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An Efficient Backpressure and RPL Routing Protocol for Adaptive Switching in IoT

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***Abstract:** In an industrial IoT applications there will be more demand for adaptability to network dynamics and throughput support in an IoT networks, hence RPL(routing protocol for Low power lossy networks) LLN which supports only for static environments, hence in this paper we discuss the disadvantages of RPL on adaptability to network dynamics and throughput we proposed BRPL(Back pressure routing protocol for Low power Lossy Network) LLN to overcome the RPL disadvantages on throughput and adaptability to network dynamics in the industrial IoT applications. An IoT protocols are mainly used in smart cities, public water system, power grid and vehicle traffic control etc in this paper we also assure authenticity for these devices by using light weight mutual authentication method. Performance results are shown on simulation using Cooja simulation software for IoT applications.*

***Keywords:** Radio frequency identification development(RFID) Routingprotocol(RPL), Low Power Lossy Network(LLN), Back Pressure Routing Protocol(BRPL), Objective Function(OF).*

I. INTRODUCTION

The concept of IoT was coined by radio frequency identification development community members [RFID] it was developed in 1999, recently radio frequency identification development community members become more relevant to this practical world because mobile devices, embedded systems and ubiquitous communication, cloud computing and data analytics plays a major role.

When we enter into the imaginary world with billions of objects which can sense, communication and share information all this objects are connected over private or public internet protocols (IP) network. The objects which are interconnected collects data regularly, analyze and use for initiating the tasks, which provides a wealth of intelligence for planning and decision making. IoT is a physical network where physical object like sensor nodes are equipped. Internet is not only made for computer network but it is evolved into the devices irrespective of size and types. Some of the examples are vehicles, smart phones, home appliances, toys cameras, medical instruments, industrial systems, animals, people and buildings which shares information between them based on the specified protocols to achieve smart reorganization positioning, tracking safe and control the personal real time, online monitoring and administration.

The concept of IoT and paradigm which consider pervasive involvement in the environment of a variety of things it may be connected through wireless or wired and unique address to the individual devices is specified for communication we define IoT in three things people to people, people to machine and machine to machine. IoT is new revolution of internet where objects recognize themselves and intelligence is obtained by making decision related to context. Emerging of cloud computing is transition for the internet towards IPV6 with unlimited addressing capacity. In 2011 IETF standardized RPL and IPV6 routing protocol for low power lossy network. To build interoperable commercial appliances for certain constraints overlapping between the LLN and IoT, IPV6 was consider as essential for further applications on IoT later RPL protocol developed as a routing protocol for IoT devices this protocol stack was defined by IETF.

As shown in the Figure1 Routing topology created by the RPL in the form of destination oriented directed acyclic graph where data packets are forward in the upward direction i,e towards root. RPL supports for communication from device to root with minimum routing state.

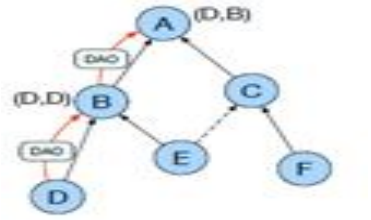


Figure 1 Routing in RPL protocol

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To support two way traffic from root to the device which means point to multipoint in RPL, it required routing state and additional control message. every node in the network must specify itself as a possible destination to the root by sending Destination Advertisement Object (DAO) this message is propagated in the form of upward direction in DODAG topology.

The rest of the paper is arranged as follows: Section II provides motivation Section III covering the related work. Section IV presents the proposed method. Section V provides the evaluation results analysis. And finally concluded paper in Section VI.

II. MOTIVATIONS

To support real world IoT applications, the networking services must reach many requirements are high throughput, adaptability to network dynamics and mobility and RPL protocols perform poorly to meet this requirements.

