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Parent Selection Mechanism To Reduce Delay In Routing (EPSD)

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Abstract-- The devices of Internet of Things (IoT) are interconnected with each other. Devices of IoT belong from various environment. The devices are used to route the packet. The energy of devices is drained, when particular devices are used to route the packet. In RPL (Routing Protocol for Low power and Lossy network), while routing the packet the preferred parent is changed frequently. This approach increases the broadcasting of control message, delay, and responsible for choosing more than one node for a transaction which leads to high energy consumption. A technique is proposed to overcome these issues which enhance the performance of the parameter. The primary objective of this work is to propose an energy-aware parent selection mechanism (EPSD) to reduce delay in routing for RPL protocol. In RPL network, during the routing the child node changes its parent frequently. This may lead to increases in delay, too many control messages are broadcasted between the child node and parent node due to which the energy is consumed on many nodes. This proposed mechanism provides a solution to select the parent node to reduce the delay in routing the packet. We propose a mechanism known as EPSD to enhance the performance of the RPL by reducing delay during the routing process in an IoT environment.

Keywords— Internet of Things (IoT), RPL (Routing Protocol for Low power and Lossy network), delay, energy-aware parent selection mechanism

I. INTRODUCTION

Internet of things (IoT) is the concept defined by Kevin Ashton. IoT devices has the capability to control and perform the complex task. The devices of IoT will not change the human life but it can simplify the human work. In IoT, different technologies are embedded together which enhances the service. This feature supports the IoT devices in dynamic platform.

The performance and capability of the IoT devices gained more user. The concept of IoT builds a chain in which object around us are connected to the network and communicate with the neighbor devices to perform some operation, which minimize the human work. The devices of IoT should built the strong relationship between the human being and to the physical environment by its performance.

In IoT, huge number of applications runs in various environment for performing various operation. Depend upon the operation, the architecture of IoT is framed. Each layer of IoT perform various operation. Application layer handle huge data from the sensor. Network layer protocols routes the packet from the sensing layer to application layer. Sensing layer collects the data from the sensors. Major issues seem to occur mostly in the network layer. The major transactions are performed in network layer.

Routing is performed by routing protocol. Routing protocol like LOADng, LOAD, RPL, CO-RPL and AODV. This research work gives focus to the issues that affects the routing in RPL for IoT.

Need for Energy and Delay aware Model

In RPL, the energy aware parent selection mechanism (EPS) is introduced to overcome the failure of issue node in the network during the routing process. To improve the performance of the existing EPS mechanism and to reduce the delay occurred during the routing, a new mechanism of EPSD is introduced. The proposed energy aware parent selection mechanism decreases the delay and reduces the broadcasting of control messages between the intermediate nodes. The energy aware parent selection mechanism reduces the energy consumption of more devices that are selected as parent to route the packet. In general, the RPL protocol constructs the path based on the objective function. The objective function is responsible for broadcasting the control message between the nodes. After constructing the path, every particular of time period and the DIO messages are broadcasted between the child node and parent node. This concept of tickle timer is used in RPL to monitor the node.

This paper is organized as follows: Section 2 presents the related work. Section 3 explains the proposed technique, computes the minimum neighborhood node that reduces the data transfer delay from source to destination. Section 4 highlights results and discussions. Section 5 is conclusion. Finally, references are cited.

II. RELATED WORKS

Normally RPL is not optimized to function with the smart grids, due to its interlinked measures and objective functions which restricts in permitting the differentiation in Quality of Service. Hence, this is rectified by proposing [1] an OFQS objective function alongside the multi-objective measures, through which the remaining energy in battery and delay are taken into consideration along with the dynamic quality of communication links.

[2] A minimum rank analysis is performed with MRHOF (Hysteresis Objective Function) and OFO (Objective Function Zero) in various regions based on large circumstances and two types of topologies. The analysis is performed based on the reliability achieved by means of power consumption, packet delivery ratio, percentage of radio activity and mean value of end-to-end delay.

The basic characteristics of RPL and the merits and de-merits prevailing in employing it in various IoT applications are presented [3]. Depending on the service type and enhancement area, the research gap present in the RPL is identified. Moreover, RPL dependent protocols are compared with each other based on some measures like security, flexibility, efficiency, robustness and reliability.

CT-RPL (Cluster Tree based Routing Protocol) is proposed [4] to improve the network lifespan and prevent the data traffic occurring between the network nodes. Three different process like cluster formation, cluster head selection and route establishment take place in the CT-RPL.

