Design and Implementation of Ad Hoc Communication Demonstration System

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Abstract. In general, in production and life, network is required to convey all kinds of information, but in the situation of emergency and disaster relief where the terrain is complex and the battlefield or communication facilities are dam-aged and difficult to be repaired quickly, it is more common to rely on the base station to deploy the network facilities, but at this time, the troops in the battlefield or rescue and relief personnel are required to communicate and dispatch by the network. At this point, the Ad Hoc network can play a very important role. The focus of this paper is to build a ground demonstration system based on wireless self-organizing network through the raspberry pie development plat-form. Implement basic communication. Using Linux system in Raspberry Pi 4B, network layer routing protocol uses OLSR to form multi-node wireless ad hoc network and cellular network dual-mode communication, which ultimately enables message file transfer between nodes, location display and conducting initial video collection tests. With these work, a communication demonstration system using Ad Hoc network is initially built, which will lay the foundation for the application of wireless self-organizing network.

Keywords: Ad Hoc Network · OLSR · Socket Communication

1 Introduction

1.1 Background, Purpose and Significance of the Study

Wireless ad hoc network (Ad Hoc) is a temporary non-static network composed of multiple communication nodes, and each node can freely join or exit. Its emergence originated from the group wireless network established by the United States considering that it is difficult to maintain the normal communication in the complex battlefield war as described in [1]. Later, the IEEE organization named this type of network as ad hoc network, and the common name in China is wireless ad hoc network. The composition of this network does not depend on a special node as the core role in the network, but each node has the same status. They jointly establish the network and maintain routing information. When the node sending information and the node receiving information cannot communicate directly, some nodes in the network will help them forward data packets to maintain the normal operation of the network as described in [2] (Fig. 1).

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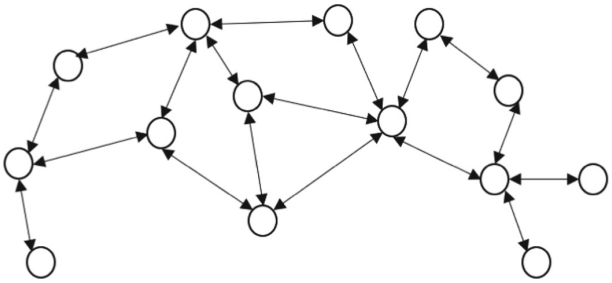

Fig. 1. Wireless Ad Hoc network system.

In the situation of rescue and disaster relief in the battlefield with complex terrain or the communication facilities are damaged to some extent, however, at this time, the troops in the battlefield or the rescue and disaster relief personnel need to communicate and dispatch through the network as described in [3]. At this time, the traditional communication facilities are more time-consuming and labor-consuming, and a more portable and faster way is needed to solve the communication problem. In general, radio or satellite communication may be used to realize actual communication. However, for radio, the number of channels transmitted is relatively limited as described in [4]. For example, during emergency rescue and disaster relief, a large number of disaster relief workers are prone to interference due to limited frequency when using radio communication, which seriously affects the transmission speed of important information, and it is not easy to share image information of different disaster relief sites in real time. However, satellite communication may not be able to respond at the fastest speed due to a certain delay in the transmission of its information, thus delaying the rescue or the best time in the battlefield, and also having a high use cost as described in [5]. In this situation, the ad hoc network shows its advantages. As long as everyone carries a small ad hoc network node, the nodes can organize the network by themselves. In addition, even if a node exits the network due to terrain or battery failure, it will not have a great impact on the whole network as described in [6]. Other nodes can still communicate normally, and the equipment of the node can join the whole network at any time after startup, It has a good effect on such temporary battlefield and real-time command in front of disasters. Therefore, it is valuable to build a ground ad hoc communication Demonstration System (terminal) to provide a solution for rescue and disaster relief scenarios as described in [7].

