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DESIGN AND IMPLEMENTATION OF MULTI-MODE WIRELESS INTELLIGENT INTERNET OF THINGS

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Abstract: With the rapid development of the Internet of Things and the updating and iteration of various standard protocols and technologies, most of the current Internet of Things IOT systems are designed for network distribution and access interconnection based on a specific wireless protocol. There are few solutions that can Adaptive supports intelligent networking and interconnection between different link layers. In this regard, a universal, intelligent and adaptive networking solution is proposed. Based on the IOT physical layer such as BLE and WIFI, this solution adaptively selects the optimal network protocol stack and deploys it to establish a mesh network, intelligently detects the status of the wireless environment, automatically identifies and quickly establishes and interconnects LLC networks and ad-hoc networks. Equipment manufacturers or service providers can use this solution to quickly make the equipment they provide intelligent and quickly connect to the Internet of Things, greatly shortening the development cycle of their products, and ensuring the stability and stability of their Internet of Things equipment and services. safety. The self-organizing network has good stability, high scalability, strong compatibility with other wireless devices, and high information security and reliability of network node devices. It also supports two independent network protocol stacks, each built on different physical above the link layer, it can meet different application scenarios.
Keywords: 6LoWPAN; Route-over; Mesh-under; Babel

1 INTRODUCTION

According to statistics, 10 billion microcontroller chips have been used in the field of Internet of Things every year in recent years. With the huge market demand for Internet of Things equipment and services in the industrial field and general consumer field, it is necessary to provide high-quality, reliable and stable Internet solutions. And devices, connecting millions or even tens of millions of smart devices to the Internet and interconnecting them is a problem that needs to be researched and solved. In industry and academia, IoT protocol standards are also a highly valued issue. The rapidly changing mobile network technology and the rapid evolution of microcontroller chips and M2M have also accelerated the development of IoT technology. Currently, international mobile chip and equipment manufacturers invest a lot of resources in the research of IOT technology and products every year, and will invest more in research and development in the IOT field in the future.

Due to the rapid development of the Internet of Things, different standard protocols and technologies have also been proposed by different standards committees, including IEEE, IETF and ITU. These standards broadly cover the entire network protocol stack at the data chain saw layer, network routing protocols, session layer protocols, and application layer protocols. These standards are designed to meet the specific needs of the IOT ecosystem, including management and security. For different geographical scopes and low power consumption, link layer protocol standards include IEEE 802.15.4, IEEE802.11[1-4], Bluetooth Low Energy[5-7], Zig bee Smart Energy[8], etc. ; Aiming at the mobility and volatility of wireless devices, routing protocol standards include RPL, Babel, batman-adv, CORPL, etc. In order to better support the transmission of IPV6 data in low-power and high-volatile IOT networks, network layer encapsulation protocols include 6LoWPAN [9-10], 6TiSCH, IPV6 over Bluetooth Low Energy, etc. In view of the diversity and security of IoT applications, application layer protocols include MQTT, SMQTT, COAP, XMPP, etc.

Due to the continuous updating and iteration of various standard protocols and technologies, the solutions proposed by various equipment manufacturers, chip manufacturers, and cloud service providers are also different. Most of them are designed for specific wireless modules and data link layers. Internet networking solutions have poor scalability and difficulty in deployment, poor mobility, poor support for the diversity of cloud services and application functions of the Internet of Things, and insufficient compatibility and security. In view of the various needs and challenges of IoT devices and services, this paper proposes a universal and efficient IoT intelligent networking system. Based on the IOT physical layer such as BLE and WIFI, this solution adaptively selects the optimal network protocol stack and deploys it to establish a mesh network. It has high device reliability, high scalability of the self-organizing network, and is compatible with interaction with other wireless devices. It is highly flexible and can support different IoT application scenarios, including smart meters, consumer wearable devices, home security alarms, factory video surveillance, geological research, energy management, disaster prediction, etc., and ensures the security of network services.