[6] Presented a protocol dubbed Congestion and QoS-Aware RPL (CQARPL) for IoT applications that upgraded the RPL protocol based on congestion management and QoS needs. This protocol chooses parents based on a multi-metric assessment that takes into account the circumstances of root routes. It also regulates the choice of parents and the children's approval of the formation of a balanced DODAG graph. It also gives users the opportunity to estimate traffic congestion and avoid it as much as possible.

[7] Suggests improving RPL by reducing the latency by employing four alternative cycle times. If most of the nodes at the MAC layer operate at low duty cycles, this augmentation is expected to provide improved results. [8] Gives a summary of current RPL protocol developments that facilitate mobility. In addition to mobility, topology management and bandwidth utilization are also addressed. Finally, a comparison of several methods is offered. [9] Proposes modifying RPL to create the RDARPL (Reliable and Delay Aware RPL) protocol. Expected Transmission Count (ETX), hop count, and delay are combined into a new statistic called ETXDHC.

[10] Offers an energy-efficient RPL (E-RPL) protocol that combines ACO-based multi-factor optimization for parent selection with a coverage-based dynamic trickling algorithm for energy-efficient DODAG creation without sacrificing network coverage or data reliability.

[11] A novel Mobility Energy and Queue Aware-RPL (MEQA-RPL) is suggested, with the capacity to detect route failure and identify the next viable route ahead of time before the present route fails. MEQA-RPL uses a constraint check on energy and queue availability while determining the next route to provide QoS for mobile nodes and a longer network lifespan.

[12] Created a novel routing protocol approach (QWL-RPL) based on queue and node-wise workload information. The designed Routing protocol's goal is to find the shortest route with the best possible performance. The suggested Objective approach must take into account connection capacity as well as indicating the condition of congestion in a specific node or device utilizing data or packet queue information.

In a social Internet of things network, [13] presented trust-based community nodes and optimized RPL. The community is made up of a mix of high trust and low trust nodes with similar tastes. The establishment of trusted node-based communities aids in the identification of trustworthy nodes in the transmission process. By picking trusted nodes as the next step in the routing process, the dragon fly optimization improves RPL performance.

[14] Describe E-RPL, a novel technique that improves the Routing Protocol for Low Power and Lossy Networks (RPL). E-RPL reduces the amount of control messages compared to RPL. The new protocol also presents a new flexible multi-constrained objective function (OF) that may combine many metrics such as energy, latency, and bandwidth to determine the end-to-end route between the sink and a specific node. [15] Present an RPL-based hybrid routing method for high N2N communications in low-power, lossy networks, dubbed HRPL.

III. A PROPOSED TECHNIQUE

A mechanism of Energy Aware Parent Selection technique is proposed in this work to reduce the Delay occurred in RPL network (EPSD) in the previous existing mechanism of EPS. During the routing process, the node E changes the parent node C and node D at every interval of broadcasting DIO message. This approach increases the delay. Energy is consumed in both node C and node D and lot of control message are broadcast between child and parent node. These issues can be overcome by introducing new mechanism of EPSD, which is used to enhance the performance of the RPL protocol.

In this mechanism, node distance, node energy and delay are considered for selecting the best parent in the DODAG. Received Signal Strength Indicator (RSSI) is used calculate the distance. Using the distance value, measures like energy, delay and the rank value are calculated through which the parent node is selected to route the packet. Through the proposed mechanism, some of the impact occurs in RPL protocol can make an effort to deal with a problem. This approach reduces the delay occurring in routing packet from the destination to root node and route the packet by using minimum number of nodes in the DODAG.

Working of Trickle Timer

Trickle timer concept is originally designed for programming language. This concept is embedded with the RPL protocol by IETF team. The concept of trickle timer is used in RPL protocol to monitor the node. The nodes are monitored for reducing the congestion and to re-route the packet by selecting the alternative path. Control messages are broadcasted at every particular time interval to maintain the DODAG in RPL network.

Let’s assume, the DODAG is constructed based on the energy. During the broadcasting of DIO message, if there are no changes in the energy of parent node, then the time span is increased to (i+i). If a change is found in the energy of the node, then the time span is reset to initial time span one.

