Design and Implementation of Multiprotocol Heterogeneous Network Communication System

Shuai Wang¹ and Boyang Liu²

¹EquipmentSimulationTraining Center, Shijiazhuang Campus of Army Engineering University, Shijiazhuang 050003, China;
²Beijing Aerospace Control Center, Beijing 100094, China
Email: 723112756@qq.com

Abstract. In order to further enhance the capacity of military communication, and make the fusion of heterogeneous network communication technology more effectively, this paper proposes a new heterogeneous network communication scheme which adopted multi-protocol gateway server, and based on Ubuntu operating system. The design is integrated with Ethernet, serial communication and USB, mobile data, telephone and other communication interface of multi-protocol gateway server. The paper developed a multi-protocol gateway control application software and communication software, encryption to decrypt the data of the heterogeneous network communications, group and group package, the function such as protocol conversion. At last the paper described how a multi-protocol prototype heterogeneous network communication experiment system is built in a laboratory environment, to carry on the multi-protocol communication test.

1. Introduction

Compared with civil communications, military communication can be identified as high reliability, high security, high speed, high efficiency, and many other requirements, any kind of monopoly communication can hardly meet the requirements, a variety of heterogeneous network integration become the inevitable trend of future network development [1]. It is urgent for us to build a high speed and efficient heterogeneous military communication network system. Wang Meng [2] who had study the intelligent household multi-protocol gateway communication and control, designed based on ARM microprocessor and Linux operating system multi-protocol gateway server realized the Wifi and Bluetooth server process under two kinds of communication protocol and the serial communication between the management processes. Liu Junjie et al. [3] studied the multi-protocol access network switch based on Android and realized the control and interaction of different camera equipment. Gengjinfei [4] designed the multi-protocol mining gateway for underground multi-network communication, developed the multi-protocol mining gateway application software, and finally completed the system test of the multi-protocol gateway. Lu Ming [5] studied the construction of a corba-based multi-protocol adaptive gateway framework structure and reusable development platform, and realized the access of multi-protocol communication protocol through a unified CORBA interface. Man zhonghao et al. [6] proposed a multi-protocol conversion gateway scheme based on FPGA data conversion, realized the mutual conversion between CAN, RS232 and Ethernet data. Zou Xiaokang et al. [7] realized embedded multi-protocol semi-duplex communication gateway integrating RS485, CAN and Ethernet on STM32 platform. Wang Tiegang [8] studied the common audio and video transmission protocols, and realized the transmission of multi-protocol audio and video by means of state machine conversion.

This paper is about to build the multi-protocol network security communication system prototype experiments, and multi-protocol access gateway server is designed and developed accordingly. And
then the design is implemented based on the application of the Android operating system communication software, realizes the multi-protocol heterogeneous network parallel access and communication experiment, and the feasibility of more heterogeneous network communication protocol is verified.

2. Design of Multi-Protocol Heterogeneous Network Communication System and Prototype Experiment

2.1. Multiprotocol Heterogeneous Network Communication System
The multi-protocol heterogeneous network communication system is mainly composed of a number of regional trunk communication networks and Beidou satellite communication network system. The regional network and trunk communication network is mainly connected with multi-protocol access gateway server, and the Beidou satellite system can be used to connect the regional communication networks, too. The regional communication network is consisted of military telephone network cable, tactical Internet IP network and the combination of these subnets. Within the area, local security communication between terminals could be realized with the support of the security policy. Trunk communication network is a secure Virtual Private Networks (VPNS), which is built in a public mobile network using the IP network with the features of bearing the corresponding authentication and authorization mechanism, according to the multi-protocol access gateway server security policy, also known as the public mobile telecommunication network of VPDN (Virtual Private Dial-up Networks). The cross-regional remote communication with information terminals users would be achieved through multi-protocol access gateway servers and trunk communication network. Beidou satellite system is mainly used for emergency communication and key distribution. The topology of multi-protocol heterogeneous network security communication system is shown in figure 1.

