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Improving Lifetime of IoT Network by Improvising Routing Protocol on Low Power and Lossy Network by using Contiki Cooja Tool

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***Abstract*— The sensor enabled applications coupled with Internet are currently increasing among everyone. Low power and lossy network (LLN) equipment have diminished memory, energy, and refining resources. In LNN power conservancy and network lifetime improvement are foremost challenges. The high energy depletion, packet loss ratio and increased traffic are due to ineffective route selection. In Internet of Things (IoT) LLN system, the routing protocol should improvise the network lifetime by enhancing proactive routing method for each node to keep up a functioning way to the sink hub. The synchronization between sinks makes it to know about the network state of nearby sink nodes and uses the occasional course support messages provided by RPL to deal network status with its neighboring sinks. The sinks can formulate a decision to improve overall performance with increased network lifetime. To appraise the performance of projected work regarding network lifetime and packet delivery ratio (PDR) over traffic load and routing metric, Contiki COOJA simulator is used.**

Keywords—Low power, Internet of things, lossy network, Energy efficiency, Routing protocol

I. Introduction

Wireless Sensor Network (WSN) is a unit of LLNs which are categorized as minimal power and energy constrained device that are interrelated with links, where LLN devices can act as data originator and router [1]. The wireless links in LNN are lossy in comparison with other wireless networks because of quality of radios and minuscule size of LNN and the routing protocols in LLN provide routing within the network. RPL supports IPv6 connectivity. RPL deploys numerous sinks inside the network. The sink node presence is identified by the network device through a control message used by every node. Depend on the number of sink availability the network is divided into many segments [2]. In RPL communication, control information transmitted by network device depends on network dynamics frequency which is used for routing topology management. The control information frequency is very less when operation in the network is idle and frequency of control messages is high if there is constant change in topology. If the device is mobile, sinks in RPL send information at high frequency which results in unstable routing paths and topology [3]. The synchronization within sink nodes permits sinks to study about the mobility level, traffic, network size, and the position application constraints perceived by every sink. RPL was proposed for issues in lossy and low power networks. Based on network reliability and topology changes RPL has great rate of control message.

A. Low Power and Lossy Networks (LLNs)

The network routers and their interrelates are exceedingly resource constrained with restricted battery power, memory, low data rates unstable links ,maximal loss rates and low packet delivery rates with point and multipoint routing [4].

B. Routing Challenges in LLNs

LLN has restricted memory, resource and power resources. In LNN power conservancy and network lifetime improvement are foremost challenges [5]. The high energy depletion, packet loss ratio and increased traffic are due to ineffective route selection [6]. LLN networks use both wired and wireless communication technologies with thousands of nodes and multiple types of trac patterns [7].

II. RPL

RPL is a separate vector source steering convention. In LLN, RPL utilizes object capacity to reduce the sink reaching cost from nodes. The DIO message is accepted by neighbors of the root to update their rank and send feedback to the root node for parent [8]. The child node uses preferred parent for routing. The node multicast DIO messages for topology maintenance and maintain all connectivity, child hub unicast periodic feedback to the corresponding parent node by destination advertisement object (DAO). The network LLN has many routers and physical devices (with sensors) with link instability and high loss rates [9]. RPL transmit the data packet from source to root in multi-hop and route selection in RPL improves the quality of service with improved utilization of energy and network lifetime enhancement. In RPL data traffic is reduced by BDI (Load and Battery Discharge Index). DODAG (Destination Oriented Directed Acyclic Graph) sends the DODAG Information Object (DIO) messages to every nodes to choose best parent. Figure 1 shows the graph for DOGAG.

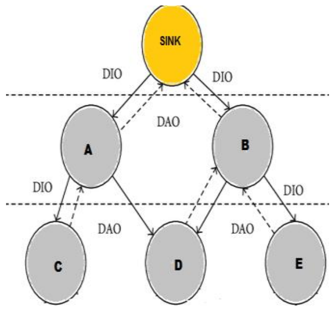

Fig. 1. DODAG Graph

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DODAG rank ascertains from least burden and BDI estimations of the hub where the member hub chooses the best parent with reduced data traffic in routing. RPL targets nodes which occasionally send information to a collection point [10, 11].