1.2 Main Research Contents

Raspberry Pi Platform

Raspberry pi is a very portable small processor, which can be used as a portable small personal computer after the system is installed. Raspberry PI foundation first developed it in Britain in order to popularize computer knowledge to students. Now it is often used as the motherboard of tracking cars and small intelligent robots.

Many kinds of hardware and software of raspberry pi are open source. The I/O pins and USB interfaces on it can be connected to various modules to realize personalized customization, and then use their own programs to achieve the desired functions. At

present, the raspberry pi B product, which is widely used, only includes a core circuit board. If you want to use it normally, you need an SD card that has burned the system and a power supply. If you connect the display through HDMI, and the keyboard, mouse and graphical interface system connected with USB, the raspberry pi will have a feeling similar to that of an ordinary desktop computer.

Raspberry party has good compatibility and strong computing power with different systems. Therefore, based on the raspberry pi platform, the development of wireless ad hoc network system and rapid and stable networking will be well realized. Building a development environment and burning the Linux system into the development board is the basis for porting the OLSR protocol and building a network environment.

Linux System Installation and Environment Configuration

Linux is an operating system that opens the source code completely. It contains a lot of micro kernels, and each part can find the complete source code. Therefore, anyone can modify and tailor Linux according to their own needs to build their own functional system. At the same time, it also supports various network protocols and a set of very complete development tools, which is very conducive to program development and migration.

Generally speaking, a Linux system contains the following parts:

(1) A boot loader for loading the Linux kernel into the main memory of the computer.
(2) An initialization program, such as traditional sysvinit and updated systemd, openrc and upstart.
(3) A software library that contains code that can be used by running processes.
(4) A standard library for the normal operation of programs written by c voice. For example, the GNU C library is a common choice.
(5) A software package for using UNIX commands of the system. For example, GNU coreutils is the most commonly used.
(6) A library of various widgets for users to write graphical user interface program projects. Common projects such as Gnome project or QT project.
(7) A management system for installing, deleting, or configuring software packages, such as dpkg or rpm.
(8) A user-friendly interface program.

Install the required compiler and other programs in the Linux system to complete the required environment as described in [8].

OLSR Protocol

Optimized Link State Routing Protocol (OLSR) is a routing protocol commonly used in ad hoc networks, which was first found in the article RFC3626. Due to the characteristics of the self-organizing network, nodes in the network may exit at any time, or some nodes may suddenly temporarily join the network as described in [9]. Therefore, each node in the OLSR protocol group network will transmit the grouping information of this node to other nodes at regular intervals, thus realizing the information update of each node in the network, so that each node can update the link and the overall network state.

The routing table is modified according to the updated information. To meet the routing requirements of non-static network structure of Ad Hoc network as described in [10].

Socket Communication
Socket is a software program used to connect IP and port. The main purpose of its call is to send and receive TCP or UDP packets. The structure and properties of a socket are defined by the application programming interface used for the network architecture. Sockets are only used when they are created in a node and when the program is finished, socket communication stops.

Socket is gradually emerging in the standardization process of TCP/IP protocol during the development of Internet. Socket is recognized externally by other hosts through the address of the socket. The address of the socket is determined by three factors: routing protocol, IP address and port number.

QT Cross Platform Development Tool
QT is a framework that supports multiple compilers and provides multiple interface designs to facilitate program development. When the application developed by it runs across platforms, such as MacOS, Android windows, Linux or embedded systems, its code basically does not need to be changed to facilitate cross platform program development.

This project plans to use QT to complete the design of graphical user interface and message exchange.

Real Time Video Transmission
Write a program using the OPENCV library to obtain the camera video data in real time and display it locally, then use the UDP protocol to send and transmit the video stream, and carry out the transmission test of the multi-channel video reception.

Node Positioning and Map Display
In this paper, BDS and GPS dual-mode positioning are used. At present, GPS is the mainstream positioning system, and has a lot of application space in military and civil fields. Beidou Satellite Navigation System (BDS) is a system developed in 2012 in China. The main reason is that the communication frequency points are different from GPS, so dual-mode signal reception can be achieved by using hardware that supports multiple frequency points. Coordinate display uses offline Baidu map, which has a number of practical APIs to achieve good display results.

