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A Review on RPL for Low Power Lossy Networks

P. Srikanth[1], Prof. S. Pallam Shetty[2]

[1]Research Scholar, Department of Computer Science & Systems Engineering, Andhra University College of Engineering(A), Andhra University, Viskhapatnam, Andhra Pradesh, India

[2]Department of Computer Science & Systems Engineering, Andhra University College of Engineering(A) Andhra University, Viskhapatnam, Andhra Pradesh, India

ABSTRACT

Wireless Sensor Networks (WSN) plays a significant role in measuring different physical factors that affects the environment in various fields. WSN are deployed into Low power Lossy Networks (LLN) in different fields like agricultural, medical and industries in sensing the physical characteristics and responding with reliable actuating devices. WSN devices communicating via internet had made new era for IOT. WSN are low energy constrained devices with sensing and actuating for continuous monitoring and sharing the information over various platforms over a network (data dissemination towards sink node).IETF has standardized RPL as an optimized routing protocol for IPv6 in Low power Lossy Networks. In real world scenarios , RPL's performance is measured by various metrics packet delivery ratio, ETX for optimization of throughput by enhancing power consumption.

Keywords : Wireless Sensor Networks, LLN, RPL

I. INTRODUCTION

In the present scenario there is a tremendous improvement in various field like Agricultural, Medical and Industrial due advent of technology and communication (ICT) tools. In any above-mentioned fields, there is a need to sense environmental changes and respond accordingly. Due to less human intervention, the sensing devices need to communicate actuating devices for relative changes. Wireless Sensor Nodes are deployed over a network needs to be communicated via internet.

In contrast to above mentioned means, Wireless Sensor Networks (WSN) growing as an emerging technology to be deployed in any fields like agricultural, medical and industrial. Wireless Sensor Networks are featured by constraint nodes with energy resources (with minimum battery power), limited memory, low processing capabilities, low range for communication and reliability in robust environment. In order to overcome the above challenges, a solution like improving the channel hopping efficiency IEEE 802.15.14e TSCH[5] with developing IPv6 Protocol Stack for improving mobile communication bandwidth.

This Low Power energy constraint nodes to be deployed in to the real-world Low Power Lossy Networks (LLN). Information obtained from various source nodes are to be routed to Sink nodes in low Power Lossy Networks. In conventional technique of routing, a traditional network model requires a reliable route for data communication which will make reasonable impact on energy consumption by various physical influential factors in environment. RPL is developed on extensively used protocol for routing and prototype model for Wireless Sensor

Networks. RPL provides connectivity among huge number of low power battery equipted wireless nodes to route the data over multiple hops using IPv6 Connectivity. Basically, Low Power Lossy Network (LLN) emphasises on pro-active, reactive and geographical routing protocols for Peer-to-Peer (P2P) communication. RPL is an optimized protocol for routing in IPv6 is standardized by IETF for interoperability among various Low Power Lossy Networks (LLN)[2].An open sourced RPL used as ContikiRPL in contiki Operating System.

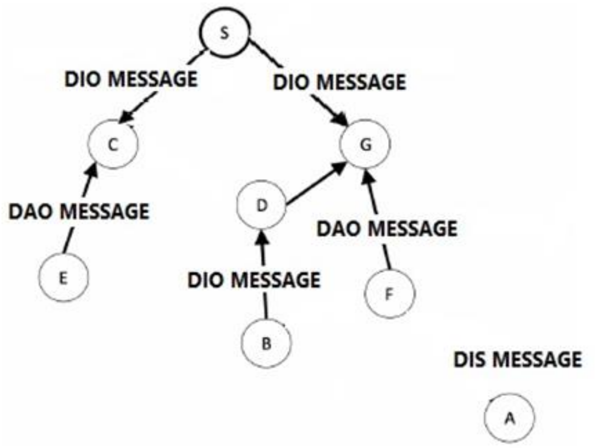
II. INTORDUCTION TO RPL

RPL is an optimized routing algorithm used for Low Power Lossy Networks (LLN) in a reactive network. RPL is distance vector protocol, routing in RPL is based upon the spanning tree constructed using Directed Acyclic Graph (DAG). DAG uses the routing of data from source node to a destination node (sink node) by constructing a Destination Oriented Directed Acyclic Graph (DODAG). The destination node in a DAG is a root node (Parent node) having no outgoing edges through it.