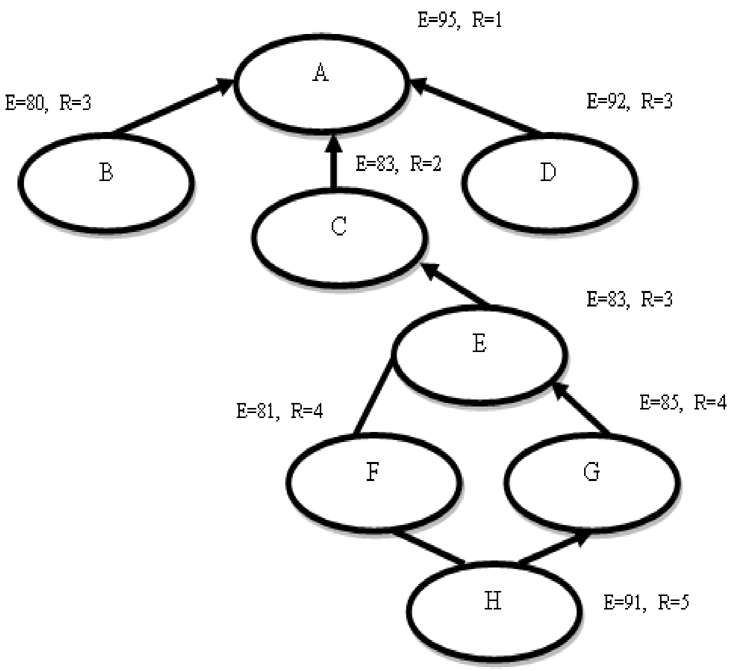


Figure 1: DODAG in RPL

Figure 1 explains the concept of trickle timer. Node H is the end node and node A is the root node. Path H-G-E-C-A is selected to route the packet. The packet starts to send from the Node H to Node G. After selecting the parent node, control message DIO is broadcasted between the child node and parent node at specific time interval. Let us consider, the path is constructed based on the energy. Node H sends the packet from the Node G. Energy of the Node present in the DODAG varies at the initial stages. Energy value of the devices is reduced when it is selected to route the packet.

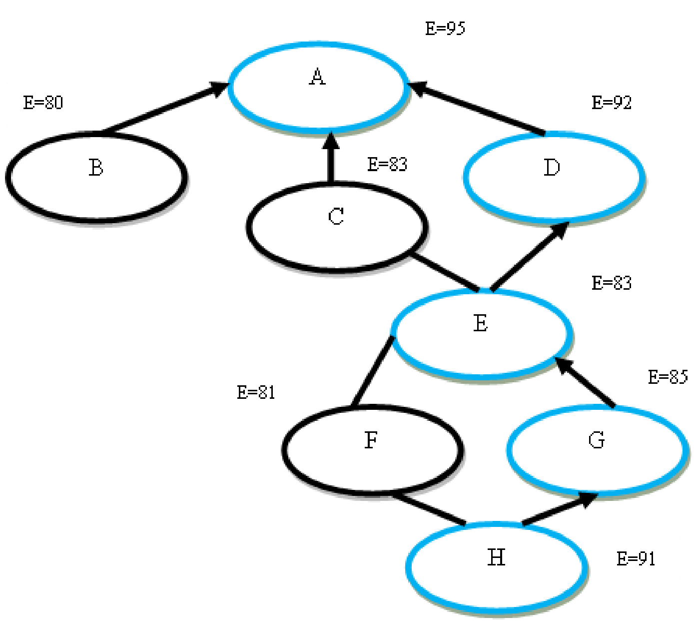


Figure 2: Energy based DODAG at Initial Stage

The energy based DODAG is shown in figure 2. First, the node H starts to send the packet to the Node G. The control messages DIO is broadcasted between the Node H and Node G. Node E is the only parent to the Node G. After the completion of transmission of packet to Node E, Node E starts to transmit the packet to Node D. The control messages are broadcasted between the node E and node D.