2 Design Scheme of Ad Hoc Network Demonstration System

2.1 Hardware Scheme

The main components of the single-point structure of the Ground Ad Hoc Network Demonstration Platform are industry-controlled embedded computer devices, wireless network communication devices, satellite positioning devices, human-computer interaction devices, video acquisition devices and energy management devices (Fig. 2).

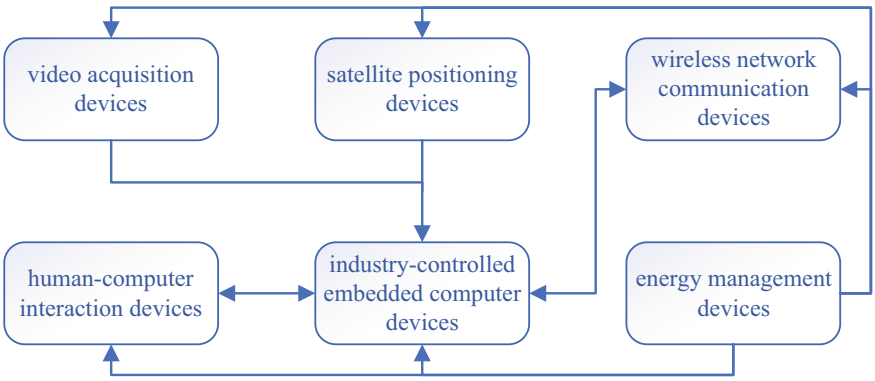

Fig. 2. Single Node Structure

The industrial control embedded computer equipment is mainly responsible for the overall planning and management of all equipment in the ground ad hoc network platform. The wireless network communication equipment is mainly responsible for data communication with other wireless ad hoc network nodes, and uses RJ45 network cable to connect with the industrial control embedded computer equipment. The satellite positioning equipment is mainly responsible for calculating the satellite signals from the Beidou satellite positioning system, and calculating and estimating the global latitude and longitude position information of the current equipment. Human-computer interaction equipment is mainly responsible for connecting with users, providing users with the operation entry and usage guidance of all functions of the ground ad hoc network platform. The video acquisition equipment is mainly responsible for the acquisition of video data, and transmits the data to the industrial control embedded computer equipment through the MIPI interface or the CSI interface. The energy management equipment is mainly responsible for providing power support for all electronic devices in the ground ad hoc network platform and supporting fast charging.

Industry-Controlled Embedded Computer Devices

Key features of the Raspberry Pi 4B include a high-performance 64-bit quad-core processor, support for dual displays with resolutions up to 4K via a pair of micro-HDMI ports,

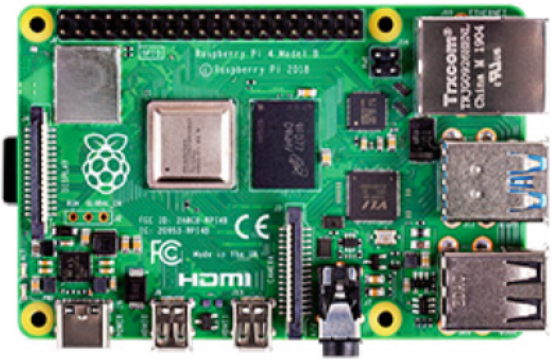

Fig. 3. Raspberry Pi 4B development board

hardware video decoding up to 4Kp60, up to 4 GB of RAM, dual-band 2.4/ 5.0 GHz wireless LAN, Bluetooth 5.0, Gigabit Ethernet, USB 3.0 and PoE capabilities (Fig. 3).

Wireless Network Communication Devices

ST9800GB-SC is a portable product suitable for wireless ad hoc networks. It has high signal coverage and is more suitable for ad hoc network construction (Fig. 4).

