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The Application of RPL Routing Protocol in Low Power Wireless Sensor and Lossy Networks

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Abstract: With the continuous development of computer information technology, wireless sensor has been successfully changed the mode of human life, at the same time, as one of the technologies continues to improve the future life, how to better integration with the RPL routing protocols together become one of research focuses in the current climate. This paper start from the wireless sensor network, briefly discusses the concept, followed by systematic exposition of RPL routing protocol developed background, relevant standards, working principle, topology and related terms, and finally explore the RPL routing protocol in wireless sensor low power lossy network applications. *Copyright © 2014 IFSA Publishing, S. L.*

Keywords: RPL routing protocol, Wireless sensor, Low-power and lossy networks.

1. Introduction

With continuous development of wireless sensor networks, it has become one of the hot spot in the industry technology. In the industrialization process of wireless sensor network, interconnected the wireless sensor networks and the Internet become a deeply research directions, along the introduction of the 6LoWPAN protocol, it is no longer a myth, which, RPL routing protocol is crucial. This article Start from wireless sensor network routing protocols and RPL basic concept, then deeply discussed the applications of RPL routing protocol in low-power wireless sensor and lossy network, in order to provide a reference for the future of the interconnection between wireless sensor network and the next generation Internet.

2. Wireless Sensor Networks

With the continuous development of modern science and technology, wireless sensor networks have emerged, which can be widely used in military, science and everyday life. Wireless sensor networks allow people to receive information from the passive turned active perception, access to information, has greatly expanded the network functions. Wireless sensor network is a multi-technology, multi-disciplinary integration, which has a network flexibility, access to information accuracy, reliability and economic advantages [1], so it has a very broad space for development and application in recent years, the wireless sensor network in the world set off a frenzy of research.

Wireless sensor network consists of many different types of micro-sensor nodes, randomly

distributed micro-sensors in the monitoring area to wireless communications, the dynamic network system composed of multi-hop and thus real-time aware of their surroundings. Once the surrounding environment changes or new things, these tiny sensors will transmit data to the gateway, and then storing or processing, storing or processing the results fed back to the terminal via a computer network, the user can monitor objects on the basis of these data or the surrounding environment controls, and ultimately human society, the physical world and computer network connectivity [2]. A typical wireless sensor network architecture shown in Fig. 1.

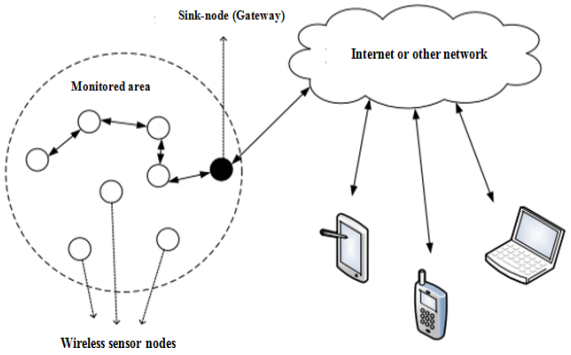

Fig. 1. Structure of wireless sensor network.

Compared with other traditional networks, wireless sensor networks wireless communication technology, and its detection, control, etc. together, therefore, the large number of network nodes, the distribution is more random and dense, at this time, if one of the nodes in the network or the energy consumption due to One way or under adverse environmental impact can easily cause a network failure; addition, the wireless sensor network node processing, communications, storage, limited energy, limited energy limits its communication capability, in this case, must be considered multi-hop routing transport mechanisms to improve the capacity of wireless sensor networks [3]. Wireless sensor networks will be energy efficient as its main objectives pursued in the network design to energy efficiency as a primary consideration, from the application of the breadth, width and depth of departure, Internet is undoubtedly the most suitable type of network, therefore, will RPL wireless sensor network routing protocols and network convergence is the future development trend and direction.

3. Low-power and Lossy Networks

Low-power and lossy networks is composed of a large number of resource-constrained wireless communication nodes, compared with the current mature Internet, which has a particularity shown in Table 1.

Table 1. Comparison of low-power and lossy network with Internet.

Characteristic	Internet	Low-power and lossy networks
Limited	Link bandwidth and node limit is not a problem	Link quality is poorer, the bandwidth is small, nodes with limited resources
Network dimension	Including hundreds of nodes	Magnitude larger than hundreds of nodes
Link and node	Stable	Link unstable, nodes often death

Low-power and lossy networks have the following three features: support for highly constrained wireless nodes to support changes or harsh environments, supporting smaller MTU [5]. Low-power lossy network has these characteristics makes the current existing Internet routing protocols do not apply to low-power and lossy networks, in this situation, RPL routing protocol as a low-power IP routing protocols appeared.