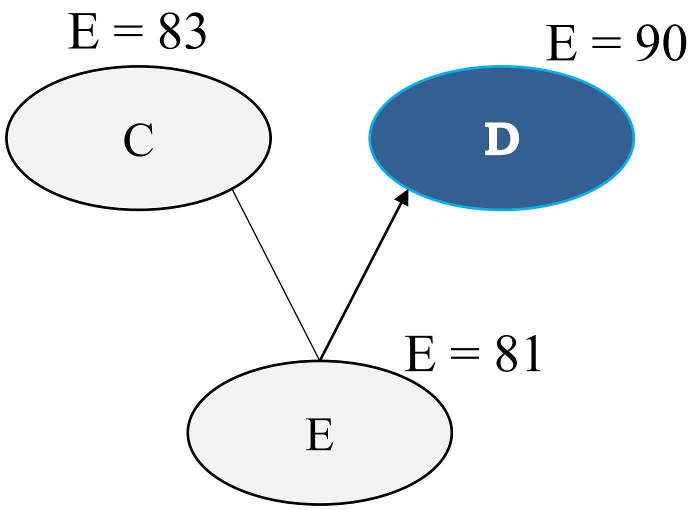


Figure 3: Energy based DODAG at 1st life span

First life span of energy based DODAG is exhibited in figure 3. Here, the energy value of node D is 90% and Node C is 83%. The rank value is varied. Next DIO message is broadcasted between the node E and node C. Now the node D is selected as a parent.

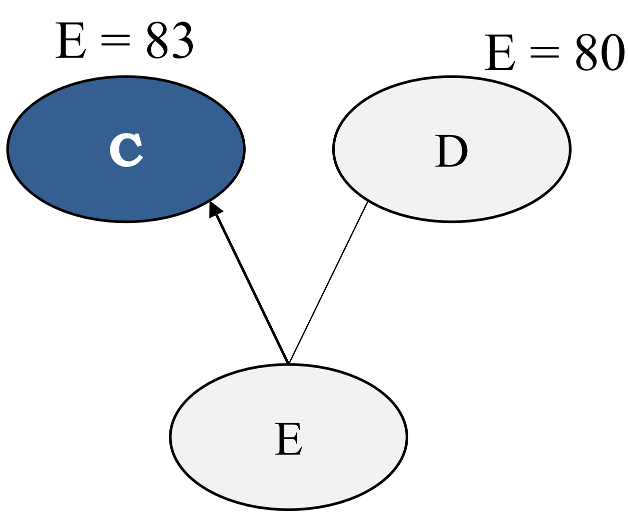


Figure 4: Energy based DODAG at 2nd life span

In the next life span, next DIO control messages are broadcasted which is shown in figure 4. Here, the energy value of Node D is 80% and Node C is 83%. Now Node C is selected as parent. Like this process will be continued until it completes the transaction.

Parent Selection Procedure

In this proposed mechanism, we improve the performance of the RPL protocol by following three important steps as:

- Finding the nearest node
- Identifying the node with maximum life time
- Calculating the energy required to send the packet

Henceforth, we select the best parent node based on above steps. These three steps are the backbone of our proposed mechanism, which is indicated via the below figure 5.

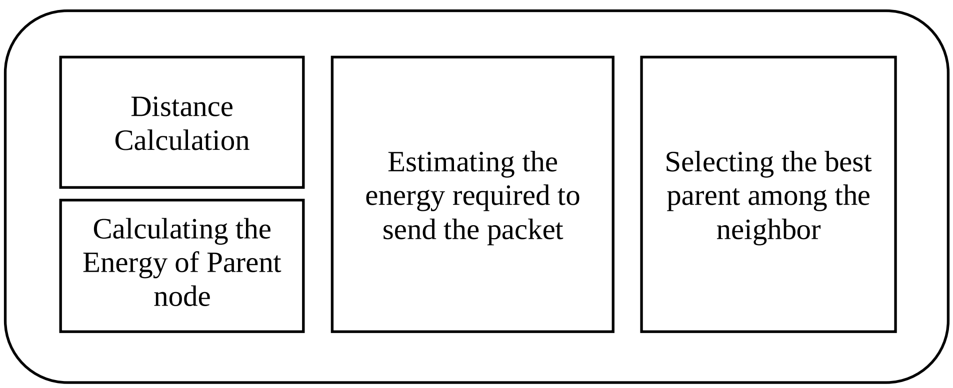


Figure 5: Working Procedure of Proposed Mechanism (EDPS)

Figure 5 depicts the working procedure of the proposed mechanism. It shows that how the parent node is being selected to route packet towards the root node. In the parent selection procedure, first step is to finding the nearest node. The nearest node is identified by the using the RSSI concept. The second step is to calculate the energy of that respective nearest node by using the below formulae 1 and 2. After finding the solution for step 1 and 2. The total energy required to route the packet is calculated as third step. Finally, the total energy required to route the packet is compared with the neighbor nodes. If the condition became true, then the node is selected as a parent. Otherwise, if the condition became false, then the same is checked with the alternative neighbor.