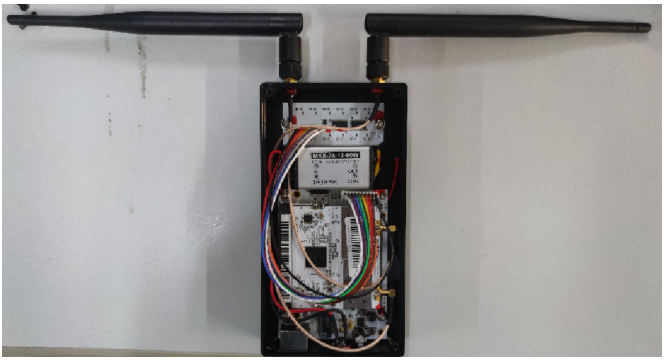

Fig. 4. Schematic diagram of wireless ad hoc network card

In order to realize the connection of the cellular network, use the CAT4 LTE module, use the copper column and the thimble to connect the Raspberry Pi, and then you can connect to the Internet (Fig. 5).

Fig. 5. Schematic diagram of cellular network card

Energy Management Devices

The power supply module uses the Raspberry Pi UPS module of Micro Snow, 5V regulated output, up to 2.5A continuous output current, which can be directly connected to the Raspberry Pi motherboard, or can be powered externally through its own USB interface, which can be used for Raspberry Pi. Pie use 2–3 h (Fig. 6).

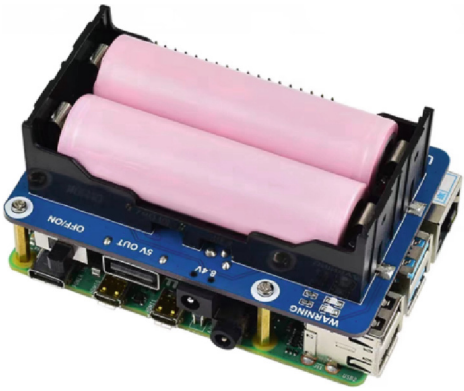

Fig. 6. Schematic diagram of power supply module

Video Acquisition Devices

The 720P 150-degree high-definition wide-angle camera of Lin Bo Shi HD908 model is selected. It has high compatibility and is suitable for Windows and Linux systems (Fig. 7).

Fig. 7. Schematic diagram of the camera

Satellite Positioning Devices

As a satellite positioning device in the ground ad hoc network platform, it is mainly responsible for computing satellite signals from the Beidou satellite positioning system, and computing and estimating the global latitude and longitude position information of the current device.

Satellite positioning equipment is required to maintain at least 10 effective satellites for positioning in an open and sunny field, and requires at least meter-level positioning accuracy. Based on the consideration of higher positioning accuracy and more complex application scenarios, satellite positioning equipment is required to be supported by at least inertial devices to realize multi-sensor information fusion integrated navigation system.

Considering the above requirements, Shenzhen Weite Intelligent's high-precision integrated navigation equipment is suitable for this solution (Fig. 8).

Fig. 8. Schematic diagram of positioning equipment

Human-Computer Interaction Devices

The touch screen uses a 7-in JETSON NANO brand IPS touch screen, using HDMI and USB as interfaces, HDMI is used for image data transmission, and USB is used for touch control (Fig. 9).

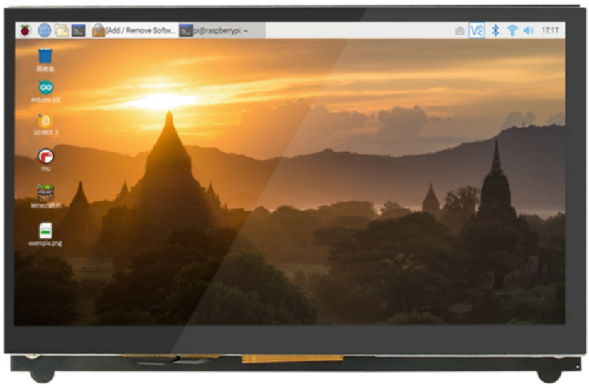

Fig. 9. Schematic diagram of touch screen

2.2 Software Scheme

Industrial Control Embedded Computer Equipment

The industrial control embedded computer equipment is selected as the Raspberry Pi 4B embedded computer, which completes the installation of the Linux kernel operating system, the installation of various routing protocols and the corresponding scheduling interface.

