The Design of Service Acquisition System for Tiantong Satellite Mobile Communication Terminal

Kaihe ZHANG, Yanjun WANG, Liquan WANG, Chong WANG and Xiangyu LU
The 54th Research Institute of CETC, Shijiazhuang, 050081, China
E-mail: 13703114970@139.com

Abstract: In order to maintain national security and social stability, the ground mobile communication system is monitored by security sector in some area that captures information to prevent crime and terrorist attack. Because TianTong (TT) satellite mobile communication system is run by China Telecom publicly, so it must be equipped with capture system to forbid transmission of crime information. By analyzing advantages of independent station, L1 interface and IU interface, the method of data distribution through fiber between Access Network and Core Network is adopted in this system. The data obtained from the IU interface, through the signalling processing and service processing equipment, forms the call list, analyses the SMS and location, and obtains the corresponding user voice of the call. Finally, these service data are stored in the database. The state list and hierarchical state machine (HSM) method is used in this design to solve the difficulty of tracking handset’s many states. This design has lots of advantages such as overall data, good expansibility, and easy implementation and so on, which can satisfy the needs of recent and further use extremely. Now, the test of this system is completed and all devices are ready to equip.

1. Introduction
In the information society, Communication network becomes an important medium for people to obtain and exchange information. At the same time, the number of criminal activities through various communication networks is also increasing, for example, command and control of terrorist acts, illegal goods trading, commercial espionage illegally obtaining the data of the other party and so on, that will endanger social stability. Therefore, the government can obtain the corresponding information of their crimes by means of business interception, and stop or combat their criminal acts [1]. At present, the ground mobile communication network is managed by relevant departments, which can realize real-time business interception and subsequent query for specific users [2].

TianTong (TT) satellite mobile communication system is an important part of China’s space information infrastructure, and the communication service is operated by China Telecom Corporation. TT satellite mobile communication system and ground mobile communication system will jointly constitute a mobile communication network, providing all-weather, all-time, stable and reliable mobile communication services for users in China and surrounding areas [3]. TT system provides voice, short message and data services. Through one-year mission support, on orbit test and trial, the satellite mobile communication system of TT gradually shows its advantages in emergency application, universal coverage, flexible business, preferential tariff, independent controllability, etc. At present, our country has approved the development projects of 02 and 03 satellites, and the ground application...
system also needs to be carried out corresponding supporting development, so as to speed up the progress of China's independent satellite mobile communication system. This system can provide strong communication support for the information security and economic security of our country, the protection of national political and economic interests and military interests, the improvement of communication support level in special fields such as national emergency communication and military diplomacy, and the enhancement of disaster relief and disaster reduction and anti-terrorism capability [4].

Therefore, while developing China's satellite mobile communication system; it is urgent to establish a set of corresponding service acquisition system to acquire services for specific satellite mobile communication terminals, so as to maintain the stable and safe development of the country.

2. Overview of TT system

TT satellite mobile communication system consists of communication satellite, operation control system, gateway station and terminals and so on. The operation control system is the operation management center of the geosynchronous orbit satellite mobile communication system. It is an important part of the whole system and an indispensable nerve center to maintain the normal operation of the whole system. The operation control system integrates the satellite service measurement and control function and the communication network operation management function, and manages the operation of the satellite payload and the communication system [5].

Gateway station completes air interface signal processing, user access, service exchange, connection with mobile users in satellite network through TT satellite, and connection with operation control system and ground communication network through ground optical fiber line. It is the core node of the whole application system. The gateway station consists of satellite access network, core network, service system and support system and so on.

Satellite access network consists of antenna and RF subsystem, wireless access and control subsystem, wireless resource management and scheduling subsystem, equipment management and maintenance subsystem, etc.[6]. It mainly performs wireless signal receiving and sending, wireless resource management, synchronous maintenance between the gateway station and the user terminal, which is used to provide the transmission channel from the user terminal to the core network, and to transmit system signaling and user data.

The core network refers to the core network architecture of 3GPP release 6, which is composed of two parts: circuit domain and packet domain. It mainly performs authentication and encryption, mobility management, service management, bill generation and output [7]. The core network and the local integrated gateway Bureau of China Telecom use TDM mode to communicate.

The gateway service system mainly includes short message service, short message broadcast service and data backhaul service. The gateway station support system is used for China telecom operation and maintenance of satellite mobile communication network. Its main functions include information collection, integrated network management and billing.

