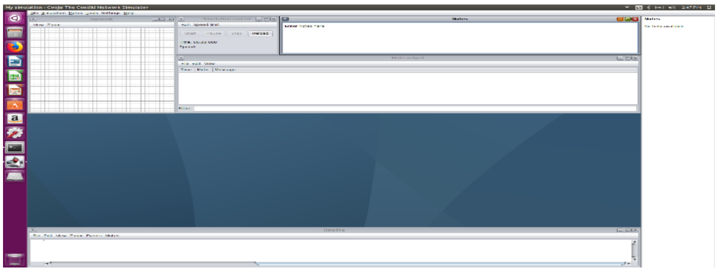


**Figure 2** Simulator Environment of Cooja

### 3.1. Indicators of Performance

In any DODAG, the objective function reflects all network topology considerations to find the best path. Here are some parameters that are taken into account when assessing RPL in various network scenarios. The parameters to considered are as observes[16]:

- **Power:** The energy used by a node in a network for sensing, communicating with the root node, calculating the data, and acting on it. The power consumption is expressed in milliwatts (mW).
- **PDR** is known as Packet Delivery Ratio. It is number of packets received by a node in a network in according to the total number of packets sent

*Pdr=(no of packets received)/(total packet send)*

### 4. Parameter of Simulation

Under the UGDM framework, Cooja simulates a Sky mote deployed in a wireless environment. We're investigating at network densities of 20, 30, and 40, as well as a single sink node and adjusting the Tx ratio to 50, 60, and 70 percent. We're experimenting with ICMP intervals ranging from 10, 20, 40, and 60 seconds. Table 1 and Fig 3 exhibit the random and linear topologies that will be used to model the scenarios stated above.

**Specifications for Cooja Simulation**

| Simulation Parameters | Value |
|---|---|
| Model | UGDM |
| Seed | Random |
| Squad Area | 100X100 |
| Mote | Sky Mote |
| Simulation in Seconds | 300 Sec |
| Topologies | Random,Linear |
| Objective Function | OF0 |
| ICMP Intervals | 10,20,40,60 Sec |
| Speed | Random Speed |
| Tx Ratio | 50%,60%,70% |
| Rx Ratio | 100% |

**Table 1** Simulation Parameters

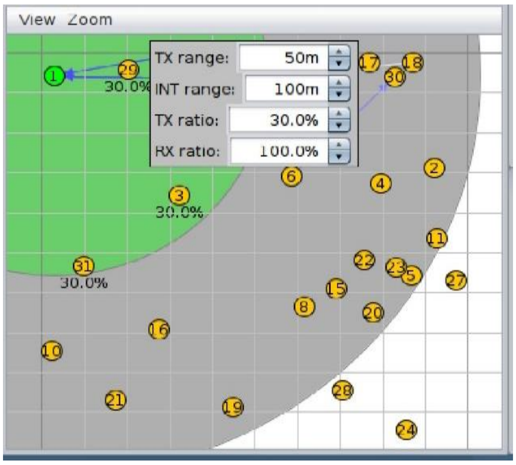



**Fig 3(a)** 30 Nodes with Random Network Topology


**Fig 3(b)** 30 Nodes with Linear Network Topology

### 5. Discussion on Results

In this research, tests were simulated on 20,30, and 40 by changing the Tx Ratio from 50%, 60%, and 70% with respect to ICMP intervals for 10,20,40, and 60 seconds, and the power and PDR were observed in Random and Linear Networks as shown in Figures