Figure 1. Topology diagram of multi-protocol heterogeneous network security communication system

2.2. Prototype Design of Multiprotocol Heterogeneous Communication Network Experimental System. The system of multiprotocol heterogeneous communication network is huge and complex, and there is no mature example for reference. Since that, this paper designed and developed a multi-protocol access gateway server, and on this basis, set up an experiment system of many heterogeneous network
security communication protocol prototypes, to implement different network communication across the ends of the agreement, its structure is shown in figure 2.

![Figure 2. Multi-protocol heterogeneous network communication system prototype structure](image)

As shown in figure 2, multi-protocol prototype heterogeneous network communication experiment system is mainly consisted of two multi-protocol access gateway servers, two wireless routing node, Beidou satellite system and several information terminals. Multi-protocol access gateway servers are the core of the prototype experiment system. Their main functions include: (1) set up a number of different protocols of secure communication channel, and realize the communication between the gateway by making the use of itself is equipped with multiple protocols channel interface, under the control of the control software, (2) establish a wireless hot spot, and built up a wireless local area network accordingly, by making the use of its own with a wireless router. Information terminal is represented with the application terminal of the prototype experiment system. The multiple information terminals is connected to the hotspot of two servers respectively, by running the communication software, not only the communications within the local area network (LAN) can be realized, but also the communication across the LAN can be realized with the multi-protocol gateway server.

3. Multi-Protocol Access to the Network Shutdown Server

3.1. Multi-Protocol Access Network Server Hardware Design

The architecture of multi-protocol access network gateway server can be divided into hardware layer and software layer. The hardware includes basic operating equipment and multi-protocol channel access interface. The software is mainly consisted of operating system and multi-protocol access control software.

The hardware layer provides Ethernet, mobile data, USB, serial and other interfaces, enabling multiple physical connections. Ethernet interface is a common connection, which is the main used by gateway server. With appropriate network adapter, many kinds of physical connections, such as optical fiber, twisted pair can be realized by using it. Furthermore, it supports a transmission rate from 2Mbps to 10Gbps, can support both communication, and interconnection between different regions; and there are two types of mobile data interface, one is based on wireless Ethernet protocol (IEEE802.11 standard a/b/g/n) WiFi interface; and the other is the wireless interface based on digital radio. By adopting a hotspot wireless network adapter, the WiFi interface provides wireless interconnection within the working area. It also has the advantages of Ethernet interface and enhanced mobile performance. Digital radio has adopted a variety of techniques such as spread spectrum, frequency hopping and adaptive anti-interference, to realize wireless interconnection in complex electronic environment. In most cases, digital radios generally are connected to the gateway server through the RS232/RS485 interface; it can also be connected to the gateway server through USB adapter or Ethernet adapter. The transmission rate of serial communication interface rate is low,
suitable for low speed digital radio station, dial-up telephone modem, Beidou terminal and other devices of this kind. For the serial port devices that do not support the network protocol, the deployment of convert program for the equipment in the gateway server is needed, which realizes the Ethernet protocol to the serial communication protocol conversion. USB communication interface has strong expansibility, namely plug and play, which is suitable for connecting WIFI network adapter and 3G/4G adapter. The driver of the adapter can realize the conversion of Ethernet protocol and link layer protocol. The hardware structure of the multi-protocol access gateway server is shown in figure 3.

To meet the needs of the multi-protocol heterogeneous communication, this paper design the multi-protocol access gateway server a total of 33 interface, including 9 kind of protocols, Specific include: 3G, 4G data, the number of USB interface for all six, WIFI interface number four, Ethernet interface number is three, Beidou, phone number, multimode fiber, serial communication interface for the two.