When in use, users only need to use the USB Type-C interface to provide power for it, or use the USB Type-A interface to provide power for the Raspberry Pi with the energy

management device installed, and do not need to care about the software environment and dependencies of the Raspberry Pi relation.

Wireless Ad Hoc Communication System

The wireless ad hoc network communication system is designed based on the ST9800GB-SC wireless ad hoc network communication board. The basic control, information reading and other logic design of the interactive system for the communication board.

When using, the user needs to connect the communication board and the Raspberry Pi computer through the provided RJ45 Ethernet cable, and provide power for the communication board through the provided power cord.

Satellite Positioning System

The satellite positioning system is designed based on Shenzhen Weite intelligent integrated navigation equipment, completes the GPS + IMU integrated navigation position and attitude estimation system, completes the information exchange debugging between the Raspberry Pi computer and the integrated navigation equipment, and completes the satellite positioning information based on the human-computer interaction system. Read and display.

When using, the user needs to connect the combined navigation device and the Raspberry Pi computer through the provided USB Type-C interface.

Human-Computer Interaction System

The human-computer interaction system is designed based on the Raspberry Pi computer equipment and the adapted 7-in capacitive touch screen equipment, completes the design of the touch driver and display driver, completes the design of the graphical UI interface based on the touch screen, and completes the design of the following functions:

Read and display the relevant information of the current node device, including: added network label, address, communication delay, latitude and longitude coordinates, etc.

The user can select any one or more other nodes on the network topology display page, send the specified information or specified file to the specified node, or apply for the specified information to the specified node. The information content can be text, command words and video, and the user can configure the information content for each target node and source node after specifying the node.

The location can also be manually marked on the map, or graphics can be drawn to record the required information on the map.

Image Acquisition System

The image acquisition system is designed based on the Raspberry Pi computer equipment and various types of camera equipment with USB interfaces, completes the design of the camera device driver, completes the real-time acquisition of the video information of the Raspberry Pi camera, and completes the data provided for the human-computer interaction system. Upload interface.

When users use it, they only need to select different types of cameras according to their needs, and use a USB data cable to connect the camera to the Raspberry Pi.

Energy Management Equipment

The energy management equipment is designed based on the special power supply for Raspberry Pi computer equipment, completes the program design of power information acquisition, power management driver, etc., and completes the data extraction and control interaction between the special power supply for Raspberry Pi and the human-computer interaction system.

When using it, users only need to install the Raspberry Pi correctly on the dedicated power supply device. After installation, the Raspberry Pi computer and the power supply device only need to be charged through the copper column connection, and there is no need to separately power the Raspberry Pi.

3 Function Realization of Wireless Ad Hoc Network Demonstration Platform

3.1 Successful Realization of Ad Hoc Network Among Multiple Nodes

Connect the Raspberry Pi node to the networking device through an RJ45 network cable, then set an IPv4 address for the Raspberry Pi that is different from the networking device in the network settings, and then use the./olsrd command to enable the olsrd protocol through the terminal. It can be observed in the terminal that different ad hoc network nodes are successfully networked through olsrd. The local IP is 10.10.10.26, and the Ad Hoc network is successfully established with three devices whose IPs are 10.10.10.31, 10.10.10.88 and 10.10.10.44 (Fig. 10).

