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AN ENERGY EFFICIENT RPL OBJECTIVE FUNCTION FOR CLINICAL RESEARCH

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ABSTRACT

Health care represents a fundamental function in the growth of the nation. A well-known truth if the health of the natives of a nation will continue working, then the economics of the country will also change. Various researchers to advance the health care system using the Internet of Things have done significant research work. Some states have already adopted cloud-based technologies to improve the health care system. An architecture for healthcare is also proposed using fog computing to enhance delay, energy, and latency. The IoT devices used in clinical research are mostly battery operated and continuously connected to the internet. The power consumption by the things is very high due to various routing protocol running when they connect with the internet. In this research, we simulate an Energy-Efficient and Secure RPL objective function to measure the QoS parameters for the things used in clinical research. To test-bed it, we execute one topology or scenario multiple times in COOJA simulator. The collected results show that The simulation results conclude that the OF0 objective function is better than MHROF in terms of Consumption of Energy, Packet Loss, Convergence Time, Listen Duty Cycle, and Transmit Radio Duty Cycle for IoT based Fog-Cloud Architecture for Clinical research.

Keywords—Health-care; Fog Computing; Cloud Computing; Internet of Things; Delay; Energy Consumption; Latency; Security; Routing Protocol, RPL.

I. INTRODUCTION

Healthcare is an inescapable component of survival. The firmly growing population and the parallel increase in continuing disease are setting the critical anxiety on new healthcare systems and the requirement for help from the hospital beds to doctors and nurses remain especially high. There is a need for technology that overcomes the stress on healthcare systems while maintaining to give high-quality attention to at-risk patients. The Internet of Things (IoT) is the solution to mitigate the stress on healthcare systems. There are various researchers have done much research work for the development of healthcare. Several relevant works have been done for the particular fields and technologies associated with the IoT healthcare. The researcher has presented various survey which focus on commercially feasible solutions, popular applications, and leftover problems. The Internet of Things continues a comparatively new area for research, and its likely use for healthcare is a field still in its infancy. In this chapter, the role of the Internet of Things is explored for the healthcare system and various technologies

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currently used for the healthcare system is highlighted. as multi-levelled equations, graphics, and tables are not prescribed, although the various table text styles are provided.

The adoption of devices that have low power is becoming the element of our regular days. The use of these devices is very useful in the smart healthcare system. The devices are resource constrained in the sensor network. They have less power, less cost, and small size. These sensor nodes are battery operated, and they cannot recharge, consequently, it is important that it work very effectively in phases of computation and data communication. The power consumption in computation activities is lesser than to power consumed during data communication. The transmission and receiving of data during data communication consume the maximum of the power. Hence, it is necessary to estimate the consumption of resources and performance of the routing protocol in sensors. These networks also called as low power and Lossy networks (LLNs) [11].

The sensors in LLN connected with each other with various links as Bluetooth, IEEE 802.15.4, Wi-Fi with Low Power, or low power PLC (Power line communication). The LLN network node transfers its own packet to the destination as well as route the packets of another node in the network. Hence, the main concern is routing that waste the resources in the devices. In LLN, there exist several alternative routes to the single node. Each route has a distinct quality and reliability [12].

Since a node in an LLN not only forwards its own packet towards the destination (sink for example) but also routes the packets of the other nodes in the network, hence routing is of great concern in wasting the resources in these devices [13]. An LLN contains several alternative paths towards a single destination but with different link qualities and reliabilities. It becomes the noticeable accountability of the routing protocol to execute sensible decisions in composing the routes from a source node to the destination node. The selection of poor path makes the drain out of resources quickly [14].The research paperis organized as follows: Section 2 includes literature survey, summary of literature survey and problem identification. In this section, different IoT based healthcare systems, various security schemes for privacy and security for the healthcare system and routing protocol for LLN’s are reviewed. Section 3, the comparison between the RPL objective function OF0 and MHROF is performed to measure the QoS parameters for the things used in clinical research. In section 4, experimental setup and simulation are performed. In section 5, the simulation results are discussed. Section 6 shows conclusion and the direction of future work.

II. LITERATURE REVIEW

Vivek Gupta et al. [2018] proposed an architecture named as Fog-Cloud based architecture. This architecture will reduce the delay, energy consumption, and the latency. To testbed, the author executes one topology or scenario multiple times. The collected results show that the proposed is reducing the delay, energy consumption, and the latency in comparison to cloud only.