Working Procedure

The following are the working procedure to enhance the Quality of Service based on energy in our effort to reduce delay in RPL:

- DODAG is constructed with the existing objective function
- Routing Begins
- Energy of the dedicated parent node is calculated
- Check node energy with the threshold
- Node energy - greater than threshold - proceed with existing Parent
- Node energy - less than the threshold - initiate the parent selection process
- If the parent selection is initialized
- Calculate the energy of parent using the below formulae 1 and 2
- Energy required to n cycle (ER(N)) - greater than threshold - proceed with existing Parent
- Energy required to n cycle (ER(N)) - less than the threshold - initiate the parent selection process
- Among the set of parent nodes, the node with high RSSI and high Energy for transmitting all packets is selected as parent.

$$\text{Energy required for one cycle (ER)} = E_{max} - E_{min} \quad \text{----- (1)}$$
$$\text{Energy required to n cycle (ER (N))} = E_{max} - EC \times \text{Number the iteration} \quad \text{----- (2)}$$

where,
E-max - Energy of the node before transaction
E-min - Energy of the node after the single transaction
EC - Energy Consumed.

IV. RESULTS AND DISCUSSIONS

Simulation Results

The Energy-aware parent selection mechanism to reduce delay in routing for RPL was simulated using COOJA simulator on Contiki operator system. Contiki is nothing but an open source and lightweight operating system, which is specifically, dedicated to Internet of Things (IoT) related applications. The evaluation was done based on the QoS parameters such as delay and control message overhead. The proposed mechanism uses sky mote nodes and the testing is carried out with number of nodes like 10, 20, and 50.

COOJA Simulator Operating Procedure

The COOJA simulator was deployed and simulated for our IoT-based delay and control message overhead applications as per the following operating procedure[5]:

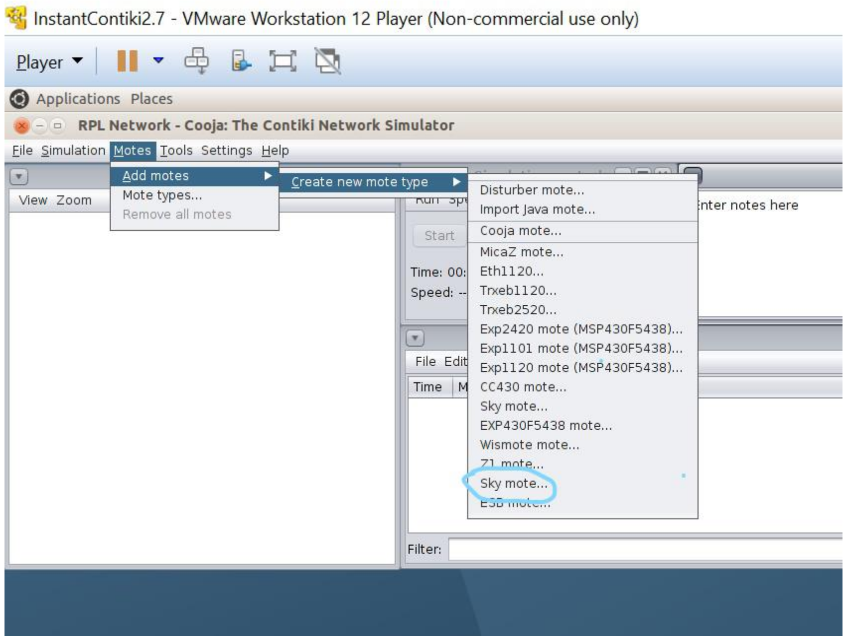


Figure 7: Pictorial guide for Sky Mote selection

COOJA Simulation Screenshots

The simulation parameters taken for our proposed experimental work is indicated in the below table 1.

TABLE 1: NETWORK SIMULATION PARAMETERS FOR THE EXPERIMENTAL SET-UP

Parameters	Description
No of Nodes	10, 20, 50
Simulation Area	700*700
Data Rate	110 Kbps
Node Arrangement	Random
Operating System	Contiki
Simulator	COOJA
Types of Sensor node	Sky Mote
Packet Analyzer	Wireshark
Technique	EDPS, RPL

The screenshot of that simulation done in the Graphical User Interface of the COOJA simulator is indicated via the below figure 8.