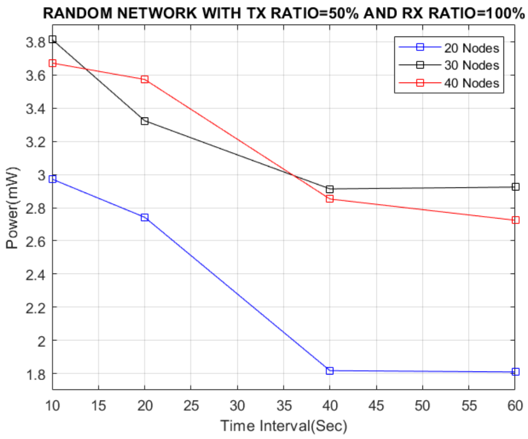



**Fig 4(a)** Power for Random network with
Tx Ratio=50% and Rx Ratio=100%

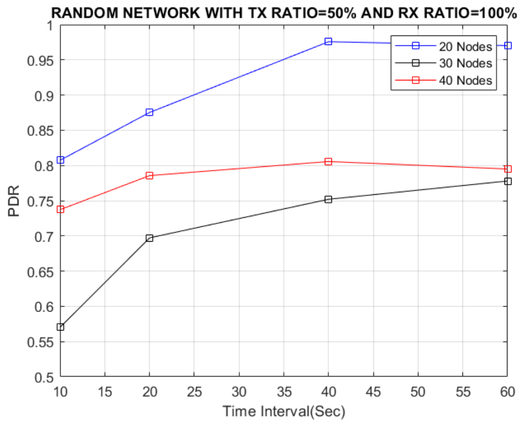



**Fig 4(b)** PDR for Random Network with
Tx Ratio=50% and Rx Ratio=100%

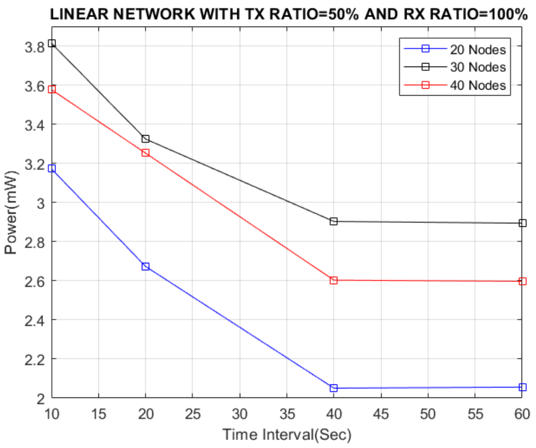



**Fig 4(c)** Power for Linear Network with
Tx Ratio=50% and Rx Ratio=100%

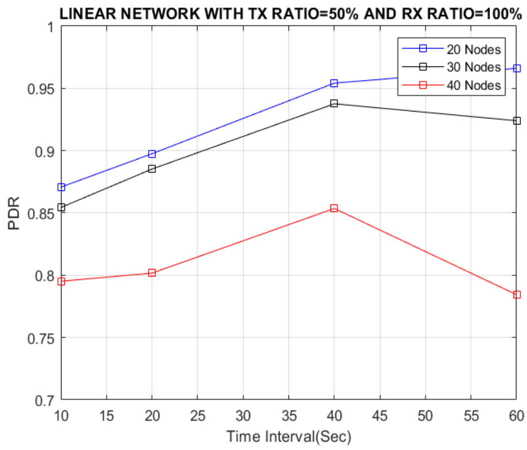



**Fig 4(d)** PDR for Linear Network with
Tx Ratio=50% and Rx Ratio=100%

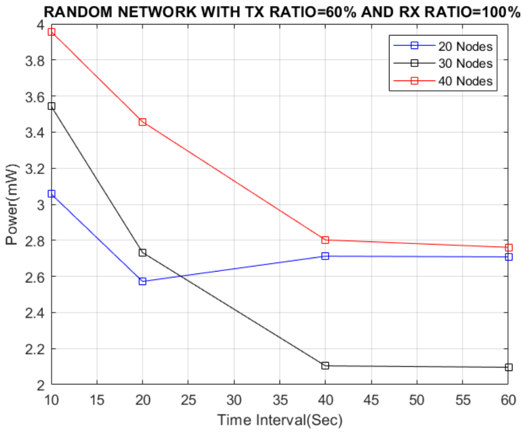
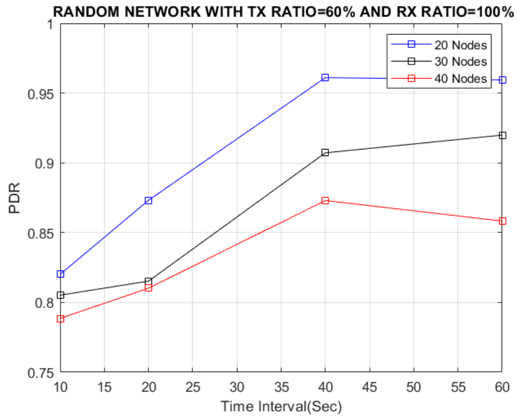