Ming Zhao et al. [2016] proposed an energy-efficient region-based routing protocol (ER-RPL). Routing is important factor in low-power and lossy networks (LLNs). The protocol is capable of delivering the energy-efficient data without negotiating the authenticity. The nodes required route identification in various conventional routing protocols. The proposed protocol requires some nodes for the discovery of the route which is extremely

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useful in saving of energy. The experimental results and the theoretical study shows that the proposed ER-RPL has an excellent performance in comparison to RPL and P2P-RPL protocols.

Guojun Ma et al. [2017] studies the issues related to security of RPL. The network security of RPL checked by setting up a test network and proposed a secure routing protocol named M-RPL based on RPL. The protocol established the clustering network topology in hierarchical way. During route discovery, the backup path between distinct clusters is establishes using the intelligent device that exists in the network. The backup path assures data routing when a network arbitrated. Various attacks proposed toward the routing protocol during the simulation. The simulation results confirm that the proposed protocol handles all attacks very efficiently and assure the security of internet of things.

AsmaLahib et al. [2017] proposed a modified version of RPL protocol named as Link reliable and Trust-aware (LT-RPL). The proposed model works for the IoT networks characteristics. This protocol revealed the inside attacks of the network in a comprehensive way. The primary objective of the proposal is to overcome the research gap by designing and integrating proposed protocol with the RPL. The model assures trust and QoS between nodes and links using multidimensional approach during the construction of network routing topology and capacitance. The simulation performed under IoT environment and result proves the efficiency and high accuracy of the system. The RPL protocol has storage limitations with the downward path within the routers in the IoT networks. It has a lack of memory for storing an entry for a sub-network that associated with it. The failing a router, cause the unreachable destinations problem. The modified version of RPL called Enhanced-RPL proposed to overcome storage limitation problem. After performing simulation, the result shows Enhanced-RPL works better then RPL standard by an average of 64%.

GhadaGlissa et al. [2016] proposed a Secure-RPL (SRPL) algorithm based on RPL use to prevent the misbehavior of nodes so that changing the nodes rank will not disrupt the network by constructing a fake topology. Transportation of data and routing over the Internet of Things (IoT) is a challenging matter where a large collection of data is expected. The Routing Protocol for low-power and lossy networks (RPL) is the reliable protocol that ensures routing in 6LoWPAN networks. However, it is unprotected to various attacks that associated to exchange control messages. The theory of rank threshold and hash chain authentication method is introduced that handle the sinkhole, black hole, selective forwarding internal attacks. The simulation is performed using Cooja simulator. The simulation results show the robust and resistant nature of SRPL.

David Airehrour et al. [2018] proposed a routing protocol namely: SecTrust-RPL. The SecTrust-RPL is time-based trust-aware RPL routing protocol that secures the IoT network from the routing attacks like Rank and Sybil attack by embedding with RPL. The proposed protocol uses the trust-based technique to detect and separate the attack. The proposed protocol is implemented and simulate using Cooja network simulator. SecTrust-RPL protocol proves its better performance in the discovery and separation of Rank and Sybil attacks. The simulation results show effectiveness and flexibility of the SecTrust-RPL in comparison to standard RPL.

Hyung-Sin Kim et al. [2017] proposed and implemented an improved version of RPL termed as DT-RPL. The Internet of things uses applications that are a low-power and lossy network (LLN) expanded, and it requires

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maintaining distinct traffic patterns. The IPv6 routing protocol for LLNs (RPL) has a performance issue while delivering of distinct traffic patterns. The proposed protocol solves the problem efficiently by updating the quality of the wireless link within both upward and downward traffic that support Diverse Traffic patterns. The results of DT-RPL tested over multi-hop testbed over IEEE 802.15.4 links shows the better performance of DT-RPL for packet delivery ratio, control overhead, and radio energy consumption in different traffic patterns.

Nabil Djedjig et al. [2015] proposed a strengthen RPL protocol. A new trustworthiness metric added to strengthen RPL during construction and maintenance of RPL. The RPL protocol is standard routing protocol used for 6LoWPAN networks. The RPL has security and privacy issues as well as it has an issue of trust management between nodes. Trust Platform module (TPM) is not sufficient to assure the trustworthiness between nodes. The new trustworthiness metric represents the trust level for every node in a network. The trust level of each node used to check whether to trust the node or not. The calculation of trust level performed by calculating selfishness, energy, and honesty components. The calculated value is used to decide whether or not trust the nodes.

