Exploration of Earthquake Early Warning Technology Integrated with CATV

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Abstract - Cable TV transmits information through video and audio, with the characteristics of indoor family as a unit and wide coverage. Because earthquakes can cause huge losses, it is urgent to realize an early warning system for the public, especially for those being indoors at the time of the earthquake. The combination of CATV and earthquake warning technology can meet these needs.

Keywords - Earthquake warning, cable TV, encryption algorithm, multi-network integration

I. INTRODUCTION

Emergency technology has achieved a huge leap in the business capacity of earthquake prevention and disaster reduction industry, whether in the perception of earthquake stations, transmission of private networks, calculation and confirmation of data centers, etc. However, there are still large gaps compared with the requirements to achieve the warning function for the general public.

Taking earthquake early warning as an example, the early warning information needs to open the information exchange channels to the government, the public, enterprises, industries and other social subjects, especially to the ordinary people indoors. Therefore, based on this scene, the public needs to be informed through sound and picture, and the home cable TV picture and sound warning treble broadcast can effectively reduce the loss of emergency disasters.

II. SYSTEM TECHNOLOGY REALIZATION

A. System Architecture

The television early warning system needs to interact with information service end of earthquake data center. Cable TV broadcasting platform sets up the early warning platform and API interface of the earthquake data center to access the early warning data in standard protocol format, and transmits the early warning information to the TV system through the TV network. In the earthquake warning system, the station network of the earthquake warning station is connected to the TV earthquake warning server installed in the radio and television network through the special line network. This server is connected to the TV set-top box through the network of the radio and television network.

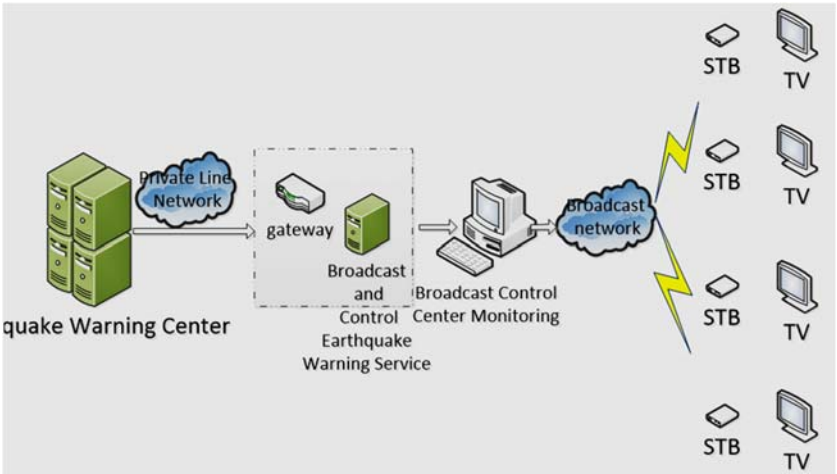

Figure. 1 Topology schematic of TV earthquake warning system.

The set-top box maintains the network connection with the TV earthquake warning server. When receiving the earthquake warning information, the TV screen pop-up window displays the earthquake warning and broadcasts the earthquake warning by voice. The topology diagram is shown in Figure 1. The propagation speed of radio waves is

300,000 kilometers per second, and that of earthquake waves is 3.5 kilometers per second. Earthquake warning is the time difference between the propagation speed of radio waves and seismic waves. When an earthquake occurs, it produces earthquake waves. After the earthquake warning instrument detects the earthquake waves, it transmits them to the earthquake warning center in the form of radio waves. After analyzing and processing the data, the earthquake warning center sends out warning signals to the outside world through the network.

The whole system follows the design of SOA [1] architecture, the module work of the system has the requirement of loosely coupling, and the modules are joined and combined through a uniform standard servlet interface [2] to achieve the overall application scenario function.

Because the earthquake warning information is relatively sensitive, it needs the security of information transmission to prevent tampering. In order to protect the security of sensitive data in the transmission process, the system uses SSL encryption technology [3], and SSL formulates the security protocol to ensure that the information exchange between front-end and back-end is transmitted through the built secure channel. SSL runs between the transport network layer and the application layer, providing an encrypted data channel for information transfer between servers, utilizing RC4 [4],RSA [5], and a 40-bit key. In addition, the HTTP protocol based on SSL is built into the front end of STB, which uses port 443 instead of port 80 to communicate with TCP / IP as HTTP does. The HTTPS protocol uses SSL to encrypt the original data at the sender, and then decrypt it at the receiver. Encryption and decryption require the sender and the receiver to exchange a common key. Therefore, the data transmitted is not easy to be intercepted and decrypted by network hackers.

B. System Composition Module

The system is mainly composed of regional early warning data management module, voice processing module, early warning data playing module, application interface module, data interface module with earthquake early warning center, terminal client (terminal part), etc. The module composition is shown in Figure 2.