Control messages involved in DODAG tree construction are 1.DIO (DODAG Information Object) 2. DIS (DODAG Information Solicitation) 3. DAO(DODAG Advertisement Object) 4. DODAG Acknowledgement[3], all these control messages uses the Internet Control Message Protocol(ICMP).Realising the construction of network topology is through the usage of control messages. DIO is broadcasted downwards for constructing a tree by routing upwards to establish a communication between non-sink(single/multiple) nodes to sink(single) node. Multipoint to single point is a residing feature of RPL. Initially the non-sink nodes in a network broadcasts DIO message, other non-sink nodes in the same network which receives the DIO will be treated as neighbours. The non-sink nodes will treat the sink node as a parent and broadcasts the same DIO for further nodes in a network for topology progression and parent set generation.

DIS is a solicitation message generated by a non-sink node in requisition to become a member of DODAG for its consistency in a network .DAO is for topology construction by routing downwards, in where a child(non-sink) node requesting the parent (sink) node of an existing DODAG. DAO emphasises on P2P (peer-to-peer) and P2MP (peer to multipoint) with two of nodes 1.Storing 2. Non-Storing , sensing the routing information stored in a table at node(mostly the root node).The root node is a storing node which is grounded in acquiring the specific goal. DODAG-ACK is a acknowledgement message from a routing node.

An OF (objective function) specifies the rules in distance estimation for choosing the neighbours of parent node The Rank computation uses distance metric Hop Count. OF used to determine the node set and parent set. Parent set generation involves route discovery which specifies a optimal path computation between a sink and non-sink node. OF0 specified by RFC6552 uses the hop count as the routing metric[1][2].OF used to minimize the energy latency in routing.



S – sink node (as root node with storing) of DODAG
B,C,D,E,F,G- non-sink nodes of DODAG

A- Non sink node does not belong to DOADAG

III. RELATED WORK

X.Liu et al. [1] used OMNeT++ as a simulation platform and made a comparative study on RPL, LOAD-ng and geographical routing algorithms. There is an extensive study on analysis of performance metrics of RPL like Hop-Count, Estimated Transmission Count (ETX), Link Quality Data (LQI), per-hop ETX, stability index and path loss metric etc.., under various objective functions. They also specify memory constraint on nodes for large scale routing, effective OF generation using fuzzy inference system, reserving the battery for long run and security issues are the challenges in RPL.

M. Zhao, I. W. Ho et al. [4] proposes a novel technique by subset of nodes into regions basing energy constraints for the job to be done. In traditional approach routing need a reliable route for P2P communication leads to energy consumption. ER-RPL a set of nodes chosen from network are taken as region for reliable transfer of data limiting the energy constraints. Nodes which are aware of location capability are treated as Reference Nodes(RN), using these RN distributed among the network can be segregated as regions in network. Using the Euclidean distance from the RN, the nodes uses Distributed Self Rejoining Algorithm to join or to leave the network.

Krishna, G. G., Krishna et al. [5] made a comparative study between Zolertia Z1 and WiSMote on RPL using Simulator. Analysed the performance metrics like latency, Packets received per node on two scenarios like 1) 1 sink and 10 senders 2) 2 sink and 20 senders. Analysing the two scenarios the packet transmission capacity is optimal at Zolertia node and packet receiving rate is optimal at WiSMote.

L. Lassouaoui, S. Rovedakis et al. [6] made comparative study between Grid and Random topologies by considering two scenarios with packet loss 1) RX=100 (no data loss) 2)RX=60 (with 40% data loss) to analyse the factors like Estimated Transmission Count (ETX), Energy Total (ENG-TOT) for energy consumption. The Experimental results specifies the ETX obtains good results on PDR and delay, energy metrics also outperforms but with poor PDR as node link is not considered. R (Routing) metrics performs better when RX=100% in grid topology by considering network link and residual energy. However there is change in Grid when RX= 60% gives better result with ETX. Analysing the both scenarios R metric does good for network life time and for better ETX include delay in end-to-end transfer.