1.1 Overall Solution Framework

In the current IoT ecosystem, there are multiple link layer and network layer standards, as well as IOT application requirements in various fields, including low-power data monitoring and high-throughput remote streaming media monitoring. This article proposes a general and intelligent adaptive networking solution that can intelligently detect the status of the wireless environment, automatically identify and quickly establish and interconnect LLC networks and ad-hoc networks. Equipment manufacturers or service providers can quickly use this solution to It can effectively make the provided equipment intelligent and quickly connect to the Internet of Things, greatly shortening the research and development cycle of its products, and ensuring the stability and security of its Internet of Things equipment and services. This solution supports two independent network protocol stacks at the same time, each of which is built on a different physical link layer and can meet different application scenarios. The overall framework is shown in Figure 1.

In low-power, volatile wireless ad hoc networks, low-frequency MCU-based sensors and actuators are commonly used as input and output devices. The object layer of these devices is generally based on low-power devices such as BLE, Zig bee, and Z-Wave [11]. Wireless module, so this IoT solution provides a 6LoWPAN-based network protocol stack to support the LLN network. Among them, RPL is mainly based on the routing algorithm of the LLN network to ensure that device nodes can access data to the Internet. 6LoWPAN is mainly to enable IPV6 data packets to be transmitted in the physical layer with short transmission packet lengths such as LLN, thereby carrying out the IPV6 packet header Compression and encapsulation. For example, the maximum frame length of IPV6 is 1 280 bytes, while the maximum frame length of IEEE802.15.4 is 270 bytes, and the frame length of BLE may be smaller.

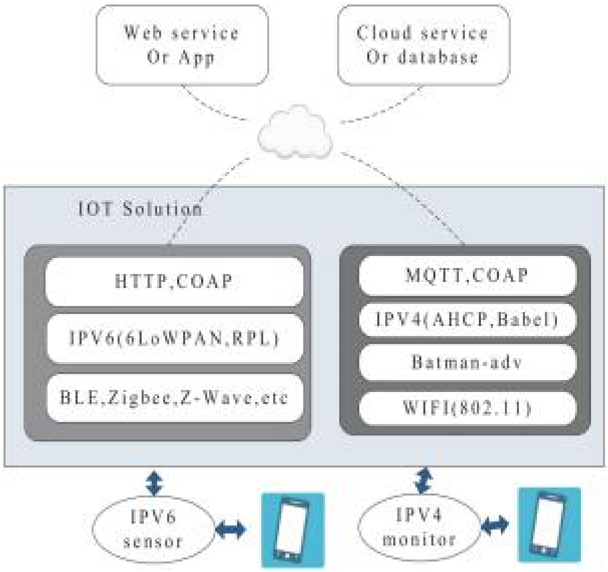

Figure 1 Overall solution framework

In wireless ad hoc networks with long transmission distances and high throughput, most of the device nodes of these networks use wireless modules such as IEEE802.11. This type of ad-hoc has wider coverage, higher stability, and higher throughput rate, and can meet the needs of Remote monitoring of streaming media and other service needs. This IoT solution also provides a network protocol stack based on IEEE802.11 to support WiFi ad-hoc [12-16] network. Among them, AHCP is ad-hoc network configuration management, which solves the IP management and allocation problems in mesh network nodes. Babel works on the lay3 layer and can provide a distance vector-based routing algorithm to avoid deadlocks. Batman-adv works on the lay2 layer. It is a distance vector-based routing algorithm that is transparent to upper-layer protocols and applications. This solution introduces the AES encryption protocol from the data link layer and TLS and TDLS from the data transmission layer to ensure the security and confidentiality of data interaction.

1.2 Network Protocol Stack Layered Structure Diagram

This IoT solution can adaptively support intelligent networking and interconnection between different link layers, and integrates two independent network protocol stacks.