3. General design of service acquisition system

3.1. Scheme comparison and analysis

In order to monitor the behavior of a specific satellite mobile communication terminal, it is necessary to establish a service acquisition system at the side of the gateway. On the basis of the analysis of the structure of the gateway station and the functional division of the service acquisition system, there are three schemes: the scheme of self-built independent system, the scheme of full data access of IU port between the access network and the core network, and the scheme of police interface system.

The scheme of self-built independent system requires the construction of the whole wireless system, adding forward and backward monitoring access stations. This system is completely independent of the normal gateway station, without additional rental and other costs. At the same time, due to the full independent development, the monitoring items can be customized according to the
needs, and the monitoring data is more comprehensive. But this system equipment is too complex, so the cycle is long and the cost is high.

The full data access scheme of IU port can collect all users’ relevant behaviours and data, realize customization and flexible data analysis. Through the research and development of IU protocol processing equipment, signalling processing equipment and so on, all terminal signalling and services data acquisition can be completed [8].

The interface of the police interface scheme is simple and easy to implement. The business center needs to establish a control center and a storage server to complete the information storage and monitoring of the designated terminal. The cost of this scheme is much lower, but the data is standard which cannot be modified, and the number of concurrent user is limited.

Through the analysis and comparison, the full data access scheme of IU port has many advantages, such as many kinds of data, high flexibility, strong expansibility, good independence and so on. Therefore, this scheme is chosen for the service acquisition system.

3.2. Overall system architecture design
In this scheme, the IU interface between the access network and the core network is divided by optical fiber, and then connected to routers, firewalls and service acquisition equipment. The service acquisition system analyzes the data to filter out the parameters of the satellite system itself, takes out the relevant data of the terminal, and then obtains the terminal status and service data. The system can process all the service data of TT satellite’s 119 beams, with a user level of one million. The system block diagram is shown in Figure 1.

![Figure 1. The block diagram of the system.](image)

The IU protocol processing equipment completes the data acquisition, analysis and filtering data of the IU interface, and only transmits the signaling and data related to the terminal to the subsequent processing equipment. The RANAP protocol processing equipment completes the resolution of the IU interface RANAP protocol, and transmits the signaling and service data to the back-end equipment respectively. The signaling processing equipment completes the users’ call signaling processing, and the SMS/location processing equipment completes the terminal short message and location analysis. The voice processing equipment completes the TT users’ voice data decoding processing and restores the voice. The service processing and data center can complete the real-time status tracking, location tracking, voice service listening and SMS browsing of the designated terminal, and even can query the status and services of terminal from the previously stored data.
4. Key technology of system

4.1. Signaling analysis and call list formation
This part mainly completes non-access layer (NAS) signaling analysis, including mobile management (MM) layer and connection management (CM) layer signaling and signaling matching with terminals. The signaling of all air interfaces includes paging, authentication, network access, location reporting, call control, PDP activation, etc. [9]. The part of terminal matching and state tracking completes the matching of signaling and corresponding terminal, and tracks the state of terminal.

The IU protocol processing equipment receives the general signalling stream from the IU interface between the access network and the core network of the gateway station, and analyzes it according to the IU protocol [10]. After the data analysis is completed, the signalling data is sent to the RANAP protocol processing equipment through the RANAP_DATA_IND message. The RANAP protocol processing equipment parses the RANAP signaling to obtain the NAS message, and then sends the NAS message to the signaling processing equipment through the NAS_DATA_IND message. The signaling processing equipment parses the NAS message content, and then sends the call information to the service processing and database center through the SST_DATA_IND message, which generates the call list and then stores it. This flow is shown in Figure 2.

![Figure 2](image depicts the flow of generating the call list)

**Figure 2.** The flow of generating the call list.

4.2. SMS/location processing
The interaction process between the IU protocol processing equipment and the RANAP protocol processing equipment is the same as described in Section 4.1. After receiving RANAP_DATA_IND message, the RANAP protocol processing equipment parses the RANAP signaling to obtain the SMS/location message, and then sends the SMS/location message flow to the SMS/location processing equipment through the SMSL_DATA_IND message. The SMS/location processing equipment parses the SMS/Location message and sends the SMS/location to the service processing and database center through the SST_DATA_IND message, which processes and stores the SMS/location information received. The whole processing flow is shown in Figure 3.