Following are the categorize of control messages in RPL protocol:

- DODAG Information Object (DIO): DIO message to build a new DODAG which contain data for identifying RPL instance. To construct the DODAG, parent set and configuration parameters.
- DODAG Information Solicitation (DIS): To initiate others to send DIO messages any node will send this message to other node and it happens only if the node didn't receive a correct DIO message.
- Destination Advertisement Object (DAO): After DODAG develops every hub G sends the message to engender node rank and routing tables' information to their precursor nodes.

A. RPL Topology

RPL systematizes its topology into DODAG where DAG rooted at a solitary destination without any outbound edges. Each DODAG has DAG root where the graph is identified by RPL Instance ID and DODAG ID [12]. The rank defines ones position of each node to other nodes depends on DAGs Objective Function (OF) which calculates function of link metrics. DODAG root is liable for organizing a number of parameters like Trickle Timer Options, Min Hop Rank Increase, Path control size and DODAG Preference Field which are carried in DIO messages. The DODAG root acts as a programmed intermediary Rendezvous Point for multicast streams began in the RPL space [13].

III. Performance Evaluation Studies using Contiki/Cooja simulator

The performance metric of RPL can be studied in many ways like End-to-End (E2E) delay, energy efficiency, length of the path, network convergence time and Packet Delivery Ratio (PDR), stability of DODAG and Trickle timer configurations [14]. As far as number of hops rank in RPL denotes the distance of router from the DODAG root. The average number of parents per node grew with the switches if the network density is kept constant [15]. The performance evaluation studies can be done on networks that range from 10 to 100 nodes on simulators such as Contiki/Cooja. Contiki Cooja is an open source framework for IoT which links tiny power microcontrollers to the Internet and for IoT it provides a reliable operation of RPL. Contiki RPL is an application of RPL which implement ETX as the default objective function. The rank is estimated based on ETX metric. The sink begins accepting information when the system is sent with low arrangement time. Table I shows the study of Contiki/ Cooja and Contiki/ WSNet performance evaluation.

In constant state, the routing overhead of network is 20% of the all trac with 10 nodes, and increase up to 80% with 100 nodes. The packet delay rate was reliant on node distance and not responsive to Packet Error Rate (PER). For network with 10 nodes, the delay is small which is fewer than three seconds and with 100 nodes network the delay is not more than six seconds. The delays maximize with number of nodes hence size of the network plays significant feature. Figures 1 and 2 show RPL and RPL DODAG in Cooja simulator respectively.

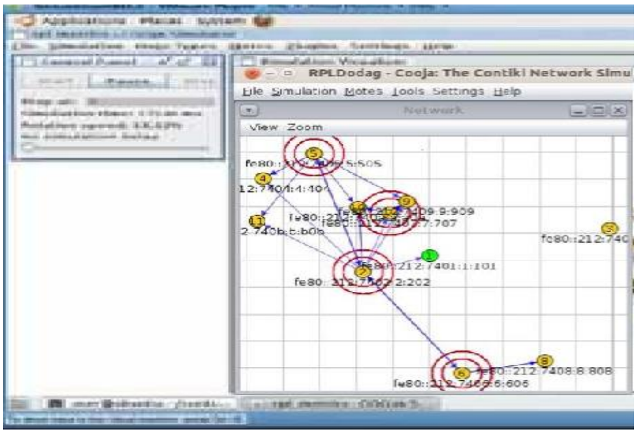

Fig. 2. RPL in Cooja Simulator

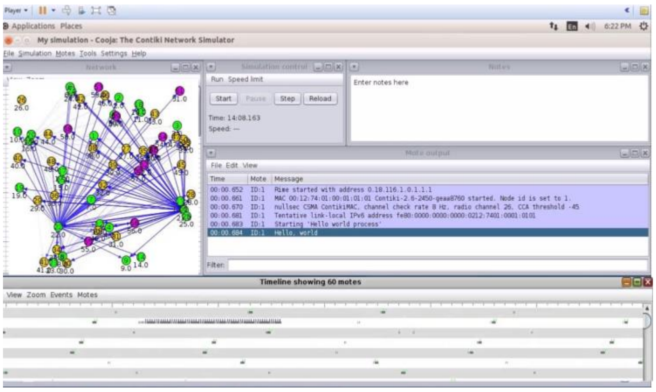

Fig. 3. RPL DODAG in Cooja Simulator

TABLE I. Performance Evaluation Studies

Result	Size of study	Objective function
PDR α Dist from sink Very low setup time Delay α N	10 to 100	ETX
PDR α PRR until PRR = 60% Power consumption α 1 / P RR MRHOF has better power consumption than OF0 MRHOF	10 to 30	ETX and Number of hops
PDR α N Minimum hop showed least delay MRHOF than LQI Poor route overall stability	200	Min hop, ETX and LQI