1) *Throughput:* RPL is suffering from congestion and high packet loss, high network traffic is due to DAGs which is defined by OFs are not using complete network capacity.
2) *Mobility:* Invalid routs and link breakage are happened in DAGs due to variations in time on network topology which causes mobility in nodes lack of flexibility in network topology and adaptivity in networks in an OF, RPL suffers from link breakage and invalid routs.
3) *Traffic Load Adaptivity:* RPL works efficiently only for fixed configuration and LLN (Low Power Lossy Network) produce traffic pattern for different time hence RPL suffers from traffic load and it leads to congestion or link breakage.

III. RELATED WORK

T. Winter and et al [1]. Proposed RPL as a de-facto in IoT standard for IPV6 and LLN's as RPL is the distance vector routing protocol which restricts the ability for routing to change the rank.

D. Medhi and k. Ramasamy,[2]. RPL is a distance vector routiung protocol due to this RPL suffer from Congestion and packet loss when traffic is high in the network this is because of DAG graphs which defines that network capacity is not fully utilize by its OF's. P.T.A. Quang and D.-S. Kim ,[3]. The message generation of RPL is time based, with routing and able to configure back –off messages is distributed with the time using trickle when DIO message is transmitted by RPL their may be two possible outputs that all the neighbor router know the message notification that contained information is from its own state or RPL itself detects that sender sends the DIO message or itself assumed that information is out dated.RPL router schedule time for emission of DIO message with trickle at a fixed time RPL protocol records all the information of DIO message.

T. Winter, P. Thubrt, A. Brandt, J. Hui,R.Kelsey, P. Levis, K . Pister, [4]. RPL performs based on priori assumption of traffic patterns. And the resulting protocol architecture reflects that constructing multipoint to point path is efficient to control traffic load. From parent, RPL selects the preferred parent for default serve towards the root thus RPL works as upward router and multipoint to point router RPL also act as a destination for traffic issues.

Roll Charter[5]. In LLN the second L specify high loss of data packets then typically seen in the network which mandatory some of the basic objects like DIO message with additional objects like auto configuration and network management.

IV. PROPOSED METHOD

This section describes the proposed extension for RPL. The aim of BRPL is to improve the performance of RPL in the field of throughput and adaptivity to network traffic dynamics. Architecture diagram for proposed system is shown in Figure 2. Proposed method has been discussed in the following steps:

A. Timer holds the logics which is related to tickle algorithm
B. Public API acts as an interface to allow the used application and to interact with BRPL.
C. Quick beta is used as an indicator for mobility awareness.
D. Quick theta is used for adjusting the parameters based on network dynamics.
E. DIO,DAO control message are send/receive between internal ICMP and ICMPV6 when ICMPV6 component send messages to ICMP the payload is extracted and DAG components is notified.
F. Application layer provides objective function OF.
G. Neighbor table is managed by the neighbor manager. Communication with IPV6 neighbor discovery the service and synchronize the neighbor table.
H. Incoming IPV6 data packets are stored by queue and data buffer is managed by queue manager.
I. For one hop neighbor rank face and link weight are calculated.
J. IPV6 routing table includes all logics related to DAG.

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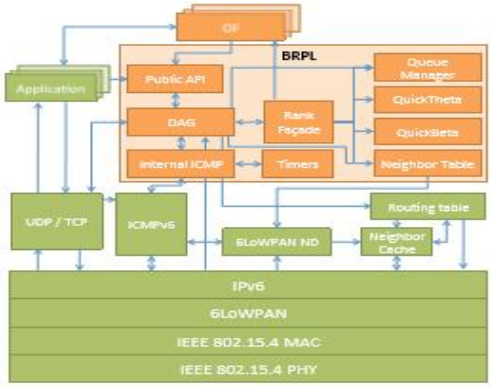


Figure 2 BRPL software Architecture.

BRPL works on the principles of backpressure and RPL routing, multi topology routing is supported by BRPL the basic idea of BRPL is to switch between Back Pressure and RPL. BRPL protocol works efficiently on achieving high throughput by using all possible resources and path for data transfer when network traffic is light in all the nodes then BRPL works as like RPL and BRPL uses the advantages of both Backpressure and RPL.