![Figure 3](image depicts the flow of SMS/location processing)

**Figure 3.** The flow of SMS/location processing.

4.3. Voice processing
The IU protocol processing equipment receives the general signalling stream from the IU interface between the access network and the core network of the gateway station, and analyzes it according to the IU protocol. After the data analysis is completed, the signalling data is sent to the RANAP protocol processing equipment through the RANAP_UID_ID_IND message. After receiving RANAP_UID_ID_IND message, the RANAP protocol processing equipment obtains the user ID from the message, and delivers the user ID information to the IU protocol processing equipment through the...
UEID_CONFIG_REQ message, which creates user services mapping table according to user ID. The IU protocol processing equipment receives the voice stream from the IU interface, matches the terminal according to the user service mapping table, and then sends it to the voice processing equipment through the CS_DATA_IND message carrying the user ID and voice stream. The voice processing equipment decodes the voice of the terminal, and then sends the voice data with the user ID to the service processing and database center through the SST_DATA_IND message. The service processing and database center stores the voice according to the call list to form a database. The whole processing flow is shown in Figure 4.

![Figure 4. The flow of voice processing.](image1)

![Figure 5. The state machine structure.](image2)

### 4.4 Terminal status maintenance

Due to the complexity of terminal state, the state machine mechanism and message driven mechanism are used in terminal state maintenance. Each terminal corresponds to an independent state machine variable, and the system tracks the state of the terminal according to the state machine. In order to solve the parallel processing problems of multi-task, multi-state and multi-message, the theory of hierarchical state machine is adopted [11].

Because the terminal needs to deal with concurrent scenarios, the first level of state machine needs to contain all possible concurrent processes and extract the mutually independent entities, that are called "parallel state machine" in the design. Each parallel state machine can include multiple processes with single dependency and serial execution, which constitutes the second level of state machine. The entity of this level is called "serial state machine". The execution sequence of each serial state machine is the same as the idea of stack first-in last-out [12].

Each serial state machine entity forms different processing scenarios due to different process contexts. These different processing scenarios are called "main states" in the design. Each main state is to complete a specific protocol action, which may require message interaction with internal and external modules, thus including a series of message waiting processes. The States waiting for a specific event are called "sub states" of a specific "main state". The state structure is shown in Figure 5.

The introduction of hierarchical state machine and stack compression simplifies the complexity of the program, reduces the difficulty of variable planning and maintenance, clearly maintains the program context, and reduces the workload.

### 5. Peroration

TT satellite mobile communication system is the first generation of satellite mobile communication system independently developed by Chinese. The system is operated publicly by China Telecom,
providing communication guarantee for public utilities, but also providing great convenience for terrorists communication. Therefore, in the severe situation of anti-terrorism in some regions of China, the service acquisition system provides technical support and guarantee for better control of TT satellite terminal. At present, the system has been tested and will be equipped in the second stage.

Acknowledgments
At the point of finishing this paper, I’d like to express my sincere thanks to my leaders, working staff, and friends and so on. Without their help, it would be much harder for me to finish the work and this paper.

Reference
[1] Chen Jie and Wan Lili 2008 Research on legal interception of communication network Power system communication 29 48
[2] Meng Xudong, Wang Jun and Tao Hai 2004 Implementation technology of L1 (legal interception) in mobile communication Jiangsu communication technology 2 30
[3] Zhang Gengxin et al 2001 Satellite mobile communication system (Beijing: People's post and Telecommunications Press) p 4
[4] Liu Siyang 2014 Development status and trend of satellite mobile communication system Modern telecommunication technology 7 23
[5] Jia Heping et al. 2017 Reseach on Architecture Characteristics of GEO Mobile Satellite System Radio Engineering 9 7
[6] Zhu Chanchan,Liu Chenyu, Gu Shaolong and Luo Pan 2017 Simulation of wireless access network in satellite mobile communication system Radio Communications Technology 6 24
[7] Zhou Wei,Zhang Yunyong,Fang Bingyi 2011 Research on distributed core network architecture and standardization Information and Communications Technology and Policy 5 57
[8] Chen Yuhua,Zhang Zhizhong and Zuo Shuchuan 2009 Research on monitoring technology of IU PS port in TD-SCDMA Network Digital communication 5 77
[9] Xiong Zhiguang and Han Xing 2017 Research and Implementation of WCDMA Protocol Analysis Technique Radio Engineering 4 69
[10] Yu Yongcong 2008 WCDMA IU interface protocol analysis and calculation method research Mobile communication 6 84
[11] Xiao Taosen and Luo Kelu 2018 Application of hierarchical state machine in cluster devices Network and communication 12 122
[12] Arda Kurt and Ümit Özgüner 2013 Hierarchical finite state machines for autonomous mobile systems Control Engineering Practice 21 184