Research on Improvement and Optimization Design of Mobile Switching in RPL Routing Protocol

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Abstract. In response to the shortcomings of the current RPL routing protocol, fully utilizing the idea of opportunistic routing, this study proposes an improved RPL routing protocol node mobility switching method to enhance the mobility support of wireless sensor IPv6 networks. Analyze existing RPL routing protocol solutions and identify their shortcomings; Analyze the challenges encountered in designing and improving routing protocols, and based on the specific application of RPL in 6LoWPAN technology, propose an overall design concept for the mobile switching method of an improved RPL routing protocol; Then, specific design will be carried out for the improved routing protocol mobile switching method, including mobile node detection, discovery and selection of the optimal parent node, link switching, etc; Finally, simulation implementation is carried out to verify its low energy consumption and low latency. Its research content involves disciplines such as the Internet of Things, computer simulation technology, and computer network technology, and has high theoretical and practical value.

Keywords: 6LowPAN, RPL routing protocol, mobile switching.

1. Research significance

Traditional static networks can no longer meet the needs of mobile work environments, and there is an urgent need to introduce support for mobility. However, although RPL (a low-speed wireless personal area network standard routing protocol based on IPv6) can solve the problem of implementing packet routing under limited resources, it performs poorly in mobile environments. When it comes to dynamic networks and node mobility, the operational efficiency of RPL is extremely low, making it difficult to prevent packet loss and separation of mobile nodes, which makes its performance not significant for some time constrained application scenarios (such as working environments or medical care). Therefore, we must make appropriate adjustments to the RPL routing protocol to improve its performance.

The RPL protocol can well support the 6LowPAN standard and adapt to IPv6 wireless sensor networks. However, with the increasing application areas of mobile networks, IPv6 wireless sensor network node mobile switching communication will become the norm. This article studies mobile communication in wireless sensor networks, and based on this, improves and designs the existing RPL routing protocol, which is of great significance for improving node mobility support.

2. Current research status of RPL routing protocol mobility

Although the RPL specification does not specifically target or explicitly define mobility characteristics, it also emphasizes that information transmission among mobile nodes should be avoided. However, for many needs in fields such as industry and healthcare, mobility has become a necessary part. These types of applications typically include multi hop networks built together by dynamic nodes (such as routers) and mobile nodes (such as healthcare workers and patients, robots and their devices in factories, etc.). So, how to achieve seamless connection between mobile nodes and fixed nodes has become a key issue and challenge.

Ghazvini et al.'s research findings [4] improved mRPL and proposed a new protocol called mRPL+. This scheme introduces an objective function when selecting the parent node, so that the node can make decisions under multiple metrics. To improve this process, they used the product of ARSSI and the cost ratio in the objective function involved in running for the father node as the

basis to determine the parent node. However, this strategy has not completely overcome the problems of mRPL, as it still requires more signal resources and energy consumption.

ME-RPL is a novel routing protocol proposed by Korbi et al. in [5]. Its main feature is to use the option part of DIO information to mark moving objects, thereby enhancing the robustness of connectivity. However, one issue with this approach is that it assumes that the mobile device can select a specific node as the root node, which means that this algorithm can only perform well when there are enough fixed nodes in the network.

Like ME-RPL, Cobarzan et al. also set constraints on moving nodes in their research. They placed moving labels on these nodes in advance to make them leaf nodes in the tree structure, thereby improving the detection effect on unreachable parent nodes. However, this approach requires assuming that there is always a fixed node around all mobile nodes as a reference point. In addition, this scheme also requires different settings for static nodes and mobile nodes, which may affect the overall flexibility.

Based on the research findings of Fotouhi et al. [7], they proposed a strategy called mRPL, which aims to use the addition of four timers to the original Trickle algorithm to more effectively reduce the switching frequency of mobile devices, and identify neighboring devices in an intelligent and efficient manner, thereby minimizing the possibility of conflicts. However, due to excessive reliance on ARSSI values, this method may trigger excessive switching behavior and sometimes form unreliable connections. This can lead to information loss and significant signal consumption during the information transmission process.

3. Design and improve the RPL routing protocol node mobility switching method

Based on the node mobility switching requirements of RPL, a lightweight low latency mobile detection and switching method is designed to address the lack of mobility support in RPL and the low latency and energy consumption requirements during node mobility switching. Enable the improved RPL network to reduce node energy consumption, reduce switching latency, and support node mobility.

Place RSSI in ACK (Knowledge character confirmation character) to enable the mobile node to obtain the bidirectional communication link RSSI. The process is executed by the corresponding parent node, and the main content of the improved ACK frame format is: frame control bit, sequence number, RSSI, FCS, with an RSSI length of 8 bits. This method can improve the accuracy of node movement detection.

After the mobile node obtains the bidirectional link RSSI, if the RSSI value is less than the established threshold, it is determined that the mobile node is moving away from the parent node and the link quality is poor. The mobile node broadcasts the DIS (Designated IS) message to find a new parent node.

In RPL routing, packets are routed along the DAG (Directed Acyclic Graph) to the destination node, and the mobile node may transmit data to the root node or communicate with other routers, that is, point-to-point communication. Choosing different parent nodes during the switching process can affect packet transmission and end-to-end latency, thereby affecting network performance. Therefore, selecting the appropriate parent node is crucial.

Due to the need to identify the response message, a DIO (DODAG Information Object) message is generated at the network layer. During the MAC layer encapsulation, the MAC frame format is improved by adding certain identifiers to the MAC header frame control domain to respond to DIO messages and messages from mobile nodes.

After selecting the optimal parent node in the mobile node, the link with the old parent node will be disconnected, and then a link will be established with the new parent node. The process of disconnecting the link will cause network interruption, which is unavoidable. But the interruption

time can be reduced through design methods. The shorter the time, the lower the possibility of data packet loss and better network connectivity.

The switching process of the parent node will affect the routing tree, and downward routing will be affected. After the parent node switching process, the downward route of the network may be interrupted, which will affect the downward data communication from the destination to the mobile node.

Due to the fact that downward routing is established through DAO (Destination Advertisement Object) messages. So, a link switching process based on unicast DAO packets was designed to maintain downward routing. When a mobile node switches from one parent node to another, first, the mobile node sends a newly designed disconnected DAO message to the previous parent node to disconnect the previous downstream path, clear the downstream route, and the original parent node parses and identifies the disconnected DAO message and clears the routing table of the mobile node. Then, it forwards the DAO to the higher-level node and deletes all routing entries related to the mobile node; Then the mobile node sends a connection DAO message to the new parent node, requesting to establish a connection. The new parent node recognizes and parses the connection DAO message, adds the routing entry of the mobile node locally, and forwards the DAO to the higher-level node until a complete communication path is established, ultimately achieving lightweight and low latency node mobility switching.

4. Using Contiki Cooja for simulation implementation on the improved interconnection scheme

Using Contiki Cooja to simulate and implement the various functions of the routing protocol RPL, and then analyzing the measured results, it is concluded that the test parent node can respond normally to ACK frames encapsulated with RSSI; Test that mobile nodes can broadcast DIS messages to find new parent nodes, and DIS messages support mobile identification; Test the candidate optimal parent node to be able to respond to DIO information, and the DIO message has DIO identifier options, etc.

Funding: 2021 Hunan Provincial Department of Education Science Research Project (21C1189), 2023 Hunan Provincial Vocational Education Teaching Reform Research Project (ZJGB2022805), 2023 Hunan Provincial Social Science Review Committee Project (XSP2023JYC164)

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