A. Improved Energy Efficacy

The nodes would suffer from uneven energy distribution which tends to maximum packet loss rate. To balance the overall energy consumption ETX (defines link stability) and other energy measures are employed to protract the network lifetime [16]. Table II shows the improvements to the RPL routing. The nodes with minimum ETX value, the success transmission rate will be higher and if nodes have higher ETX value it will pave way for unstable residual energy, reduction in lifetime and network partition [17, 18]. The value 0.4 is assigned for simulation with DIO MinInterval set as three seconds. The use of ETX and the parent nodes remaining energy identifies the ideal parent

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increase the network lifetime. Figure 4 shows the Cooja simulator result for average power consumption.

TABLE II. IMPROVEMENTS TO THE RPL ROUTING

Idea	Improvement	Number of nodes
Congestion avoidance using multipath routing	evade congestion, improves reliability in high data trac and minimize delay	25
QoS aware fuzzy-logic OF	Backwards compatible with RPL, minimize packet loss , number of hops, and average delay	200
Composite metric for improved energy efficiency	Distributes energy well network lifetime is more prolonged	3 to 6
Propose an improvement to MAC protocol for better energy efficiency	for Nodes which is far from DODAG root average delay is reduced	15

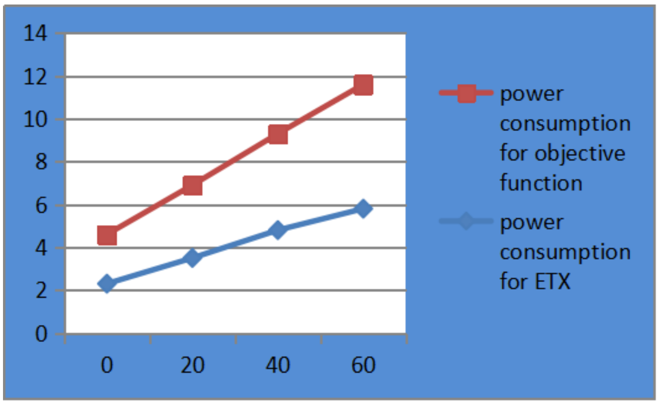

Fig. 4. Cooja Simulator result for Average Power Consumption

B. Control Traffic Overhead

The absolute traffic control is mentioned under OF0 and ETX while running an irregular recreation of the RPL procedure during 1000 s iteration times. OF0 need more control messages in dense network system for route calculation than ETX where the network size increase hop count is increased [19]. Figure 5 shows the overhead between ETX and OF0.

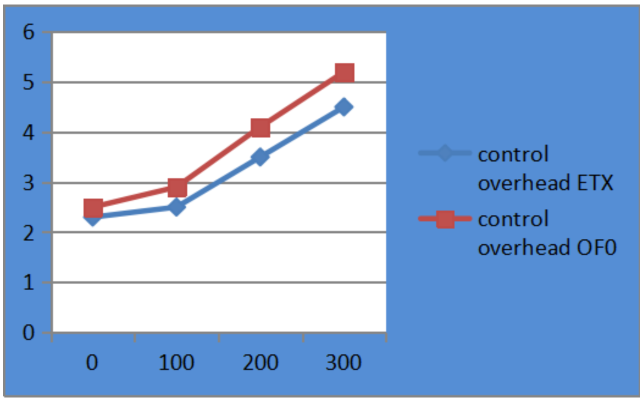

Fig. 5. Control Overhead between ETX and OF0

IV. CONCLUSION

RPL is a standard routing convention for low power control and lossy networks designed to cater to the routing issues posed by LLNs. It was build to save network energy and better utilization of limited resources which would optimize the network lifetime. For efficient energy use control messages are sent periodically than continuously. Contiki/Cooja simulator for IoT links tiny low-cost and power microcontrollers and provides reliable operation of RPL. RPL grow Internet of Things as it involves effective usage of assets and vitality which increment the general system lifetime.

REFERENCES

[1] Howser, G. (2020). Populating and Maintaining the Route Table. In Computer Networks and the Internet (pp. 193-198). Springer, Cham.

[2] Damaj, I. W., Mardini, W. E., & Mouftah, H. T. (2020). A mathematical framework for effective routing over low power and lossy networks. International Journal of Communication Systems, e4416.

