Design and Implementation of an Intelligent Shipborne Terminal System

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Abstract. To solve the problem that network services provided by ships can't distinguish different users and the Quality of Service (QoS) is poor, an intelligent shipborne terminal system which combines advanced positioning technology and wireless communication technology is designed in this paper. The overall design of the system including hardware design and software design is proposed. The test results show that the system can distinguish between different users' Wi-Fi connection, intelligentize the management of system users, realizes the function of GPS positioning navigation and has a rich local resource storage, which all proved its good application value.

Keywords: QoS · Shipborne terminal · Wi-Fi · GPS positioning

1 Introduction

In recent years, the Internet of Vessels has become an emerging field after the Internet of things and the Internet of Vehicles. The Europe proposed an inland waterway shipping integrated River Information Services (RIS) in the literature [1]. Through the integration, synergy and standardization of RIS, it provided all the users with a comprehensive and convenient information services and realized the safety, economy, efficiency, energy saving and environmental protection of inland navigation. In [2,3], these studies showed that GPS and wireless communication technology successfully realized the real-time monitoring of the ship's running status and position. The authors studied the main challenges of developing wide area Wi-Fi access to RIS in the Danube with the location and variety of antennas in [4]. Another study proposed an integrated wireless network system consisting of mobile ad hoc networks, cellular mobile communications networks and satellite mobile networks to provide richer maritime services for mobile users in [5]. However, none of these documents refers to the Wi-Fi sharing function and provides different quality of service for different users.

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In 2014, the number of smartphone users in China has exceeded 500 million, and it is expected to reach 700 million in 2018. The popularization of intelligent terminals and the development of mobile Internet have brought the rapid expansion of Wi-Fi access requirements. As one of the indispensable transportation, tens of thousands of passengers' travel by vessels every day. Their demand for the internet is very large, they want to use their mobile phones, tablets to get news, use social media, listen to music, watch videos and so on. However, most of the ships are not equipped with enough network terminals for passengers' entertainment or handling official business, and other ships equipped with Wi-Fi equipment also have some annoying problems in network supply. There are still many drawbacks in existing shipboard terminal system:

- There are few ships that can provide Wi-Fi network service which cannot provide Internet access services.
- The existing shipborne Wi-Fi system only provides Wi-Fi access with poor QoS, but does not distinguish different users with their different network requirements.
- The bandwidth of existing wireless access is too low, so the speed of loading or browsing video or audio resources is very slow, which strongly affects the user experience.

Therefore, this paper designs an intelligent shipborne terminal system. The hardware part designs the function module and interface circuit according to the demands. The software part designs the GPS positioning function [6] and Wi-Fi connection with WeChat authentication [7]. Through this system, passengers will enjoy the stability network services and rich information contained in system, and the different needs of users will experience a different Qos, which can greatly enhance the passenger travel experience.

The rest of this paper is organized as follows: Sect. 2 overviews the design of the system. Section 3 introduces the system function. The system test results and analysis are presented Sect. 4. Finally, Sect. 5 concludes this paper.

2 System Design Overview

In order to show the feasibility of our designs, we build a system topology model that is detailed description in Fig. 1. Mobile intelligent terminals (such as smart phones, laptops, etc.) and intelligent shipborne terminal system (equipment designed in this paper) connect through wireless Wi-Fi connection. After the successful connection, passengers can access the intelligent multimedia database in the shipborne terminal system, and it can connect to the Internet through the intelligent shipborne terminal system, which makes network services available for mobile intelligent terminal equipment. At the same time, the intelligent terminal system can connect the shipborne camera and LED display to provide shipborne TV advertising and video services through the Ethernet port, through the serial port and shipborne sensor, it can obtain ship status and provide business like GPS positioning service, authentication charging and advertising push.