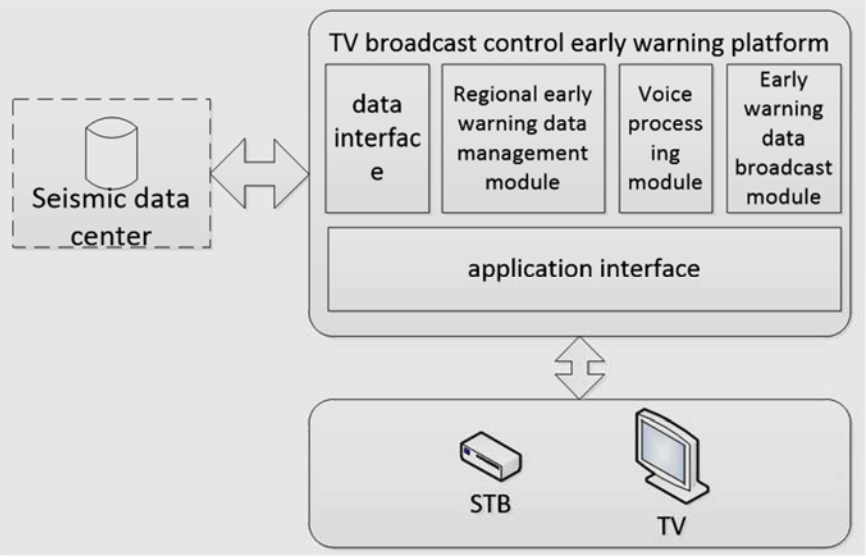

Figure. 2 Module Composition Diagram.

Data interface module with earthquake early warning center: it mainly realizes the docking of early warning data with earthquake early warning center system, and real-time docking and pushing through private interface protocol.

Regional early warning data management module: provides regional group authentication management and related services for early warning terminal. The module belongs to the cloud module relative to the set-top box terminal. After the set-top box is turned on, it actively requests the module to query its region. After the cloud feeds back the longitude and latitude data, the set-top box carries out subsequent processing.

Voice processing module: it mainly realizes the voice processing of early warning data, so as to realize the voice broadcast function of early warning information in the terminal. Because online real-time voice conversion will consume precious time of seconds, which is too much sacrifice for the earthquake warning system that can't wait for any time, the voice splicing method is adopted in the voice conversion mode. When the set-top box is turned on, the digital voice file is cached locally in advance, and the splicing is calculated by the terminal of the set-top box.

Early warning data broadcast module: mainly realize the broadcast of early warning data, and accurately broadcast

the specified content according to the request of the terminal. After receiving the early warning data from the data interface module of the earthquake early warning center, the early warning data broadcast module sorts out and processes the data to form metadata suitable for further calculation of the set-top box for subsequent processing.

Application concurrent interface: encapsulated application interface between terminal early warning application and TV earthquake early warning system. The communication between the two sides follows the application layer MQTT [6] protocol. Compared with HTTP, establishing a connection for each request will produce a lot of overhead. MQTT can greatly reduce this overhead by using persistent connection. MQTT also contains unstable networks. MQTT recovers from failures such as disconnection without further code requirements. HTTP itself cannot achieve this effect, but needs to re code, which greatly reduces the efficiency of the system. Under the background of strong real-time requirement of early warning, if the information is not published to the public in time due to the blocking of firewall capacity on the network, it will lead to the expansion of the loss. Therefore, the fault tolerance of firewall has become a consideration. The general firewall limits the outbound connection to some predefined ports, which are usually limited to HTTP (port 80) and HTTPS (Port 443) 〉MQTT is displayed as an HTTP upgrade request, so it can be run in this case. At the beginning of its design, MQTT also aims at low power consumption, which is one of the reasons for choosing it. At the same time, in the case of connecting millions of clients, it needs a lot of work to maintain millions of concurrent connections in the HTTP stack. On the contrary, MQTT perfectly supports large concurrency.

Terminal client: Set-top box application plug-in for earthquake warning resides in the set-top box terminal. When receiving earthquake warning information, you can display earthquake warning and voice broadcast earthquake warning in TV screen pop-up window in collaboration with cloud module according to the content broadcast by the warning system at any time.

In the data transmission network, the overall communication path of CATV network is divided into core network, metropolitan area network and access network. The interactive data of earthquake early warning also passes through the core network, metropolitan area network and access network through the cable network in turn through the cable network, and finally reaches thousands of set-top box terminals. In the core network and metropolitan area network, early warning information is transmitted by multiplexing optical channels in the mode of wavelength division. The channel in the access network is HFC [7]. In the final network channel from small building to home, coaxial cable channel is the main channel. In order to reduce the uncontrollable delay caused by IP concurrency pressure of server-side data, the real-time earthquake early warning is affected. Using similar wireless communication cellular network technology[8] as reference in access network, the coaxial channel is multiplexed by frequency division multiple access mode[9], so that each frequency point resource can be fully used in each building in the community without disturbing the use of other buildings at the same frequency point.