[3] Mishra, M., Shukla, P., & Pandey, R. (2019). Assessment on different tools used for Simulation of routing for Low power and lossy Networks (RPL). International Journal of Scientific Research in Network Security and Communication, 7(4), 26-32.

[4] Wang, J., Chalhoub, G., & Misson, M. (2019). Adaptive Downward/Upward Routing Protocol for Mobile-Sensor Networks. Future Internet, 11(1), 18.

[5] Li, W., Wang, Y., Sun, Y., & Mao, J. (2020). Research on Low-energy Adaptive Clustering Hierarchy Protocol based on Multi-objective Coupling Algorithm. KSII Transactions on Internet & Information Systems, 14(4).

[6] Jing, X., Zhang, X., & Xun, S. (2019). Application of Multi-path Assignment Model of Bicycle Traffic Flow from GIS for Street Space Quality in Ecological Planning Management Information System. Ekoloji Dergisi, (107).

[7] Zheng, W., Sun, K., Zhang, X., Zhang, Q., Israr, A., & Yang, Q. (2020, August). Cellular Communication for Ubiquitous Internet of Things in Smart Grids: Present and Outlook. In 2020 Chinese Control And Decision Conference (CCDC) (pp. 5592-5596). IEEE.

[8] Mon Solomon, F. A., & Sathianesan, G. W. (2020). Fog Level Trust for Internet of Things Devices Using Node Feedback Aggregation. Journal of Computational and Theoretical Nanoscience, 17(5), 2181-2186.

[9] Rashid, S. A., Hamdi, M. M., & Alani, S. (2020, June). An Overview on Quality of Service and Data Dissemination in VANETs. In 2020 International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA) (pp. 1-5). IEEE.

[10] Sahay, R., Geethakumari, G., Mitra, B., & Goyal, N. (2019, March). Investigating Packet Dropping Attacks in RPL-DODAG in IoT. In 2019 IEEE 5th International Conference for Convergence in Technology (I2CT) (pp. 1-5). IEEE.

[11] Onwuegbuzie, I. U., Razak, S. A., & Isnin, I. F. (2020). Control Messages Overhead Impact on Destination Oriented Directed Acyclic Graph—A Wireless Sensor Networks Objective Functions Performance Comparison. Journal of Computational and Theoretical Nanoscience, 17(2-3), 1227-1235.

[12] Nandhini, P. S., & Mehtre, B. M. (2019, July). Directed Acyclic Graph Inherited Attacks and Mitigation Methods in RPL: A Review. In International Conference on Sustainable Communication Networks and Application (pp. 242-252). Springer, Cham.

[13] Belavagi, M. C., & Muniyal, B. (2020). Multiple intrusion detection in RPL based networks. International Journal of Electrical & Computer Engineering (2088-8708), 10.

[14] Sourailidis, D., Koutsiamanis, R. A., Papadopoulos, G., Barthel, D., & Montavont, N. (2020, August). RFC 6550: On Minimizing the Control Plane Traffic of RPL-based Industrial Networks. In Second International Workshop on Data Distribution in Industrial and Pervasive Internet 2020 (DIPI 2020).

[15] Lamaazi, H., & Benamar, N. (2020). RPL Enhancement Based FL-Trickle: A Novel Flexible Trickle Algorithm for Low Power and Lossy Networks. Wireless Personal Communications, 110(3), 1403-1428.

[16] Singh, H., Bala, M., & Bamber, S. S. (2020). Augmenting network lifetime for heterogenous WSN assisted IoT using mobile agent. Wireless Networks, 1-15.

978-1-7281-7274-3/20/$31.00 ©2020 IEEE

[17] Bhowmik, T., & Banerjee, I. (2018, December). An Improved ACO Based Energy Efficient Routing Algorithm in WSNs. In 2018 15th IEEE India Council International Conference (INDICON) (pp. 1-6). IEEE.

[18] Yuvaraj, D., Sivaram, M., Ahamed, A. M. U., & Nageswari, S. (2019, October). An Efficient Lion Optimization Based Cluster Formation and Energy Management in WSN Based IoT. In International Conference on Intelligent Computing & Optimization (pp. 591-607). Springer, Cham.

[19] Kumar, S., & Tiwari, R. (2020). Optimized Content Centric Networking for Future Internet: Dynamic Popularity Window based Caching Scheme. Computer Networks, 107434.

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