III. PROPOSED WORK

The Low-Power and Lossy Networks (LLNs) constrained to the nodes, which have less processing power, insufficient memory, and energy in case of battery operated devices. When the routers interconnected with the lossy network, they give the low data rate and unstable packet delivery. In addition, in these networks point to point traffic patterns not provided. RPL protocol is design for these networks that satisfies the requirements for the battery operated internet of things. RPL works with the nodes that power-constrained. The main advantage of RPL is it form the route when needed respite of maintain the routing tables. The RPL is a Distance Vector (DV) and Source Routing protocol.The most significant features of the RPL protocol is Objective Function (OF) which performs a significant task in constructing a network stable with limited convergence time and less consumption of energy. RPL uses OF to build the DODAG. OF is also applied to determine the rank of a node, which is a node’s distance from a DODAG root node. RPL discovers the complete topology by forming the DODAGs within occurrences, where each instance is connected with a specific OF. OF joins the metrics and constraints to determine the reliable path. However, RPL’s has no default OF. Therefore, OF0 is designed as a default function that is well known to all implementations and provides interoperability between various implementation..

A. OF0

RPL uses Objective Function Zero (OF0), where a node combines a rank increment to the rank of its preferred parent. It chooses a preferred parent and a possible backup in case the preferred parent is not accessible. OF0 uses ranks that approximates the hop count to the root. It prefers fewer “even if longer or poorer” hops. It estimates rank increase as follows:

$$R(N) = R(P) + Rank\_Increase.$$

Where, R(N) is the Rank of node N, R(P) is the Rank ofthe parent of node N, and,

$$Rank\_Increase = (R_f * S_p + S_r) * MinHopRankIncrease.$$

Where R_f is the Rank factor to provide weight to the wanted connection, i.e., wired over wireless, S_p is the Step of rank based on the link properties with a certain neighbor, S_r is the Stretch of rank to select another feasible parent.The algorithm used by the OF0 is shown in figure 1.

B. MHROF

RPL further practices Minimum Rank Objective Function with Hysteresis (MRHOF). It dynamically applies the Expected Transmission Count (ETX) as the default metric to determine the rank. It chooses the route that reduces the metrics adopted and utilizes hysteresis to decrease the churn "change of parent" affected by short metric shifts over time, by withdrawing choosing a new parent except its rank is smaller than the modern one by a presented threshold. If the selected parent is off, a node chooses from a collection of possible parents.

The algorithm used by the MHROF is as follows:

1. First, the path metric is calculate based on objective function.
2. If the parent is not existing, then maximum path cost is used to calculate path metric.
3. If objective function is not used then path metric= rank + link metric
4. If objective function is used then path metric= energy metric + link metric
5. Finally, compare the path metric.

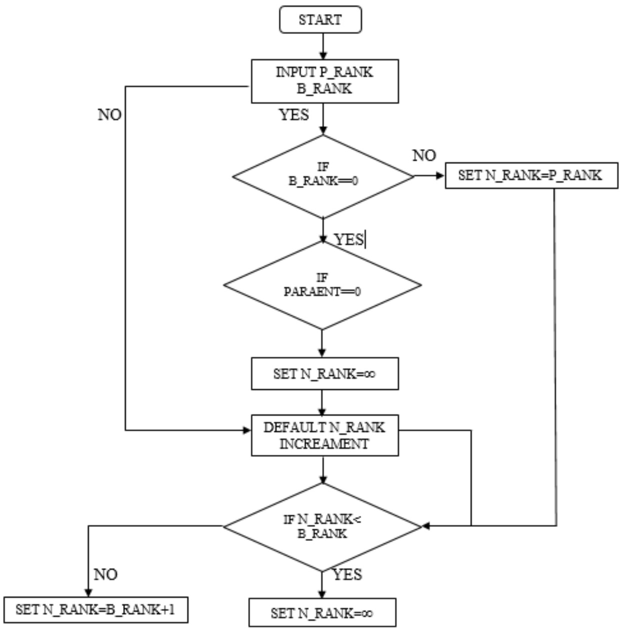

Fig. 1. OF0 Algorithm

In the research the performance of two objective functions is compared for the IoT based Fog-Cloud Architecture for Healthcare.

IV. PERFORMANCE EVALUATION

The performance of the two objective functions MRHOF and OF0 in the RPL protocol is measured using Cooja network simulator for clinical devices. Cooja is network simulator that implemented in Java. Contiki Sensor Network Operating system mainly designed for the Wireless Sensor Networks. C programming language used to

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perform the simulation. The primary objective of the simulation is to see the response as well as to estimate the performance of Routing Protocol for low-power and lossy network (RPL). The concerning different performance metrics are Packet Delivery Ratio, Signalling Overhead, Power Consumption and Latency.

