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A Survey on Mobility in RPL for IoT Applications

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Abstract - *In recent years, Low Power and Lossy Networks (LLNs) have greater potential due to vast development in IoT applications. Routing plays an important role in the overall Architecture of the IoT which must include efficient routing and low power consumption. Routing Protocol for Low- Power and Lossy Networks (RPL) is an ad-hoc Distance Vector routing protocol for LLNs that works on IPv6 with IEEE 802.15.4 standard. In this paper we will study framework for RPL (Routing Protocol for Low power and Lossy Networks) based routing protocols. We will study various methods that discuss the different protocols of WSN with detailed explanation related to RPL. Also, we explore various directions that discuss the mobility extension to the RPL.*

Key Words: **IoT, WSN, LLN, Routing protocol, RPL, Mobility.**

1. INTRODUCTION

The Internet of things (IoT) is a new appearance of the Internet which is a network of physical smart devices that are connected to each other for exchanging the meaningful information [1] via the Internet. With such types of low-powered, easy to handle, cost-effective smart devices, IoT has many applications in many domains such as electrical grid, parking system, environmental monitoring, home automation, health-care, supply-chain management, transaction processing and numerous more. With the evolution of such smart devices, a need arises to devise a protocol which is not only an energy efficient but also take other factors into considerations such as performance and mobility [2].

Wireless Sensor Networks were designed for many home and industrial sensing applications such as monitoring of the environment with a set of sensors (e.g.: temperature, humidity, brightness, carbon dioxide, etc.). A set of sensors are deployed in the targeted sensing field. They collect the sensing data from different locations and forward it for further processing to a Wireless Sensor Networks were designed for many home and industrial sensing applications such as monitoring of the environment with a set of sensors (e.g.: temperature, humidity, brightness, carbon dioxide, etc.). A set of sensors are deployed in the targeted sensing field. They collect the sensing data from different locations and forward it for further processing to a local or remote gateway also called a sink local or remote gateway also called a sink [3].

The nodes of a Low-Power and Lossy-Network (LLN) network is interconnected by different kind of link layer technologies such as Bluetooth, IEEE 802.15.4, ISA100a, and Wireless HART. The IEEE 802.15.4 in particular is a low-power radio standard specifically created for LLNs. It has a maximum data rate of 2,50,000 bits/s, and a maximum packet size of 127 bytes. This standard operates over free license radio bands in the 868 MHz, 918 MHz and 2.4 GHz ranges [4]. To route the data between the nodes, a routing protocol is required. The RPL protocol (Routing Protocol for Low-Power and Lossy Networks) is an IPv6 distance vector routing protocol designed for large scale WSNs. It is a relatively new protocol specified the Internet Engineering Task Force [5]. The protocol supports three different types of traffic: point-to-point, point-to-multipoint and multipoint-to-point.

The main concept of RPL is that the nodes are able to self-organize themselves by forming a tree topology with a root at the top (sink). There are redundant links in the topology that uses up and down directions depending on the network traffic pattern. Upwards traffic to the sink can be described as multipoint-to point, downwards as point-to multipoint and point-to-point traffic between nodes [6]. Given that RPL forms a tree topology with redundant paths and multi-hop infrastructure it can be adapted to support mobile nodes [7]. Considering energy Consumption, the protocol uses a proactive approach to construct and maintain the topology and a reactive approach for resolving routing conflicts the protocol constructs a hierarchical tree like topology also called Directed Acyclic Graph (DAG) with the aim of minimizing the path cost to the DAG root. Each sender node has a preferred parent, which acts as a gateway for that node and also determines the default path.[8].

The main concept of the protocol is that RPL organizes nodes by forming Destination Oriented DAGs (DODAG) where the sinks or gateways serve as roots of the DAGs. DODAG roots are uniquely identified by DODAGID. The LLN may consist of one or more DODAGs which form together an RPL instance identified by a unique ID, called RPL Instance ID. Each node has a rank which determines the relative position within the DODAG. The rank decreases up and increases down in the topology [5].