BRPL is implemented in an Cooja simulator software on Contiki OS for LLNs, based on simulations with Cooja simulator on a private cloud with 18 servers, BRPL works with RPL and Backpressure Routing. The results shows that BRPL achieves the advantages of both backpressure routing and RPL.

Some of the methods used in BRPL for achieving high throughput and adaptability to network dynamics are followed:-

1) *Multi-topology Queuing System:* Each IoT device which is running on BRPL is required to maintain a queue for every DAG and BRPL follows the principle of MTR as like RPL and individual DAG is built by an OF. BRPL works as upward data routing by combining all individual queue and OFs.
2) *Neighbor Table Maintenance:* When one-hop neighbor sends a DIO message to any node, in neighbor table it will update some of the fields from the senders record. Every node must broadcast individual DIO message to its one-hop neighbor. This BRPL protocol are fully distributed routing protocol.

The dataflow diagram for BRPL protocol on IoT application of the proposed system is shown in Figure 3.

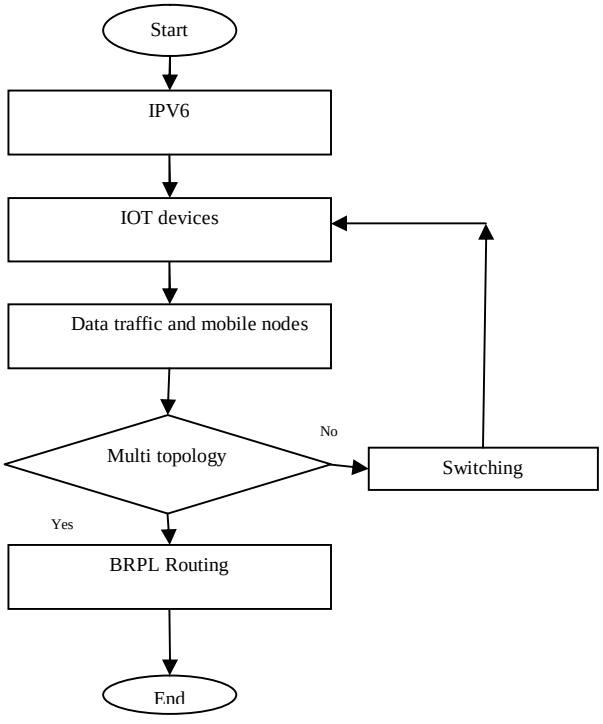


Figure 3 Dataflow diagram for BRPL protocol

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The data flow diagram represent the complete scenario of the working of BRPL protocol and data flow diagram initiate with start IPV6 are used for sending message to IPV6 are used to send the message to ICMP component and payload data is sent to IoT devices and if data traffic is high and congestion occurred in the mobile nodes and if the network is multi topology the BRPL protocol activates and starts its functions to avoid the congestion or else it switch to the IoT devices for data transfer.

Cloud is required for both RPL and BRPL to store and retrieve the data when it is necessary and BRPL works on 18 servers at a time. And authentication is required for data storage and retrieve, hear we take the smart city as the industrial IoT application where system need to update some of the parameters like temperature, vehicle traffic, air quality, noise level and some private information of the vehicle are updated or retrieved from/to the cloud.

Authentication is provided using light weight mutual authentication method for vehicle data by generating public key and private key by encrypting and decrypting the data.

Authentication is provided by taking two users ID and based on that identities of users public and private keys are generated that is (if A B are the two users PKA,SKA and PKB,SKB are the public and private keys of both users) if two users are mutually authenticate then output for that data is 1 if both users are not mutually authenticated then the output is 0.

V. RESULT ANALYSIS

In this analysis performance evaluation of BRPL protocol, BRPL gives high throughput and adaptability to the network dynamics compare to RPL where RPL is for fixed configuration and hence it is suffering from congestion and high loss of data packets. When BRPL is implemented and applied in the industrial IoT application like smart cities etc the throughput is improved and data loss is reduced and also authentication is provided for private data using lightweight mutual authentication methods and encryption and decryption techniques are used for key generation.