4.1 Simulation and Experimental Setup

Cooja is a heterogeneous method in terms of the cross-level emulation and simulation tool. In this research, the simulation is performed including a single sink node with multiple source node and using Random topology The RPL network is designed using OF0 and MRHOF by setting the experiments. The default RPL parameters used for the simulation is listed in table 4.1.

TABLE 4.1 PARAMETERS FOR SIMULATION

Parameters	**Value**
OF	OF0, MHROF
TX Ratio	100%
TX Range	60-100m
RX Ratio	100%
Simulation Time	20 min

4.2 Network Topology

The random topology is used to perform the simulation that allow the sink node to contact with the source nodes directly or by contacting each other to reach the sink. The random topology is standard network topology that is used by many real world applications.

Using the Cooja simulator three random topologies will construct with 7, 17 and 27 nodes. Each topology consist of one sink node and sender nodes as shown in figure2 and 3.

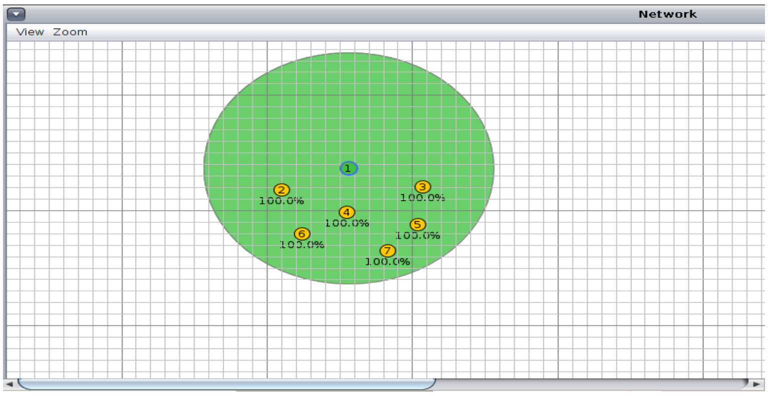

Fig. 2. Random Topology with 7 nodes. TX=60

The Cooja simulation time will be set to 1 hour with the movement are repeated multiple time. Each topology is tested 100-meter transmission range. The overall waypoint of the topology is shown in figure 5.

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4.3 Metrics

The main compared metric obtained the convergence time of the network. checking if every one of the objective functions applied will adversely affect the time required to fully develop the network under those various scenarios. Also, obtaining the structure of the DODAG tree at the convergence time, and at 20 minutes of the simulation time. Then applying other metrics to analyse the results of the two objective functions two times, one time was at the convergence of the network and the other time was at 20 minutes from the starting time of the simulation. Those metrics are the average churn “change of parent” in the network, the Average Power Consumption (APC), Average Listen Duty Cycle (ALDC), Average Transmit Duty Cycle (ATDC), the average received packets “metrics updates”, average lost packets, average duplicate packets, and average hop count.