**Fig 4(e)** Power for Random network with Tx Ratio=60% and Rx Ratio=100%




**4(f)** PDR for Random Network with Tx Ratio=60% and Rx Ratio=100%

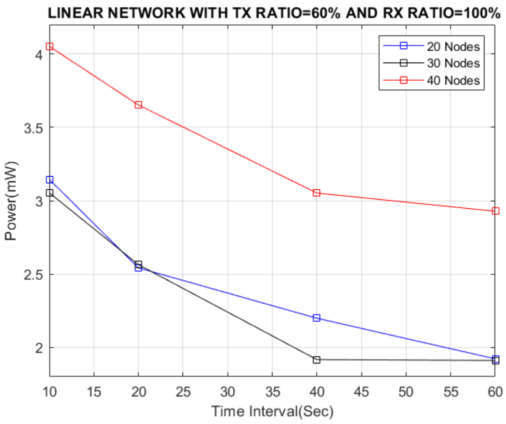



**Fig 4(g)** Power for Linear Network with Tx Ratio=60% and Rx Ratio=100%

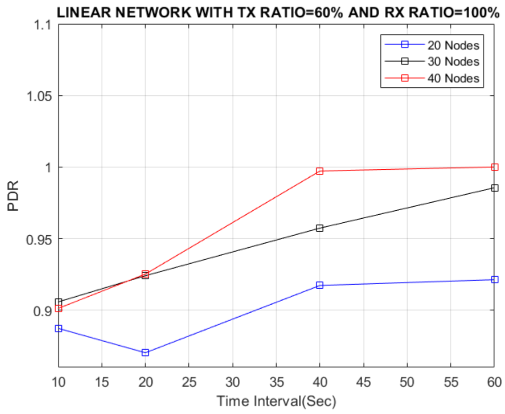



**Fig 4(h)** PDR for Linear Network with Tx Ratio=60% and Rx Ratio=100%

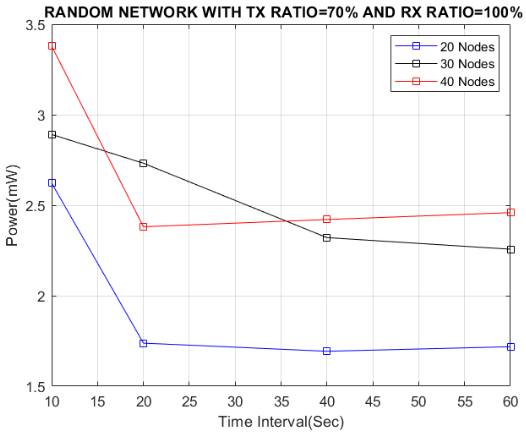
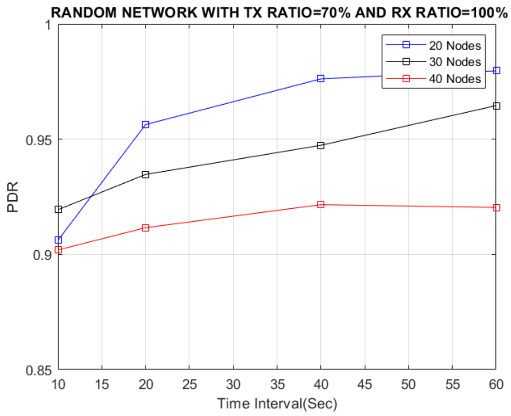



**Fig 4(i)** Power for Random network with Tx Ratio=70% and Rx Ratio=100%




**4(j)** PDR for Random Network with Tx Ratio=70% and Rx Ratio=100%

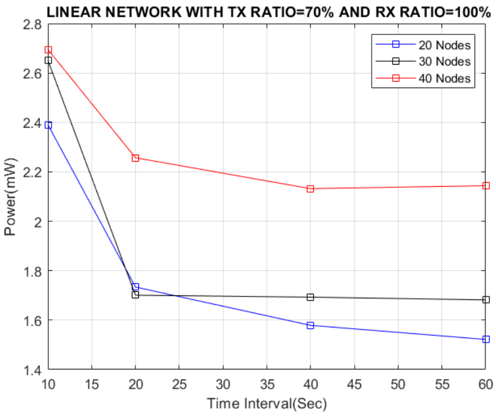



**Fig 4(k)** Power for Linear Network with Tx Ratio=70% and Rx Ratio=100%

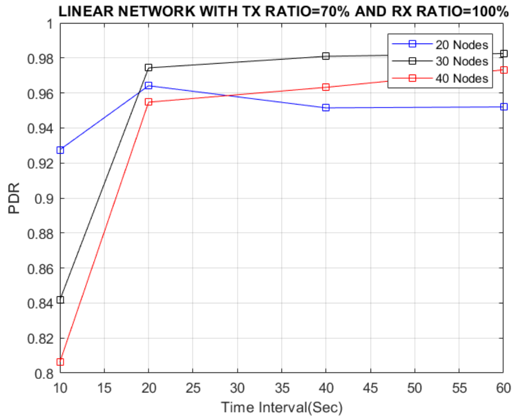



**Fig 4(l)** PDR for Linear Network with Tx Ratio=70% and Rx Ratio=100%

**Conclusion and Future Scope**

By altering the network size, transmission ratio, and ICMP time interval Range, we investigate the influence of Power consumption and Packet Delivery Ratio on the sink node in this article. There is a convergence of Power consumption and PDR at ICMP time intervals from 40sec to 60sec, when the ICMP time intervals is varied at 10sec, 20sec, 40sec, and 60sec. The power consumption and PDR is a variation of 2.47% and 3.523% respectively.

In inclination to the variance of ICMP time intervals the performance metrics power and PDR maintains a negligible deviation. In contrast to dynamic network circumstances there of essence of dynamic ICMP intervals in adapting the network scenario. A fine tuning of the de-facto ICMP intervals can be accomplished with the soft computing to approach. Fuzzy Logic, ANFIS and genetic algorithms etc.., can be applied for the performance enhancement in the dynamic environment

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