After the system is started, the IOT platform will start two completely independent protocol stacks to meet different application scenarios and service needs, and speed up the establishment of LNN and ad-hoc networks. The WIFI wireless module will search for wireless signals in the environment and establish a WIFI ah-hoc network according to the IBSS protocol. After receiving the message that the network interface is successfully established, AHCP quickly allocates network IP resources to ensure the uniqueness of the IP address in the mesh network node and Used to identify devices at the lay3 layer, Babel will exchange HELLO, IHU, and Update messages through the WIFI wireless module and generate routing table information based on the Bellman-ford shortest path algorithm to prepare for subsequent more efficient and stable sending and receiving of UDP/TCP packets. The startup and establishment of the BLE wireless module is similar to the WIFI module. The LLN network is generated from the establishment of the data link layer. The IPV6 address is automatically configured and generated by the global uniqueness of the MAC address without the participation of protocol standards such as AHCP. RPL is specifically for wireless devices. A network routing protocol developed for mobility and volatility. But when the system has no data to transmit, the module can quickly enter sleep mode to save power consumption. When data needs to be sent and received, the module can quickly wake up and perform data processing. The two wireless modules form independent wireless self-organizing networks and are interconnected. The adaptive configuration will select a more stable data transmission method to access the Internet based on the surrounding environmental noise.

2 ROUTING MECHANISM

The network routing method of the 6LoWPAN system based on the LLN network is the routing table forwarding mechanism of lay3. 6LoWPAN is between layer 3 and layer 2 in the OSI network model. It is an adaptation encapsulation layer and is mainly used to compress, segment and reassemble IPV6 data packets. When the data packet passes through each HOP, 6LoWPAN will reassemble the data packet uploaded by the MAC into a complete IPV6 packet and deliver it to Layer 3. Layer 3 will choose whether it needs to be handed over to the upper layer application for processing or processed again based on the destination address of the IPV6 data packet. Find the next hop HOP of the target IP for forwarding. Based on WIFI ad-hoc network routing methods include router-over and mesh-under, which respectively correspond to Babel in layer 3 and batman-adv in layer 2 of the IoT solution. The IOT platform integrates two routing algorithms for WIFI ad-hoc. Equipment manufacturers and IoT service providers can choose a more appropriate method according to specific application needs and scenarios. This provides flexible function choices and scenarios for upper-layer applications and services. Adaptation. batman-adv refer to Figure 2. UDP / TCP data packets are determined by layer 2 of the next hop HOP MAC address of the target machine. The data link layer does not need to hand over the data to the layer 3 network layer for decision-making - whether it needs to be processed by itself or to look up the IP routing table and select One-hop HOP avoids leaving decision-making to the layer 3 network layer, so the transmission efficiency is higher, but the stability is lacking.

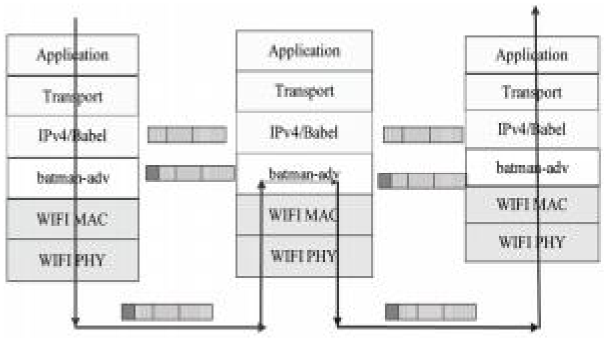

Figure 2 Mesh-under routing algorithm based on WIFI ad-hoc network

Babel Refer to Figure 3. UDP / TCP data packets pass through each network node, and the data link layer data will be handed over to the layer 3 network layer for decision-making - whether it needs to be processed by itself or to look up the IP routing table and select the next hop HOP. Due to the gap between the source device and the destination device The layer 3 network layer of any node will participate in data forwarding, so the stability is higher, but the transmission efficiency is lower than layer 2.

When the WIFI ad-hoc network environment is good, the effect of mesh-under routing will be better than that of route-over. When the WIFI ad-hoc network environment has a lot of noise, the effect of choosing route-over will be better than mesh. -under. This solution counts the message delivery success rate and the quality of the air interface environment in a certain period of time in the past, and adaptively switches to a better routing method to ensure the reliability of message transmission and the stability of system response.