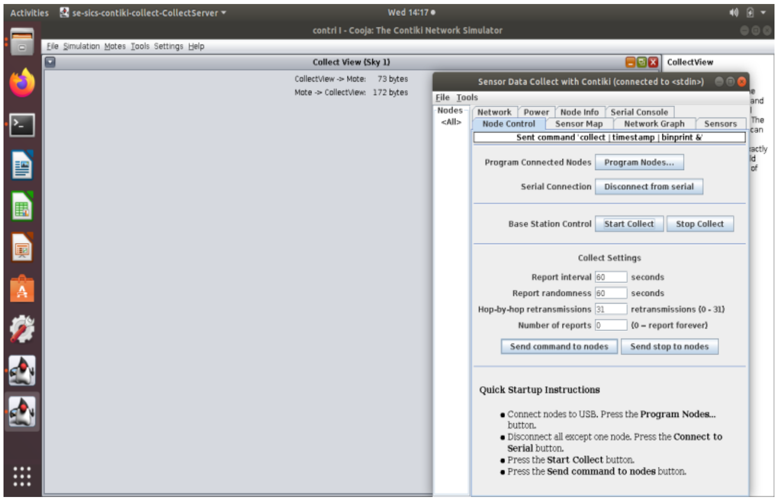
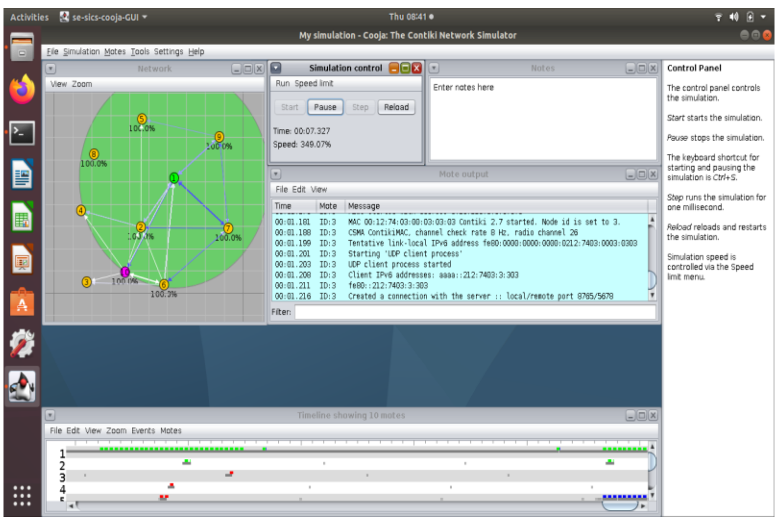


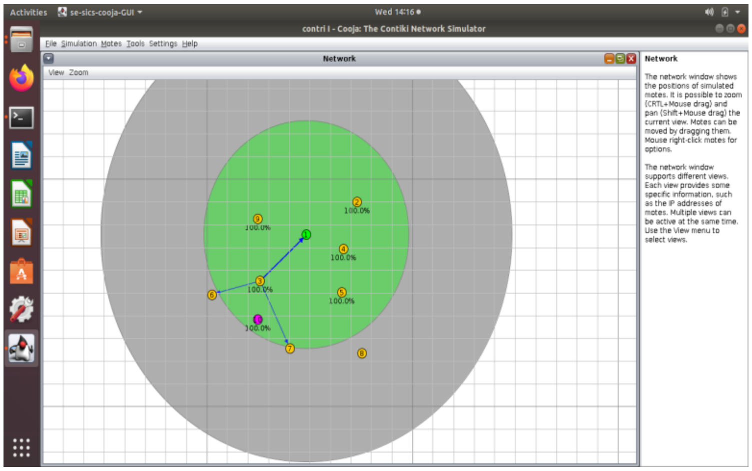
Figure 8: Simulation Screenshot

Simulation of 10 Nodes

Then, we proceed with the testing for three cases of nodal numbers by carrying out simulation z and followed by the sensor mappings for every case of considered nodal number. For 10 number of nodes, the simulation screenshots with zoom functionality enabled is indicated in the below figure 9.