2. RPL ROUTE DISCOVERY MECHANISM

RPL is a kind of routing protocol designed for IP framework, in line with the future, which solves the problem of not compatible with the IP architecture [9] that existed in the

traditional Cluster-Tree and AODV routing protocols developed on ZigBee proprietary protocol stack. In ICMPv6 RPL defines DAG information object (DIO) and DAG announced target object (DAO) [10] to complete node discovery. RPL parent node sends DIO messages to notice down DAG which contain characteristic information of the sender. DIO messages are used for the discovery of DAG and maintenance. RPL child nodes send DAO messages to spread up the sender information, and filled in the parent node down routing table. In addition, there is a kind of DIS messages which is used to requests DIO messages to the near parent node and similar to routing request message of the neighbor discovery protocol in IPv6. RPL based on distance vector RIP chooses the optimal path, and by discovering the path set of nodes to the DAG (Directed Acyclic Graph) root node build the DAG. Compared with tree topology, RPL provides redundant paths, if the node storage permitting, there will always be multiple routes between node and DAG root node. Compared with mesh topology, orientation characteristics of the RPL solve the problems of resource waste, and have the advantages of quickly discovery, which are necessary in LLN requirements [20].

2.1 DISCOVER NODE

As shown in Figure 1 [20], in the RPL network PARENT node periodically detects perception area to find whether there are new nodes not added to the network.

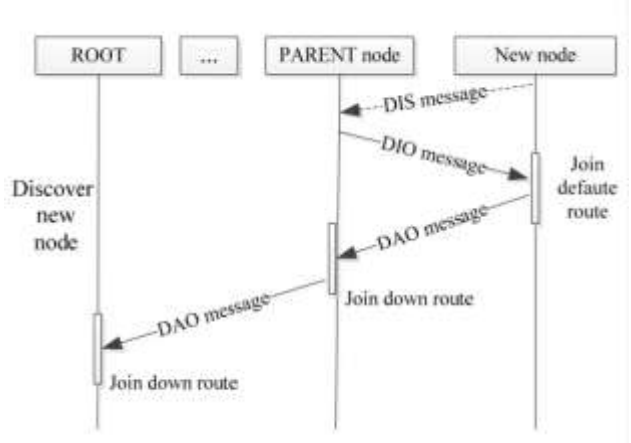

Fig-1: New Node's Discovery Process

The PARENT node sends a DIO message, and a new node receives the DIO message. The new node in the message handler deals with the DIO messages to take out the information of PARENT node and DAG. The new node based on this information creates local INSTANCE and DAG in first. Then the PARENT node is inserted into its neighbor node table, and set to its default routes. Finally, the new node returns a DAO message to PARENT node, thus join the network PARENT node located. In addition, after receiving the child node's DAO message, PARENT node needs to fetch the information contained in the message, and joins the child node to its downward routing table. Then the PARENT node sends up the DAO message of the child node, other upper ancestor nodes receive the message and add it to their own downward routing table. Such layer of iteration, at the end the new node's down routing was whole built. After the new node has completed initialization and entered the network area, if there is not a parent node sending DIO message to invite it to join [11], then it sends a DIS message actively, which active request to the parent node to send DIO messages.

2.2 NETWORK UPDATE

In order to adapt to changes of network topology, the network needs to be updated regularly, when the PARENT node regularly initiates the update process, the child node responses to process. PARENT node sends a DIO message to the child nodes. After received the message, the child node processes the message immediately. The child node first fetches PARENT information in the DIO message, then compares it with the already existed preferred PARENT information. By performing comparative algorithms, the more high-quality PARENT node is resulted and updated to the default route. After updated the default routing, the child node sends up DAO messages to update ancestors' down routing [20].

3. RPL MOBILITY EXTENSION

RPL was intended to hold static network, even though there are a number of open issues necessary to be resolved to get better network performance. Hence, a number of extensions have proposed to resolve these problems under the mobility scenario: This section intended various recently proposed RPL extensions that cover to handle mobility scenario.

H. Fotouhi et.al. [12] introduced proactive routing protocol named mRPL (boosting mobility in the internet of things). The proposed method is based on the Received Signal Strength Indicator (RSSI) value. The RSSI value is used for the mobility detection during the data transmission phase and the newly preferred parent prediction during the reaction phase, by selecting highest RSSI value (closer to zero) that is considered as strong signal. However, mRPL consume more energy due to the signaling overhead.