P.-O. Kamgueu, E. Nataf et al. [7] used Fuzzy inference system a hybrid technique combines the ETX, delay and node remaining energy into a single value for generating optimal Maximum Rank Hysteresis Objective Function (MHROF). This Objective Function (OF) is designed basing on the trade-offs for energy consumption and Quality of Service(QoS) factors in Multi Constraint Optimal Path Problem (MCOP). Experimental setup on 28 nodes deployed on 14 offices (two nodes per station) specifies results performs good on ETX with low packet loss ratio, routing stability and optimising the energy on reliable node to node transfer.

P. Levis, T. Clausen et al. [8] proposes a trickle algorithm for propagation and updating in wireless sensor networks periodically. Trickle algorithm uses a policy "Polite Gossip" periodically broadcasts summary of code to neighbours if it has been heard recently, which broadcasts the update. A Mechanism of suppression uses point of transmission in which communication rate scales logarithmically with Network Density (ND). Trickle uses the maximum Interval I_{max} ,minimum interval I_{min}, redundancy constant K and counter C as parameters to propagate control messages periodically.

B. Djamaa, and M. Richardson et al. [9] proposes the trickle algorithm for routing to address short time listening problem with less cost consistency in lossy networks but latency is considered as a problem in trickle algorithm. In worst case scenario with 90% data loss rate and same propagation delay in multi hop network short-trickle works 4 times faster the normal trickle algorithm and with increment in value of constant 'k' and decrement of propagation delay the short trickle works 3.5 time faster than normal trickle. In single hop network short-trickle works 5 times faster than normal trickle algorithm in 0% data loss.

G. Oikonomou and I. Phillips et al.[10] specifies that RPL uses trickle algorithm to multicast but uses an alternative method Stateless Multicast RPL Forwarding (SMRF). SMRF out performs the Trickle Multicast (TM) on delay and energy efficiency with a little packet loss. Performance and Energy Efficiency are analysed at various Network Density (ND) at 0.14, 0.36 and 0.71 respectively. TM is mostly affected by slight changes in I_{min} in duty cycling algorithm and contrastingly the performance of SMRF in not affected by natural variances with little loss of reliability

A. Aijaz, H. Su et al.[11] proposes a routing protocol CORPL for Advanced Metering Infrastructure (AMI) networks with cognitive radio enabled in smart grids. CORPL address the routing challenges in AMI networks by protecting Primary User (PU) and obtaining the reliability in secondary network in cognitive radio network. Reliability and data delivery with low latency are the challenges in AMI networks. CORPL maintains the reliability of AMI network by reducing the 50% of human interference and reducing the probability violation deadliness for delay sensitive traffic.

E. Ancillotti, R. Bruno et al. [12] mentions about the low data rates and design choices notifies about unreliability of the data transfer. RPL have a salient feature of cross layer design, optimised routing and enhancing linking capabilities for routing with efficient neighbour tables. Analysed the effectiveness of RPL with AMI networks as test case which obtained 200% increase in data delivery rate on 100 nodes differentiated by lack of duty cycling.

IV. FINDINGS FROM THE LITEERATURE SURVEY

In RPL routing protocol, various author made a comparative study of performance metrics in various scenarios .RPL is developed to over the design issues related to Low Power Lossy Networks. The design issues include various performance metrics like ETX, Hop Count, Packet Delivery Ratio (PDR), Energy efficiency and reliability of data transfer between nodes. Researchers also exploited the features like cross layer design, optimisation of objective function using fuzzy and time delay multicasting the control messaged using trickle in obtaining a decent result.

V. CONCLUSION

We reviewed the studies on RPL routing protocol by various researchers. This study specifies that various metrics outperforms in different scenarios but mostly reliability, delay and reserving the energy for future use are the common challenges. Basically fuzzy inference system is in regulating energy consumption and ETX, selecting an efficient region with limited nodes improves the reliability, optimizing the trickle algorithm decreases the delay. The future recommendation is to choose a hybrid objective function which covers all the design issues.

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