(a) Simulation window for 10 nodes

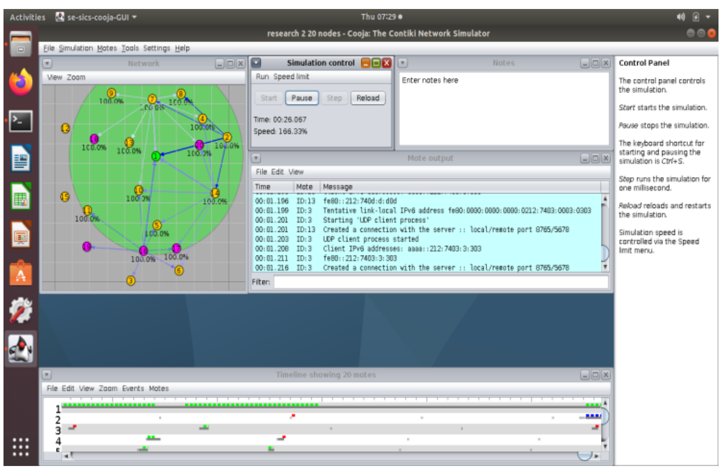


(b) Zoomed Simulation window for 10 nodes

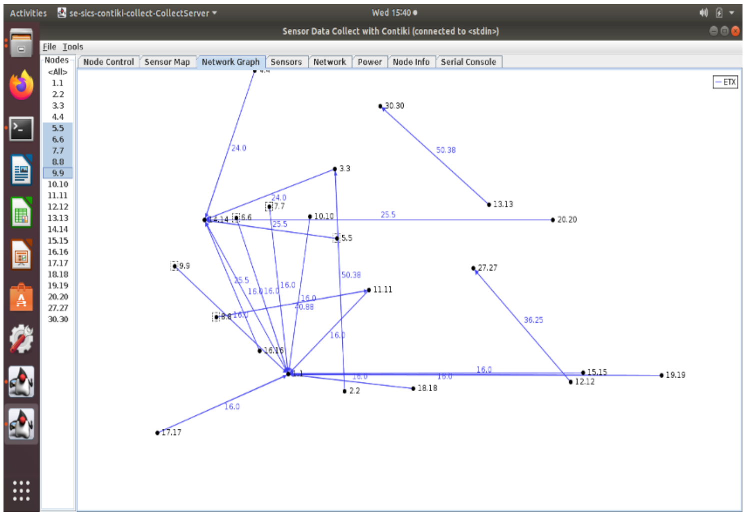
Figure 9: Simulation screen shot of node deployed with 10nodes

Simulation of 20 Nodes

The similar fashion simulation and sensor mapping was done for the case of 20 number of nodes as well, which is indicated in the below figure 10.



(a) Simulation window for 20 nodes

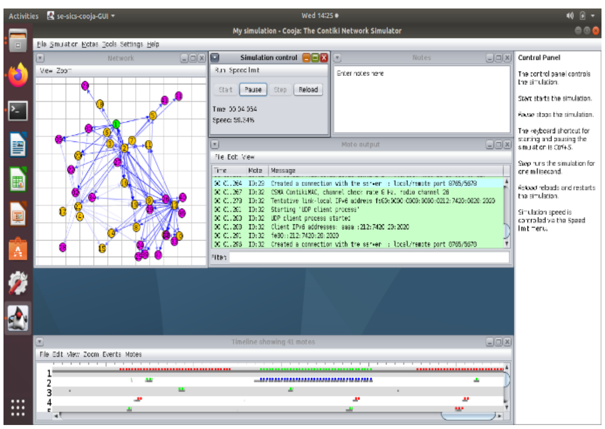


(b) Simulation sensor mapping for 20 nodes

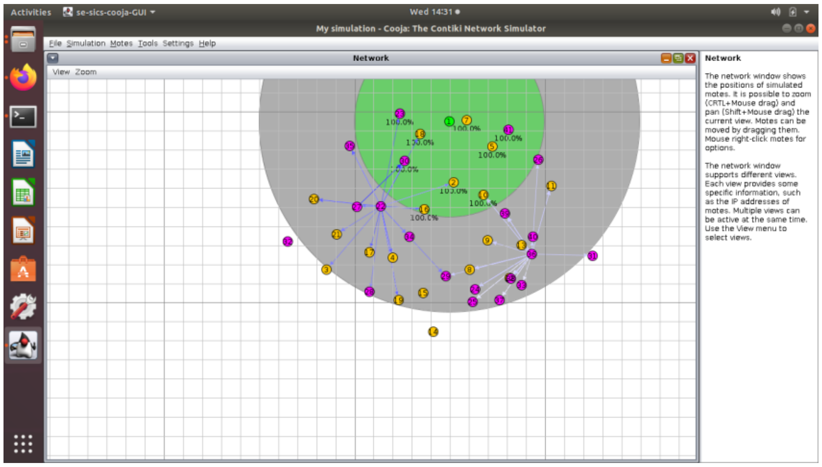
Figure 10: Simulation screen shot of node deployed with 20nodes

Simulation of 50 Nodes

Finally, we simulate and map the sensor for the case of 50 number of nodes and we indicate the simulation window along with its settings panel in the below figure 11.