M. Bouaziz et.al. [13] addressed the issue of mobility in IoT by proposing a new attachment prediction method. In this method new attachment prediction is made before the disconnection and made between the nodes based on RSSI using the cross-layer approach named EC-MRPL. The author claimed that it is an extension of RPL where various performance metrics such as signaling cost, handover delay, data loss rate, energy consumption and also mobile node lifetime is improved. The main idea of their proposed work focused on optimizes the signaling cost to reduce the power consumption. However, as given RSSI value may be affected due to some obstacles in environments, so that it is better to enhancing the prediction method for better network performance.

J. Wang et.al.[14] proposed a RRD (RSSI, Rank, and Dynamic) mechanism which is enhancement of original RPL that is based on a combination of Received Signal Strength Indicator (RSSI) monitoring, Rank updating and dynamic control message management coping with the mobile nodes environment, where performance of overall network seems to be improved in terms of packet delivery ratio, end-to-end delay between source to destination and control packet overhead although they did not consider energy consumption by the mobile node.

Z Latib et.al. [15] evaluated the performance of original RPL under the three different strategies in a mobility scenario viz.

1. both sink node and sensor nodes are static,
2. static sink node and mobile sensor nodes,
3. sink and sensor nodes are mobile

under various performance matrices such as packet delivery ratio, energy consumption and packet rates. This strategy avoided the bottleneck problem during the sink (collection point) positioned at the border of the network and also consume more power, provides poor PDR and increases duty-cycle rate in the mobility scenarios compared with the static scenario. However, they considered random waypoint mobility model for simulation with this scenario. They further specified that this mechanism implemented with other mobility models such as the random walk model, random direction model to evaluate the better performance of the network.

M. Zhao et.al. [16] introduced a novel energy efficient region-based routing protocol, in which only a subset of nodes in the whole network to route discovery, rather than considering every network node. This seems to be more energy saving compared to the original RPL. ER-RPL is identified as the type of a hybrid of proactive and reactive routing protocol. It makes use of the region information of networks. Although, the author did not consider the mobile node scenario in the proposed protocol it only focused on the static network scenario. However, the proposed protocol helps to get better performance under the mobile node scenario.

M. Bouazizi et.al.[17] introduced a proactive routing protocol called EKF-MRPL for mobility scenario. It is an enhancement of RPL to make original RPL mobile obedient and also overcome problems due to node mobility. This proposed protocol works on the principle of extended Kalman filter to predict the movement of the mobile nodes with direction and also provide the faultless and continuous connectivity. Based on the Simulation they identified that this protocol consumes less energy than ECMRPL protocol by reducing the signaling cost.

C. Cobârzan et.al. [18] introduced a new cross-layer protocol named as Mobility-Triggered RPL (MT-RPL) which operated between the MAC and routing layers. MT-RPL is based upon the following three assumptions: The network is composed of only the static nodes (i.e. non-moving) and mobile nodes and a node are able to determine in which category (static or mobile) it belongs. Where the various performance metrics such as node disconnection time and control traffic overhead seem to be reduced and also the packet delivery ratio from the mobile node to the root is increased.

Y. Tahir et.al. [19] developed a new protocol named BRPL by adopting the backpressure-based optimization to the original RPL operations. It used two novel algorithms QuickTheta and QuickBeta for supporting the dynamic data traffic load and nodes mobility respectively in the dynamic network environment. They claimed that the performance of the network in terms of various performance parameters such as network throughput, reliability, and adaptability is improved.

4. CONCLUSION

This paper first introduces the RPL routing protocol discovery mechanism of wireless sensor network, then researches and analyses the theory and technology related to route discovery, RPL has been considered as a promising routing protocol for low-power and lossy networks. Also, it has been identified that mobility is one of the major concerns for dynamic/mobile node-based applications. Hence, the survey on different techniques providing mobility to RPL has been discussed and studied. It has been concluded that the techniques discussing mobility in RPL with different parameters can further be studied and explored as a future work.

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