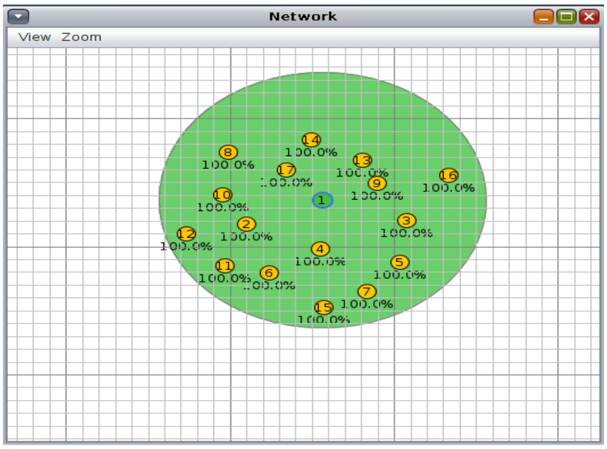

Fig. 3. Random Topology with 17 nodes. TX=80

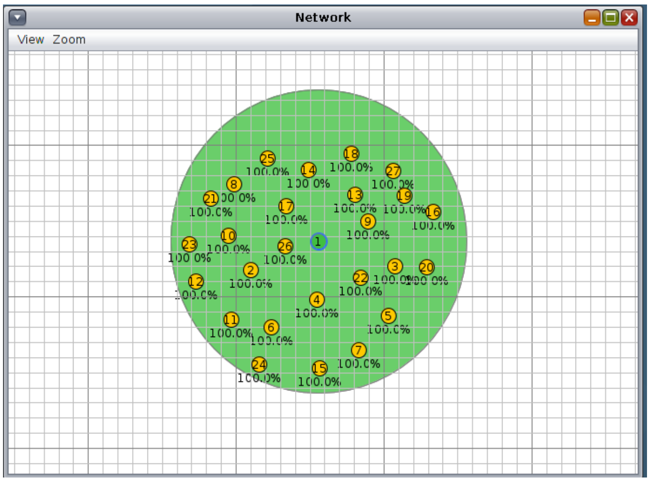

Fig. 4. Random Topology with 27 nodes. TX=80

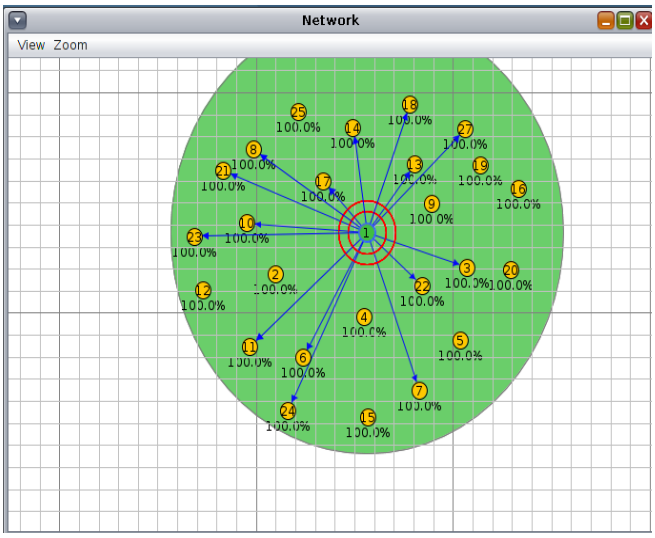

Fig. 5. Waypoint of 27 nodes.

V. RESULT & DISCUSSION

The simulation results has been recorded and the comparison is performed for the metric between both the objective functions.

5.1 Convergence Time

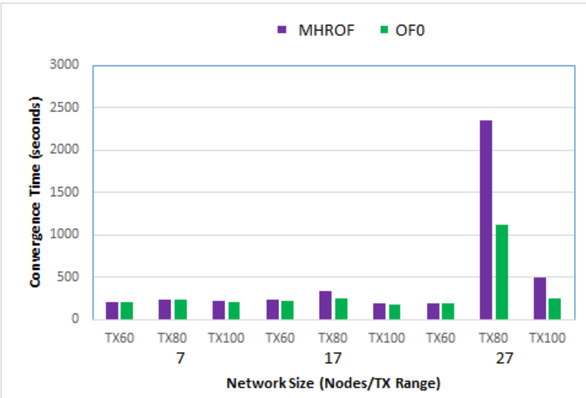

Fig. 6. Convergence time for Random Topology.

5.2 Power Consumption

The MHROF always consumes more power because the nodes keep updating their new metrics, radio duty cycle and radio listen cycle. The average power consumption, average transmit duty cycle and average listen duty cycle is recorded for both the objective functions. From there, seeing that MRHOF always produces the highest duty cycles. Like the power consumption, the difference between OF0 and MRHOF increases with more nodes, and with more neighbors around the node. The figure 5.2, 5.3 and 5.4 shows that MHROF always consumes more power.

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5.3 Lost and Duplicate Packets

The number of lost packets and duplicate packets will increase with the increase in the number of nodes and with an increase in transmission range. The result of simulation shown in figure 5.5 show that MHROF causes more packet loss in comparison to OF0 when network size is large. In small network, the packet loss is almost zero.

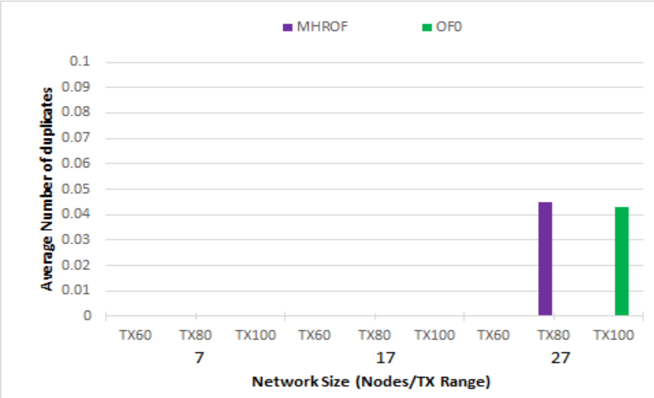

Fig. 7. Average Power Consumption.