(a) Simulation window for 50 nodes



(b) Settings panel of simulation done for 50 nodes

Figure 11: Simulation screen shot of node deployed with 50nodes

Comparative study

Now, we compare the delay outcomes that's received with our efficient parent selection methodology and the existing works of Routing protocol for low power and Lossy network (RPL) and Minimum Rank with Hysteresis Objective Function (MRHOF) for validating the reduced delay in the network.

The below table 2 shows the network delays for Energy aware Parent selection to improve Packet delivery ratio in RPL networks (EDPS) along with two other methods like RPL and MRHOF for three different kinds of node counts like 10, 20, and 50 respectively.

TABLE 2: PERFORMANCE EVALUATION OF PROPOSED AND EXISTING WORK FOR DELAY (MS)

Techniques/ Node	**10 Nodes**	**20 Nodes**	**50 Nodes**
Routing protocol for low power and Lossy network (RPL)	0.41	0.87	0.97
Minimum Rank with Hysteresis Objective Function (MRHOF)	0.39	0.74	0.93
Energy aware Parent selection to improve Packet delivery ratio in RPL networks (EDPS)	**0.35**	**0.71**	**0.89**

From the table, we can infer that the proposed EDPS method give rise to a reduced delay time for all the cases of considered number of nodes as shown with the bolding style in the above table 2. The same values are plotted in the below figure 12 as well by taking the existing as well as the proposed methods in the x-axis and the average end to end delay time in the y-axis respectively.

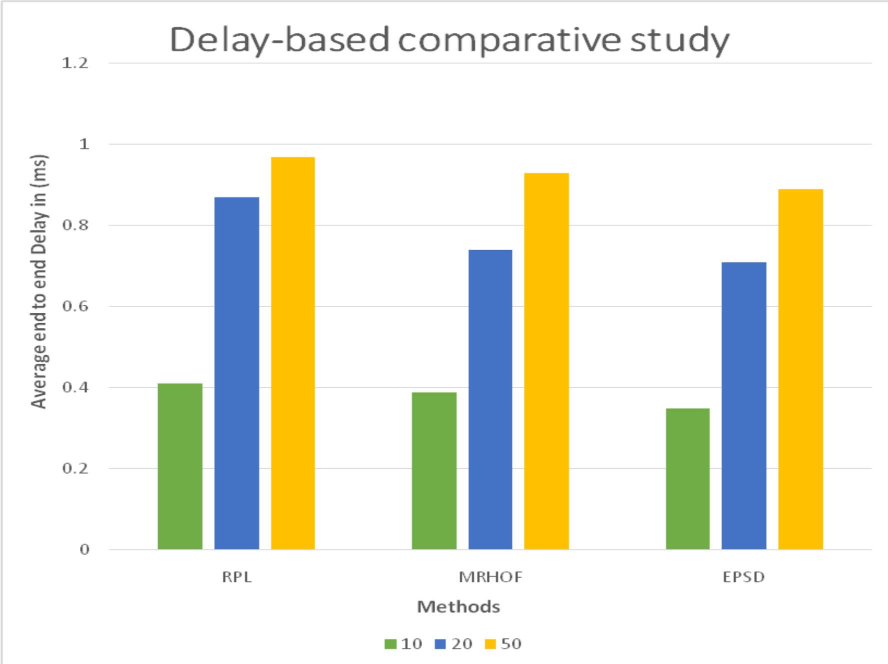


Figure 12: Comparison of Proposed EPDS with existing RPL and MRHOF

v. CONCLUSION

Energy-aware path-selection process was enhanced by reducing the delay time in the RPL network. In this proposed work, RSSI value and energy along with the delay time were considered as the criteria while selecting the best possible parent. The concept of RSSI was used to find the node position and energy was considered to avoid selecting the node with minimal energy. The node- parent selection took place not only based on the rank value and energy estimations, but also it was efficient in terms of delay as per our objective. However, still the control of overheads in the control packets is necessary in order to control the congestion, which is helpful in maintaining the connections in any network.

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