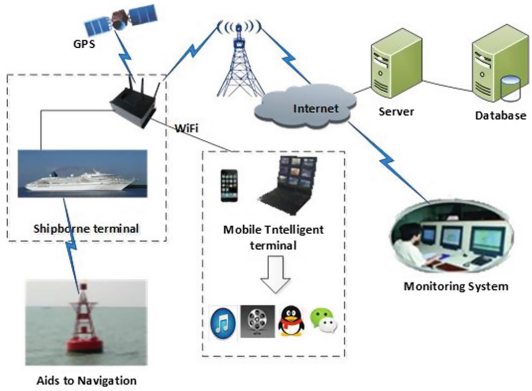

Fig. 1. The network topological structure of intelligent shipborne terminal system

2.1 Hardware Design

Considering the principle of the intelligent shipborne terminal system, the hardware system of intelligent shipborne terminal mainly includes power module, master control module, routing module, 4G communication module. Hardware framework of intelligent shipborne terminal system can be seen in Fig. 2.

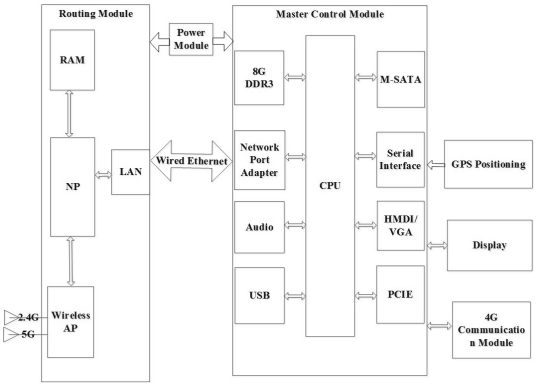

Fig. 2. Hardware framework of intelligent shipped terminal

Power module uses Cincon Electronics CHB100W-24S12, the input voltage of the module is broad, ranging from 9 V to 36 V, and the output voltage and current are 12 V, 8.3 A, and the power is 100 W, so it can provide a stable power supply for the system modules.

The main control module is the core module, using the PCM3-QM77 industrial mainboard with high performance and high reliability onboard IntelQM77 chip. The board has strong compatibility and abundant interface, which is convenient for system development and expansion.

The routing module is composed of dedicated network processor, memory and radio frequency antenna. The module is mainly used as an access point (AP)

for the intelligent terminal connect to local resources and Internet. This module communicates with the master control module using wired Ethernet and then accesses the Internet through the 4G communication module. Users can access to the multimedia database contained in the system by accessing the intelligent shipborne terminal system through its Wi-Fi signal.

The 4G communication module is SIM7100CE, it is an ultra-compact, highly reliable wireless module based on the Qualcomm MDM9215 multi-mode.

LTE platform network adapter module uses the MPCIE-RJ45, this module uses half-height Mini PCIE slot to Gigabit Ethernet interface RJ45 and integrated RTL8111E chip.

2.2 Software Design

According to the functional requirements of intelligent shipborne terminal system, the software system framework is composed of Linux operating system and embedded route operating system.

The main operating system uses Linux operating system, it is a multi-user, multitasking and multi-threaded operating system, which is based on POSIX and UNIX [8]. It can run the major UNIX tool software, applications and network protocols, and supports 32-bit and 64-bit hardware. The routing operating system [9] is an embedded operating system which using a transplant Linux kernel, so it has the best scalability, the fastest speed for routing support, and works well in support of routing CPU. It mainly achieves wireless routing and providing network access for intelligent terminals.

3 System Function Design

The system focuses on providing local multimedia services. There are massive multimedia resources stored in the local server, users can access the resources through the local area network, thus avoiding the congestion caused by the large number of users accessing the Internet through the 3G/4G channel at the same time. In this way of enjoying the multimedia services through the local area network, on the one hand it can improve the communication capacity of the intelligent shipboard terminal system, providing users with a good service experience, on the other hand, the decreasing number of users who accessing the Internet through 3G/4G channel also cut down the traffic of 3G/4G channel, thereby reducing the operating costs.

3.1 System User Status Query

The system user status query can query the IP, MAC address, uplink rate, downlink rate, total traffic, downlink total traffic, connection duration, and connection type of the user connected to the intelligent shipborne terminal system, also can monitor the network status of each user, and pass the data in the POST format to the database for subsequent operations. Implementation of the system user status query flow chart is shown in Fig. 3.