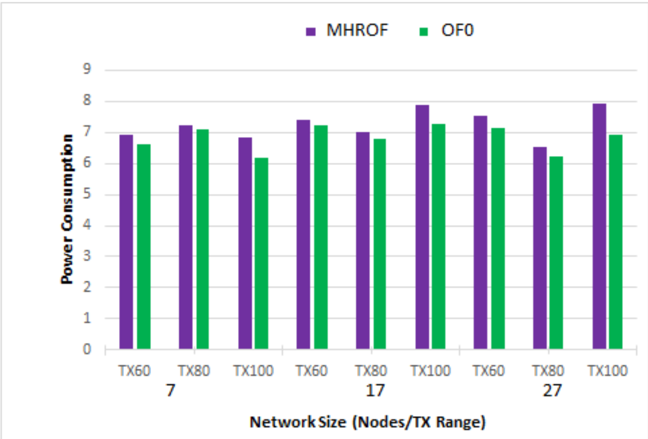

Fig. 8. Average Radio listen duty cycle %.

The collected results show that The simulation results conclude that the OF0 objective function is better than MHROF in terms of Consumption of Energy, Packet Loss, Convergence Time, Listen Duty Cycle, and Transmit Radio Duty Cycle for IoT based Fog-Cloud Architecture for Clinical research.

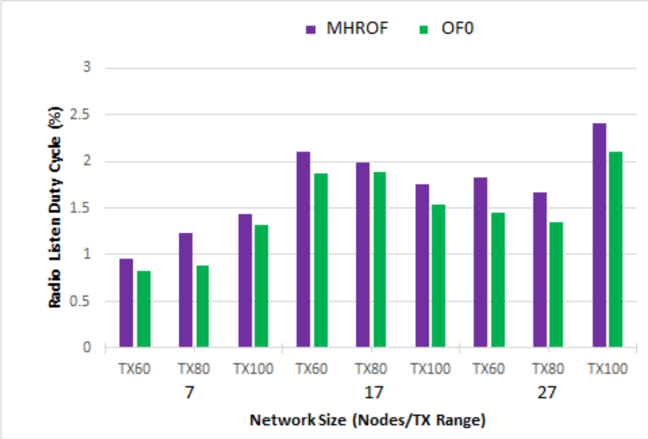

Fig. 9 Average Radio transmit duty cycle %

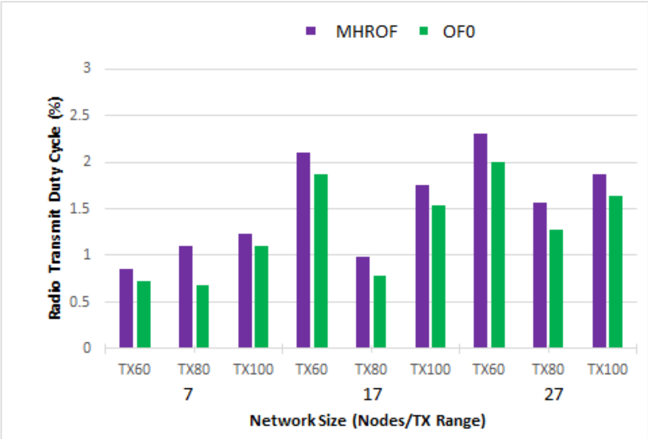

Fig. 10 Average number of duplicates.

VI. CONCLUSION & FUTURE WORK

The IoT devices used in healthcare are mostly battery operated and always connected to the internet. The power consumption by the things is very high due to various routing protocol running when they connect with the internet. In this research, we simulate an Energy-Efficient and Secure RPL objective function to measure the QoS parameters for the things used in clinical research. PRL use the objective function OF0 and MHROF to get the better results from battery operated devices while connected internet. The simulation is performed in COOJA simulator.

The collected results show that the OF0 objective function is better than MHROF in terms of Consumption of Energy, Packet Loss, Convergence Time, Listen Duty Cycle, and Transmit Radio Duty Cycle for IoT based Fog-Cloud Architecture for Clinical research.

The security protocols and algorithms can be used to secure the communication of IoT devices used in further clinical research.

ISBN : 978-81-941721-7-8

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