4. RPL Routing Protocol

Low power data easily lost networks (LLN) is composed of many embedded devices, typically, the energy of these embedded devices itself, processing, and storage capabilities are limited, the embedded device via Bluetooth, IEEE 802.15.4, or WiFi and other wireless technology to connect to the instrument [6]. Low power data easily lost network is currently widely used in environmental monitoring, smart home, building automation, urban sensor networks, industrial control, asset tracking, healthcare and other aspects. Low power data easily lost determine the characteristics of the network itself easy to lose low-power data network protocol (RPL) specific requirements.

February 2008, ROLL Working Group on evaluation of existing routing protocols such as OLSR, IS-IS, OSPF and AODV, etc. The results revealed that one of the existing routing protocols can't meet the low-power easily lost network routing requirements, based on this situation, ROLL working group developed to meet the low power requirements easily lost network routing routing protocols, in this case, RPL routing protocol came into being.

RPL routing protocol as an IPv6-based distance vector routing protocol [7], which can be routed through a consideration of the objective function and constraints and routing re-establish a directed acyclic graph, in a directed acyclic graph, where each node

(except the root node) will have a parent node as a directed acyclic graph up the default route [8]. When any one RPL node to acquire IPv6 addresses, it will exchange with the surrounding nodes 3 ICMPv6 messages to choose their own parent node to join a goal-oriented directed acyclic graph. There are three kinds of RPL routing protocol data flow patterns [9]: Point to point and multi-point and multi-point. RPL routing protocol in Non-Storing Mode and Storing Mode two working modes. In the flow of data from point to point mode, Non-Storing Mode First, data is sent to the source node and the destination node common parent node, followed by the parent node to transmit data to the destination node, but Storing Mode will first transfer the data to the root node and the data from the root node to the destination node. The flow of data in multi-point mode, Non-Storing Mode only the root node to the following node stores the routing table at this time, the root node in the routing table built under the guidance of the remaining nodes in the source route, but different Storing Mode, in which the root node has a routing table, and the rest, at this time, the root node can only reach the destination node determines the next hop address, but can't build the source route [10]. The flow of data in a multi-point manner, Non-Storing Mode and Storing Mode nodes are the parent node defaults to the next hop routing, therefore, will be considered by the parent node to transmit data to the root node.

Low power networks are often easy to lose no predefined topology, this time, RPL routing protocols need to connect automatically discover and create and maintain topology. In this case, it is necessary for RPL routing protocols to create and maintain a topology by RPLInstanceID, DODAGUD, DODAGVersionNumber and Rank [11].

RPL routing protocol node through the exchange of DIS, DIO, ICMPv6 and DAO3 control messages, thus creating the topology and routing, RPL routing protocol establish divided into the following two processes: topology to establish and build up the route, the route down the establishment. Down route established when there are two modes: Non-Storing Mode and Storing Mode [12].

5. The Applications of RPL Routing Protocols in Low-power Wireless Sensor and Lossy Network

5.1. Building Process of DODAG

RPL routing protocol provides new ICMPv6 control messages to exchange information and build topologies are requesting information, DODAG notice of information objects and the destination. Figure constructed from the root, the border router begins, the root exploit DIO message broadcasting related map information while listening root DIO neighbor nodes receive and process messages, according to the characteristics of DAG, the objective function and the broadcast path cost, etc. ultimately determine whether to join this figure medium [13]. If the node into the diagram, this time, it appears a route leading to the root DODAG this case, the root node becomes the parent node. Next, calculate the node where their figure rank values sent to the parent node contains information of the DAO route prefix information while using the DIS node can actively request message to neighbor map information, if the neighbors were all repeat the process, then the entire network can appear to LBR as root DODAG [14]. At this point, LBR send DIO messages received when listening LBR nodes will add it after the figure, and the prefix information of the DAO contains its own message to the LBR. Node A sends a message DIO, B added to the figure after receiving and DAO reply message, the network starts, B node C receives the message sent by the DIS, the Node B added to the diagram, the C sends DIO, are invited to join C DODAG, DAO node C to B to send the message, when the node B receives the message integration, to their parent node sends DAO message, the last step by step will send DAO messages to the LBR, LBR contains all nodes in the prefix information. DODAG build process shown in Fig. 2.