3.2 GPS Data Acquisition and Processing

GPS data is collected through the serial port system, so it must initialize the serial port and set the basic parameters of the serial port to provide GPS positioning information. Implementation of the GPS data acquisition and processing flow chart is shown in Fig. 4.

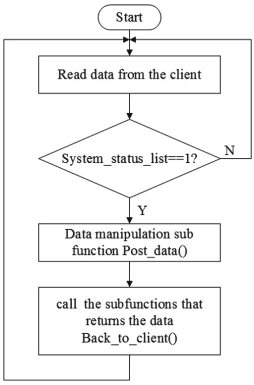

Fig. 3. System user status query flow chart

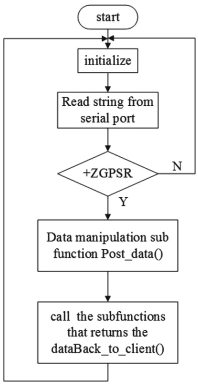

Fig. 4. Flow chart of GPS data acquisition

3.3 System User Qos Control

System user QoS control can give users different bandwidth based on different needs, it can control the priority of user (IP address), selection of access to 3G/4G line, maximum upload rate, minimum upload rate, average upload rate, maximum download rate, minimum download rate, and average download rate to bring users different experience, so as to improve the QoS. Figure 5 shows the QoS control flow chart of the system user.

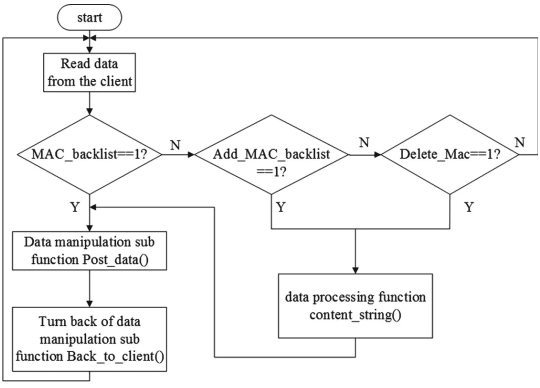

Fig. 5. QoS control flow chart of the system user

3.4 System User MAC Address Blacklist

System user status query can query the user's physical address (MAC address) [10], the system user MAC address blacklist can restrict the user access to the Internet by adding the MAC address to the blacklist, and user is only allowed to access to the LAN server, which can further distinguish different users, reduce the flow pressure of 3G/4G channel, and enhance the user experience. Implementation of the system user MAC address blacklist flow chart is shown in Fig. 6.

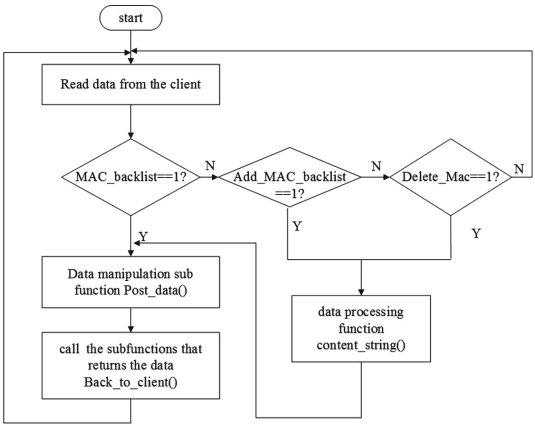

Fig. 6. System user MAC address blacklist flow chart shown

4 System Test and Analysis

The test of intelligent shipborne terminal system includes system user management function test, GPS positioning information test, automatic disconnection function test and system software login platform test, because the development of this system is the infrastructure development, so we use the code to realize the test. The material object of intelligent shipborne system is as shown in Fig. 7.

Fig. 7. The material object of intelligent shipborne system

4.1 System User Management Function Test

To accurately control the user information of each shipborne terminal and provide different service quality for different users, the system has the function module of system user management. In the testing of the system user management function, a client test program was written, through the client test program can connect system user management module, query information and accept the information returned by the system management module. When reading the system connection status through the client, the result of test is shown in Fig. 8.