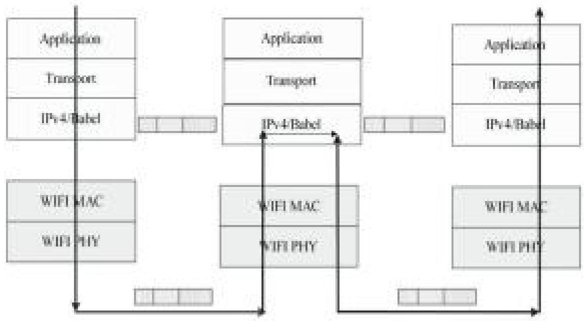

Figure 3 Route-over routing algorithm based on WIFI ad-hoc network

3 ROUTING ALGORITHM PERFORMANCE ANALYSIS

This system performs experimental comparison of the performance of route-over and mesh-under routing algorithms in the same channel noise environment. The basic parameters of the experiment are shown in Table 1.

Table 1 Basic experimental parameters

Project	Parameter
IP layer packet length	1 500 bytes
MAC layer MTU length	100 bytes
Total number of mesh nodes	3, 6, 9
Hop series	Level 1-9 Jump
number of fragments	15
route-over routing algorithm	Babel
mesh-under routing algorithm	batman-adv

According to the size of the MTU length of the MAC layer, the IP layer packet is divided into 15 fragmented packets through the Layer 2 layer. The number of nodes in the wireless ad hoc network of the mesh network is 3 to 9 respectively. Experiments show that different HOP hop levels The success rate of IP packet transmission is as shown in Figure 4.

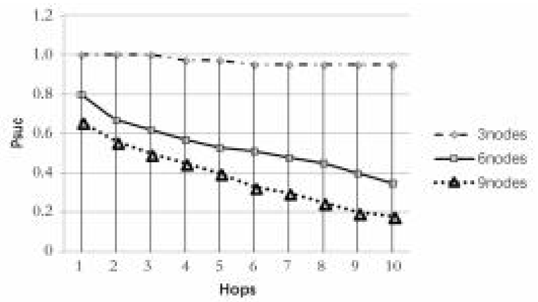

Figure 4 IP packet sending success rate of batman-adv routing algorithm

It can be seen from the analysis results that when the number of nodes in the mesh network gradually increases, the IP packet transmission success rate of both routing algorithms decreases significantly. This is because the channel has more competition points and the channel noise is relatively large, which reduces the individual The success rate of nodes seizing the channel. In addition, when the number of Hop levels in the communication path gradually increases, the IP packet transmission success rate of batman-adv also decreases. Compared with Babel, although the increase in network channel competition and conflicts also reduces the IP packet transmission success rate, the communication path The gradual increase in the number of medium Hop levels does not have much impact on the transmission success rate of IP packets. This is mainly because each hop in the route will reassemble the packet and return it to the IP layer for next routing selection. The packet probability of each level of Hop returns to 1. Therefore, the route-over routing algorithm is better than the mesh-under routing. The algorithm is more stable and robust, but the disadvantage is that each level of Hop point in the routing must support the complete Lay3IP protocol stack, and each fragmented packet needs to be assembled, routed, and disassembled of the IP message. The operation of the package increases the CPU MIPS, memory resource requirements, current power consumption, etc. of the jump point. Therefore, the route-over routing algorithm has certain requirements on the hardware configuration and power supply life of the devices in the Internet of Things.

4 CONCLUSION

A universal, intelligent and adaptive wireless module networking solution is proposed. Based on the IOT physical layer such as BLE and WIFI, this solution adaptively selects the optimal network protocol stack and deploys it to establish a mesh network. This self-organizing network has good stability, high equipment reliability, and high scalability, and is compatible with other wireless devices. Interactive compatibility is strong. This solution can intelligently detect the status of the wireless environment, automatically identify and quickly establish and interconnect LLC networks and ad-hoc networks, support different IoT application scenarios, and ensure the security of network services. Equipment manufacturers or service providers using this solution can quickly make the equipment they provide intelligent and quickly connect to the Internet of Things, greatly shortening the development cycle of their products, and ensuring the stability and stability of their Internet of Things equipment and services.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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