![Hardware Structure](image)

**Figure 3. Multi-protocol access network server hardware structure**

### 3.2. Multi-Protocol Access Network Server Software Design

The software of multi-protocol access gateway server mainly includes operating system and multi-protocol security access control software. Multi-protocol security access control software is developed with JAVA language, multi-protocol access gateway server software is composed of multiple modules, including identity authentication module, access control module, communication module, the communication channel pattern selection module, file segmentation module, session key application module, data encryption module, data sending module, data receiving module, receiving module, data decryption module, session key file merge module, information encryption storage module, multi-channel TCP module, software composition and functional description is shown in Table1. It should be pointed out that, choose a communication channel module set the channel order is "twisted-pair cable channel - fibre channel - channel 4G - 3G channel - USB serial port channel channel - phone channel", the big dipper channel used for emergency communication, WiFi interface is used to form a wireless local area network (LAN).
Table 1. Multi-protocol security access software component module and its functions

| Name | Software Module | Function |
|------|----------------|----------|
| Identity authentication module | Used for authentication of mobile information terminal and the user's authentication, provide a wide range of client identity authentication, including simple user name password mode, SMS password mode, dynamic password mode, such as certificate authentication way. Uses the role associated technology, time, location, authentication, terminal and consider factors such as health, users belonging to different roles, then service resources to different roles, to meet the same user in different time, different locations, in different authentication way, on different terminal equipment, login to the network access can be obtained are also different, to achieve dynamic change access strategy. |
| Access control module | Select communication mode for communication, including voice communication, short message communication, file transmission, etc. According to the user's needs or when one of the communication channels is disturbed or attacked, switch to another communication channel quickly to ensure the robustness of the system. |
| Communication mode selection module | It is used to divide the files to be sent into several blocks to meet the needs of packet transmission. |
| Communication channel selection module | Used to generate the session key negotiated with the communicating party and establish VPDN in the public communication network entropy. |
| File segmentation module | Used to encrypt sending data using session key. |
| Multi-protocol access to the network shutdown server | Used to send data to the receiver over the selected communication network. |
| Session key request and negotiation module | Used for receiving data or information, etc. |
| Data encryption module | Used to receive session keys from the receiver and establish VPDN on the public communication network. |
| Data transmission module | Used by the receiver to decrypt the received data using a session key. |
| Data receiving module | Is used by the receiver to merge the received block files into one original file. |
| Session key receiving module | The data in the gateway is encrypted and stored to prevent data leakage through the built-in encryption card and the universal encryption algorithm library. |
| Data decryption module | In multi-protocol access gateway server operating system to load the multichannel TCP module, number of communication channels with the currently available will send files by several block transmission to the receiving party, the receiving party after receipt of each packet according to the multichannel TCP modules in system kernel automatically assemble them into a complete information. |

4. Application Communication Software System

Implemented in this paper, the communication software that installed in information terminals was based on the android operating system in the information terminal hardware modules and their driver and the support of all kinds of communication protocol. To be able to in the application layer to provide users with a short message, such as file transfer communication service, structure system can be divided into hardware layer, the driver, protocol layer and application layer, as shown in figure 4.
The configuration hardware layer of information terminal is shown as in Figure 4. In order to realize short message communication, so the Beidou communication module is added to the hardware system, in addition to the general calculation module, storage module, and WiFi communication module; The driver layer ensures that the above hardware modules can be called normally. The protocol layer is used to implement the communication protocol for multi-protocol communication. Application layer is the function of the specific application of communication software, providing features include: (1) the search for Wi-Fi hotspots, certification after automatically assign IP addresses and a mobile wireless local area network (LAN), can be implemented based on IP address within the local area network (LAN) communication; (2) the encryption and decryption function of communication enables the encryption and decryption of text communication, file transmission and other communication contents according to the encryption algorithm; (3) Beidou short message communication function, capable of Beidou short message transmission based on Beidou short message protocol and Beidou communication module.

5. Multi-Protocol Heterogeneous Communication Network Communication Experiment

5.1. Multiprotocol Heterogeneous Communication Experiment Hardware and Software
According to the experimental environment set up in section 1.2, the main hardware devices include multi-protocol access to network shutdown servers, wireless routers and information terminals. Among them, the multi-protocol access to the network shutdown server is customized as 6U standard chassis structure, PS2 and USB keyboard and mouse interface, DVI and VGA display interface, which can extend the connection to KVM.