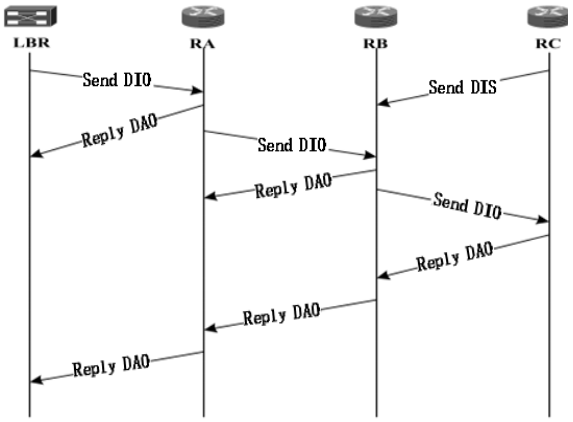

Fig. 2. Simplified building process of DODAG.

Node receives DIO information, select the parent node, add routing, broadcasting diagram information, so build up a map of all nodes have access to their parent node routing table entries at this time, leaf nodes can also be sent to their parent node data until transfer to the root node, such model is up route. Similarly, LLN network information from the root node or external intermediate nodes to transmit data to a leaf node, down the route to achieve this need [15]. In short, if the node to route up, the need to give them to the parent node, the parent node will send it to their parent nodes until the root node; when downward route node needs to be performed or when the network storage point communication different modes, the data is sent to the root node.

5.2. Loop Avoid and Loop Detection

Compared with the traditional networks and network protocols, RPL routing protocol is not to eliminate loops, but to avoid loops, it defines two rules to avoid loops [16]:

1) Maximum depth principle, the node selection principle does not permit a greater depth of the node as its parent node;

2) Rules for refusing greed nodes, the node is not allowed to move to a deeper place to increase their number of potential parent node.

The RPL routing protocol loop detection strategy is to set the relevant bit RPL routing header bit, bit by bit detection data validity. For example, a node to their child nodes transmit data packets, the bit position is denoted down, after sending the packet to the next hop node receives a packet down bit node routing table, if found packets uplinking, which proves that a loop, this time the received data packet to be discarded, and trigger local repair.

5.3. Global Repair and Local Repair

RPL support global repair and local repair two repair mechanisms, when a neighbor node or link failure, the node is not a router in an upward direction, this time, local repair is triggered, and look instead of the parent node or path [17]. But it is worth noting that local repair network may destroy the optimal mode, this time, the root node will trigger a global repair mechanism reconstruction DODAG, this way, all the nodes in the figure runs to re-select the optimal objective function of the parent node.

5.4. Trickle Timer Management

With other routing protocols in different timers, RPL using "Trickle Timer" as a timer and complete the adaptive timer mechanism automatically, the timer can be controlled DIO message sending rate. When a node detects network loops or nodes removed or added to the network, Trickle Timer can decide when to broadcast DIO messages. The network is stable, RPL reduce the number of messages, network instability, the timer sends DIO messages faster, which helps resolve issues quickly [15].

6. Simulation

In this paper, the RPL routing protocol achieve simulation analysis in lossy low-power wireless sensor networks by COOJA simulation tools. Simulation sensing area is a square region of side length of 200 m, in the region LBR only one node, and nine ordinary nodes, said node power range 75 m, in a power range of the node sending the packet loss rate is zero, the node in accordance with the random distribution law of distribution sensing area, the node platform sky. DIO message time interval initial value is 1 second, after which the simulation time interval with the change, the maximum time interval of continuous DIO message is 18.2 hours, down to achieve P2P, P2MP, the child node sends a message to the node DAO, after you create a child node prefix in the routing table. In the simulation of this article, do not use source routing.

RPL network routing protocol in this process is: LBR node starts DIO node receives a message, the message diffusion DIO, DIS node sends a request message, the node sends a message to the parent node DAO established routes. In this simulation, after LBR started broadcasting DIO message, listen LBR nodes will be calculated after the receipt of DIO rank, after adding the LBR neighbor cache, while some DIS node sends the request, the request received DIS will return to the root node will DIO, adding DAG node keeps sending DIO message, this time, listening to the DIO message node to accept the invitation to join the network, send a message to the parent node after DAO access network node, the parent node receives the news send Finally, the integration of the root prefix information after receipt. In this process, Trickle timer RPL can effectively adjust the route node sends a data packet rate, fast response, DIO node sends a message to monitor the time interval.

7. Conclusions

RPL routing protocol is used to solve the prejudicial question of low-power and lossy networks, RPL routing protocol is used to improve ICMP message format, adapted by DIO, DAO and DIS which are three kinds of messages to achieve the final routing process, in which the objective function without an explicit request, which on the different needs of different networks according to their different objective functions to determine the final build appropriate network topology. Using RPL routing protocols to detect network failures or unexpected events quickly and accurately, and to respond quickly to meet low-power and lossy networks.

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