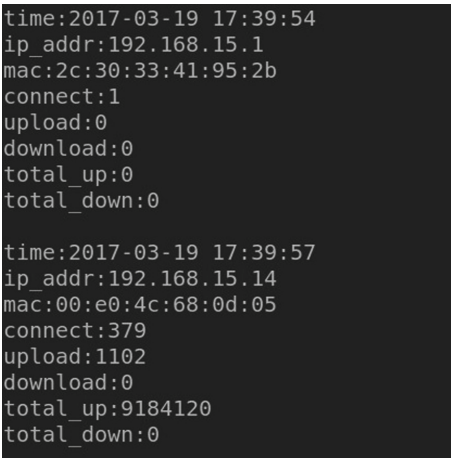

Fig. 8. The parsed data

From the analysis of the data we can see that there are two users connected, where the user whose IP is 192.168.15.1 has no data communication and there is only one connection, this is the IP of the routing module itself. While another users IP, MAC address, connection time, connection number and the total flow can completely output.

When users use the mobile phone to connect the intelligent terminal, the system did not make any control to the user and use client test program to send users control commands to the system, the measured user speed is as shown in Fig. 9. Figure 10 shows that after data processing, the user with IP 192.18.15.11 had QOS control in wlan1 port and control time is 24 h, the allowed minimum, maximum and average upload and download speed are: 80, 120, 100 KB/s, respectively.

When using the MAC blacklist to control users, the client receives the processed data returned by the system is as shown in the Fig. 11, it can be found that the user whose ID is 1 and the MAC address is a4:44:d1:33:2f:27 was intercepted by MAC. When we use mobile phone to connect the system, it can be connected, but cannot access to the Internet.

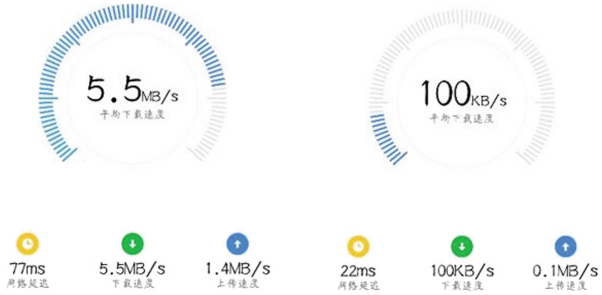

Fig. 9. No speed limit/speed limit test results

```
name:192.168.15.11
ip_addr:192.168.15.11
interface:wan1
time:00:00-23:59
week:1234567
min_up:80 max_up:120 avg_up:100
min_down:80 max_down:120 avg_down:100
```

Fig. 10. The results after system QOS analysis

```
id:1
mac:a4:44:d1:33:2f:27
```

Fig. 11. The MAC interception information

4.2 GPS Location Information Test

The master control module receives GPS data through the serial ports, and the analytical function will read and extract the useful positioning information, then output those information in a special format to other functions. The positioning information display result is as shown in Fig. 12. Positioning information includes date, time, latitude, longitude, altitude and direction angle. In this case, the date is March 19, 2017, time is 9 p.m. and 50 s, the north latitude is 25.2825933333 degrees, the east longitude is 110.3209633333 degrees, the height above sea level is 135.9 m and the direction angle is 149.00833 degrees.

```
/*****************GPS information*****************/
UTC date: 2017-03-19
Time: 21:00:50
Lat: 25.2825933333 deg, Latitude:N
Lon: 110.3209633333 deg, Longitude:E
Altitude mean-sea-level:135.9 m
Course over ground:149.00833 deg
```

Fig. 12. The GPS positioning information

4.3 Automatic Disconnection Function Test

The function of automatic disconnection can end the connection between the user and the intelligent shipborne terminal system and provide better service quality for the users in need. This function is connecting the routing module through the client test program client, then querying the disconnect network user list in routing module and receiving the return information of the routing module for test. The client test results is as shown in Fig. 13, when the client sends a GET command, the routing module will return the information about disconnect the user's MAC list, when using the ADD and MAC address to add user, the routing module will return OK, however if using a mobile phone connect the routing module, the routing module SSID can be seen but cannot connect.

```
GET
00:0C:29:4B:E5:F7
00:E0:4C:68:0D:05
ADD,A4:44:D1:33:2F:27
OK!
GEET
Please enter the correct command!
GET
00:0C:29:4B:E5:F7
00:E0:4C:68:0D:05
A4:44:D1:33:2F:27
DELETE,00:0C:29:4B:E5:F7
OK!
GET
00:E0:4C:68:0D:05
A4:44:D1:33:2F:27
```