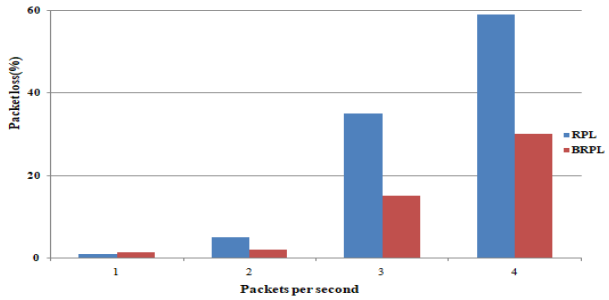


Figure 4 packet loss.

The RPL and BRPL performance are shown in the Figure 4 where x axis shows the number of packets sent per second and y axis shows the packet loss in the percentage where in RPL as packets increases percentage of packet loss also increases but in BRPL the loss of packets are reduced when compared with RPL.

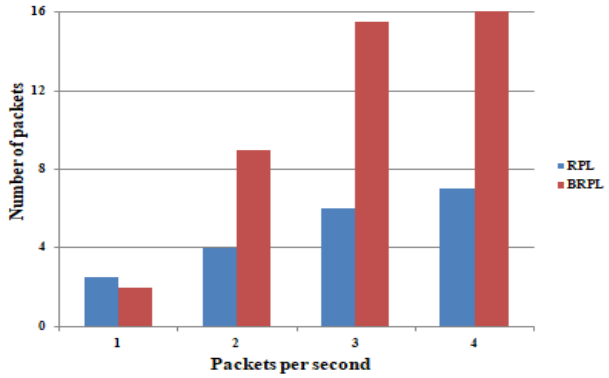


Figure 5 communication over head.

The communication over head performance of RPL and BRPL are shown in the Figure 5 where x axis specify the packets per second and y axis specify the packets that reaches the destination, graph shows the comparison of RPL and BRPL where BRPL gives the high throughput compare to RPL due its backpressure nature.

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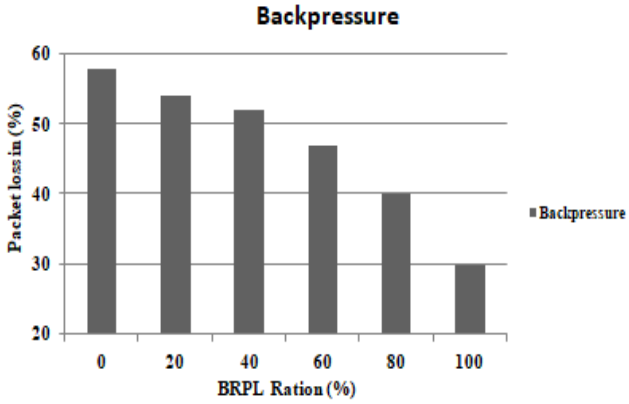


Figure 6 performance of Backpressure.

The performance of Back pressure is shown in the Figure 6 where Back pressure is incorporated with RPL protocol and that exist BRPL. Hear x axis shows the BRPL performance ratio and y axis shows the packet loss as the BRPL node deployment in the network increases the packet loss in the network decreases, hence BRPL reduce the data loss when we compare to RPL protocol in the industrial IoT applications.

VI. CONCLUSION

This work shows the disadvantages of RPL protocol that is low throughput, high data loss, low adaptability and variation in time while sending the data and RPL does not work properly for mobility nodes hence BRPL is proposed where Back pressure is incorporate with RPL to avoid all the disadvantages of RPL for certain level, the back compatibility switch between RPL and back pressure when network traffic is low only RPL protocol is used for routing and when high network is occurs then RPL switch to BRPL, where BRPL supports for node mobility and balance the network traffic by utilizing all the routs when it is necessary, multi topology queuing system and neighbour table maintains methods are used to control data traffic congestion and to update the information. All data is sent to the private cloud to store and retrieve. When we take the smart city as the example for IoT applications where few data need security hence for security purpose lightweight mutual authentication method is used to authenticate the data in the private cloud