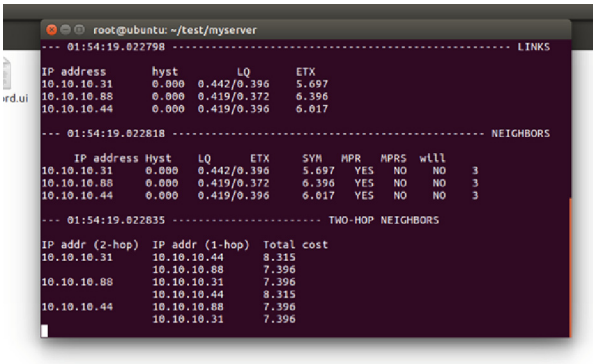

Fig. 10. Networking between devices through olsrd

3.2 Realization of Cellular Network Networking

After using the cellular network device to connect to the Internet, use the zerotier tool to configure the network, and then the device can be connected through the cellular network.

3.3 Implementation of Multi-node Positioning and Status Display

After the device is connected to the positioning device, the mobile test is performed outdoors, and the real-time location display can be realized on the offline map (Fig. 11).

Fig. 11. Single node positioning display

When multiple nodes are connected, the positions of all nodes can be displayed and shared on the map, and the dual-mode connection status of the ad hoc network and the cellular network can be displayed (Fig. 12).

Fig. 12. Multi-node positioning and status display

3.4 Implementation of File/message Transfer Function

Select the node on the map to communicate, enter the information in the message box and select send to send it, and select the TCP connection to establish a connection to perform file transfer (Figs. 13 and 14).

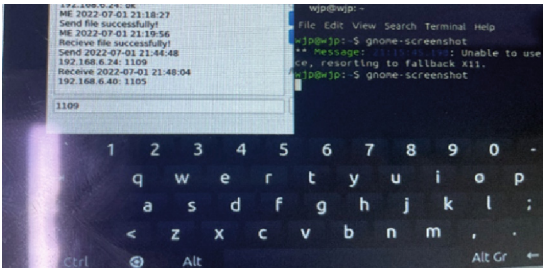

Fig. 13. Message send/receive display

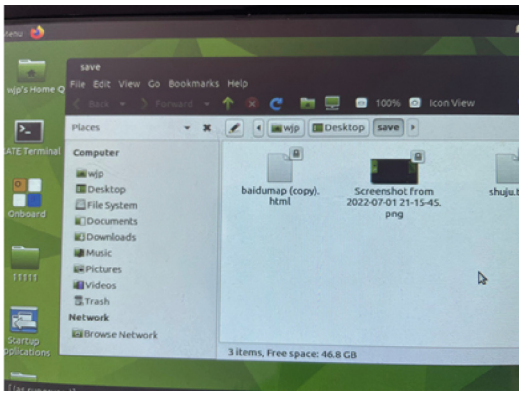

Fig. 14. File reception display

3.5 Preliminary Video Transmission Test

Using the ad hoc network and the cellular network respectively, the image information obtained by the cameras of the two nodes is pushed to another node, and received and displayed (Fig. 15).

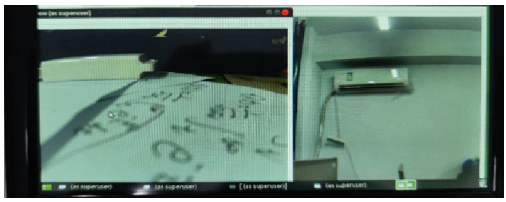

Fig. 15. Dual-channel video reception display

4 Conclusion

This paper applies self-organizing network, socket and positioning related technologies. Firstly, the characteristics of wireless ad hoc network without central node and non-static network structure are expounded, and then the overall hardware and software scheme is proposed according to the research goal of this paper. Realized the construction of the ground ad hoc network demonstration system based on Raspberry Pi 4B, realized the operation of the OLSR protocol in the Raspberry Pi, and completed the connection of the cellular network based on the cellular network hardware, and displayed all network nodes on the offline map. Location, and on this basis, the transmission of messages and files, and the use of camera to acquire image data and conduct transmission tests, demonstrate the practicability of wireless ad hoc networks and this demonstration system.

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