Fig. 13. The command and return messages

4.4 Software Login Platform Test

The system software login platform test is done by using a mobile phone to connect the intelligent shipborne terminal system. As shown in Fig. 14, the mobile

phone will pop up the authentication information after connecting intelligent shipborne terminal system (as shown in a), when clicking the trial certification, the time of trial certification and the number of daily certification will be set, and the authentication failure will happen while the set limit exceeds, at that time only the intranets can be accessed (as shown in b). However, clicking the WeChat certification, the page will skip to the enterprise WeChat official account. After finishing the authentication, the various resources in the local server can be accessed via mobile phone. The "Wi-Fi + WeChat" authorization mode will automatically skip to the WeChat public number (as shown in c), it can avoid the complicated operation process of traditional web authentication. Making Wi-Fi connection process more concise, and not hinder the service provider information display and the opportunities of push advertisements (as shown in d), bring users a new experience in the mobile Internet era.

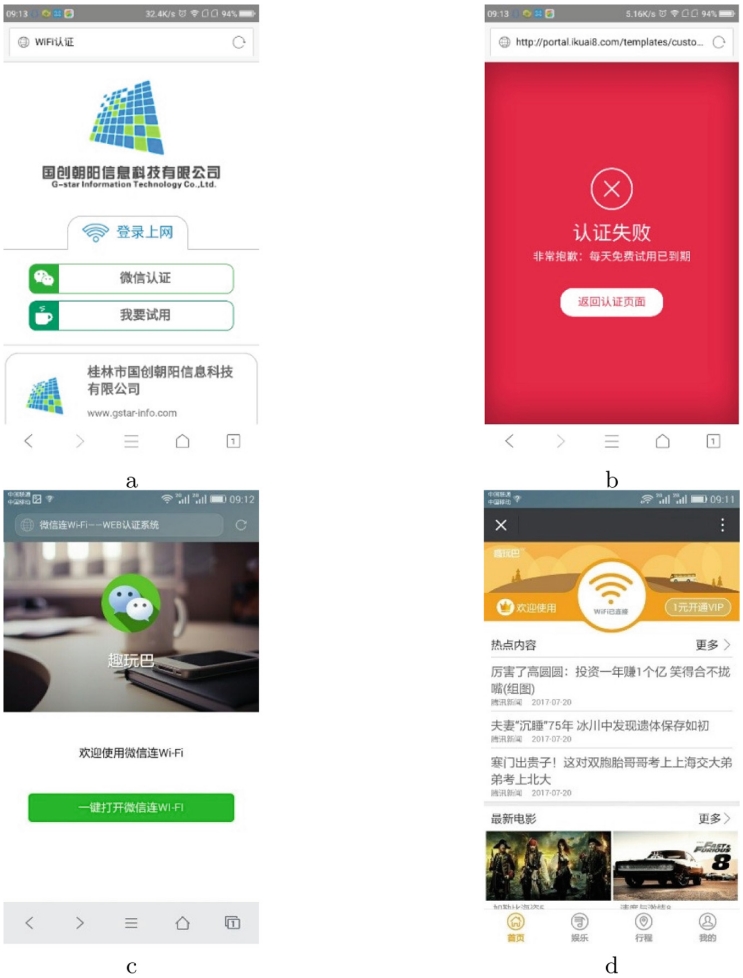

Fig. 14. Example of placing a figure with experimental results.

5 Conclusions

In this paper, an intelligent shipborne terminal system is proposed. First, we gave a detailed introduction of its hardware and software design scheme. The system can provide the wireless network sharing services, multimedia services, GPS positioning services for the end users and it also has the advantage of distinguishing different users. Then the test results shows that the system is easy to use, it has low configuration cost and stable operation. Users can enjoy local storage of videos, music, news, games and other multimedia entertainment information programs for free. This can better meet the demands of different users for the network and makes the journey on board be more pleasant. So it has good application value and practical significance.

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