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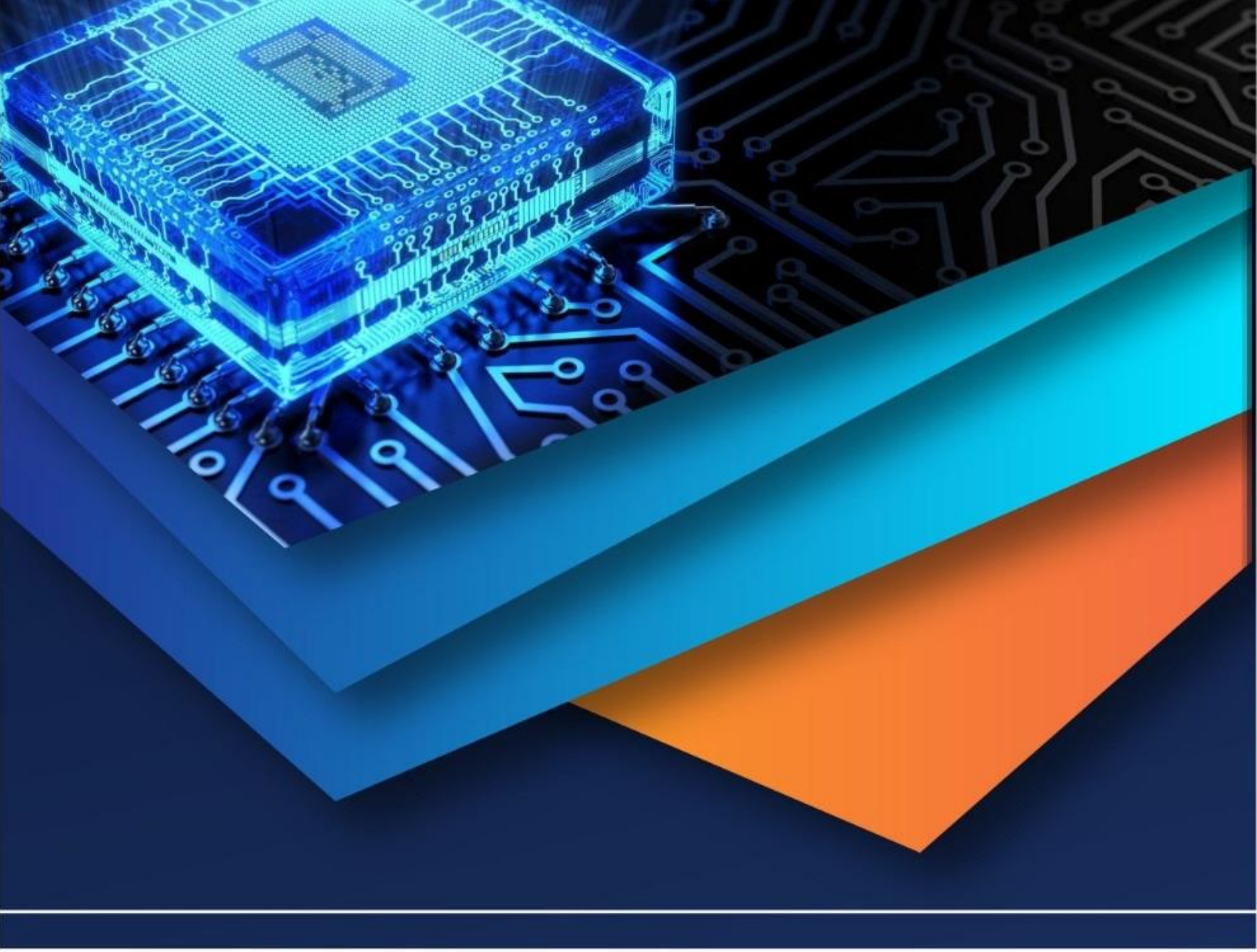
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