The operating system of the multi-protocol access gateway server is Ubuntu, and the supporting software includes C++ and JAVA development and debugging environment, SQLite database, WebSocket interface service, etc. Multi-protocol access gateway server, known as MCFramework platform, is adopted in the software development, software applications through a WEB interface by the background process to realize the user communication content monitoring and access control, data channel and select file transmission service and communication network, and other functions.

The information terminal uses the Beidou handset containing the Beidou module. The operating system is Android 5.1, the development platform is Android studio 3.01, and the JAVA development version is jdk 1.8. Figure 5 is the multi-protocol gateway server control interface.
5.2. Multiprotocol Heterogeneous Communication Experiment

Wireless LAN network test refers to the prototype system is shown in figure 2, with more than two protocol gateway server set up WiFi hotspot, information terminal using the allocated to obtain IP address, network 1 and 2 hot IP gateway address: 11.1.1.0 and 192.1.5.0, network 1 and 2 gateway server to assign IP addresses are: 11.1.1.10 and 192.1.5.1, information network 1 and 2 terminal assign IP addresses are: 11.1.1.11 and 192.1.5.3.

The test of multi-protocol heterogeneous network communication mainly includes the test of connectivity under two conditions of encryption and non-encryption, the test of Beidou key distribution, the test of short message communication and the test of file sending and receiving. The encryption algorithm adopts DES, and the specific results are shown in Table2.

| Experiment content                  | Test method           | Results                                                      |
|-------------------------------------|-----------------------|--------------------------------------------------------------|
| Connectivity test                   | PING command          | "PING" each other succeed                                     |
| Beidou short message key distribution test | Send encryption key | Key successfully sent                                         |
| Short message transfer test         | Chinese characters,   | In the case of encryption, the short message is encrypted    |
|                                     | English, Numbers, etc.| successfully and the receiver is decrypted successfully. The |
|                                     |                       | message was sent and received without encryption             |
| File transfer test                  | Pictures, documents,  | Files below 200MB can be successfully sent                    |
|                                     | video and other files |                                                               |

6. Conclusion

This paper put out a new type of heterogeneous network communications solutions, designs and implements multi-protocol access gateway servers, which is developed on the android operating system.
system with the co-operation of the Beidou satellite communications software. The design of the multi-protocol heterogeneous network communication is testified with the laboratory experiments, and the good communication effect of that proved the feasibility and effectiveness of the solution. However, there are some problems to be improved. For the hardware aspect, is the insufficient number of interfaces, that is, the access scale of multi-protocol gateway server is limited. As for the software aspect is the limited communication capability of the test software, which currently only supports file size within 200MB and message transmission below 5000 bytes. All the above problems, are pointing out the direction of subsequent studies, and breakthrough will be made in the foreseeable future.

7. References
[1] Zheng J D. Design and implementation of a multi-protocol gateway 2010 Xidian university.
[2] Wang M. Communication and control of multi-protocol gateway and smart home 2017. North China University of Technology
[3] Liu J Wang F. Based on the android intelligent terminal more agreement access gateway application research 2013 Programmable Controller & Factory Automation 186- 88
[4] Geng J F. Design and realization mining gateway on the multi-protocol based on ARM 2014 China University of Mining & Technology 2014
[5] Lv M. Design and implementation of multi-protocol adaptation gateway based on CORBA 2001 University of Electronic Science and Technology of China
[6] Man Z Quan G D Xu Z. Design of multi-protocol translation gateway based on FPGA 2015 Coal Mine Machinery 36 298- 300
[7] Zou X K Liu S Zhang H R. Design of embedded multi-protocol gateway based on stm 32 2016 Microcomputer & Its Applications 35 38-40
[8] Wang T G. Technology acquisition and implementation of large-scale multi-protocol-based network video data 2015 Beijing University of Posts and Telecommunications