C. Edge Calculation

After processing by the broadcast and control platform warning platform, the earthquake onset time, epicenter and magnitude are obtained, and multithreaded concurrently sent to the set-top box terminal. Finally, the warning voice information, such as the arrival countdown of seismic wave, is calculated from the end edge of the set-top box. The seismic wave is divided into shear wave and longitudinal wave, in which the earthquake damage is mainly caused by shear wave, so only the arrival time of shear wave is calculated. The key algorithms for calculating the countdown of earthquakes along the edge and predicting the level of earthquake susceptibility at locations are shown in the following two formulas:

$$D = R * arc\,cos(sin\Phi A sin\Phi B + cos\Phi A cos\Phi B cos(\lambda B - \lambda A) \quad (1)$$

$$T = \frac{R*arc\,cos(sin\Phi A sin\Phi B + cos\Phi A cos\Phi B cos(\lambda B - \lambda A)}{3.5} \quad (2)$$

Where:

D is the latitude-longitude distance of the earthquake center and the latitude-longitude distance of the set-top box. T is the countdown to the arrival of the shear wave. The set-top box automatically queries the latitude and longitude of the cloud after boot-up and persists to memory. R is the radius of the earth, longitude and latitude of the area where the set-top box belongs are lambda A and A respectively, longitude and latitude of the earthquake epicenter are lambda B and B respectively, t is the time consumed by the server, calculation of the set-top box and network transmission. The agreed seismic S-wave velocity is 3.5 km/s.

The code for calculating the distance between two points in PHP is as follows:

```
d[n,m] = l = R * arccos[siny1siny2 +cos(x1 - x2)cosy1cosy2 +]
for n = 1 : 101%n->1-101,m->2-102
    for m = n+ 1 : 102
            numdex = cos(sj(n, 1)- sj(m, 1)) * cos(sj(n, 2)) * cos(sj(n, 2)) + sin(sj(n, 2)) * sin(sj(n, 2));
            d(n,m) = 6370 * acos(numdex);
    end
end.
```

III. RESULTS AND DISCUSSION

After field test and verification, the broadcasting and television network makes full use of the characteristics of short delay and wide coverage, meets the need of second-magnitude response for earthquake warning, and is an ideal way to transmit earthquake warning information. In the actual test, by docking the radio and television broadcast control platform with the data center of the earthquake warning network, the radio and television network can push different long warning information for users in different regions, not only before the arrival of the simulated destructive earthquake wave, but also realize the accurate access of the warning information. The TV side validation model is shown in Figure 3.

Figure. 3 TV End Alert Diagram.

The time delay from the occurrence of the simulated source earthquake to the start of broadcasting in the set-top box of the home user is less than 500ms. The countdown of the arrival of the shear wave of the earthquake and the simulated shear wave almost reach at the same time, which meets all the requirements.

The cable TV broadcasting platform has large data cloud map showing real-time earthquake warning, which provides quick earthquake reporting service for government, enterprise, metro, aviation and other units in time for earthquake warning, so as to facilitate emergency decision-making. The cloud map model of broadcast-controlled earthquake warning is shown in Figure 4 below.

Figure. 4 Cloud Map for Broadcast and Control Earthquake Warning.

IV. CONCLUSIONS AND FUTURE WORK

This paper introduces the technical exploration and research of earthquake warning emergency broadcasting with cable TV, establishes a laudable theoretical model, finally completes the research and development of system model and field verification, and is actively promoting landing in relevant pilot areas.

In the future, based on the exploration results of cable TV early warning broadcasting, we will continue to expand the early warning broadcasting services to dock emergency broadcasting, mobile phone, computer and other multi-screen and multi-terminal, study the early warning mode through wireless transmission, use 5G communication technology to solve the delay problem[[10] of wireless earthquake early warning, and use MIMO diversity technology and multiplex technology to solve the reliability and efficiency[11] of early warning information. In the service scenario, we will conduct in-depth research on opening information exchange channels to government, enterprises, industries and other social subjects. Explore the real-time production and processing of the data output from seismic data processing to form various kinds of earthquake information services, such as earthquake warning, earthquake parameter quick report, earthquake intensity quick report, earthquake parameter quick report, emergency response and so on, which can be issued to the public, government departments, railways, nuclear power, water conservancy, gas, chemical industry, medical and health, Education and other industry demonstration users. We will continue to expand custom terminals for various emergency earthquake information services to ensure timely transmission of emergency earthquake information. Centralize the processing of emergency earthquake information service data to form a unified data service platform for relevant governments, industries, the public and so on.

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Yu Jie (1988 -), male, holds a Master Engineering degree, works for Jiangsu Cable Data Network Co., Ltd. He is mainly engaged in image error concealment, broadband wireless communication and sensor network technology. He has participated in major projects such as OTT unified operation platform of Jiangsu cable and virtual TV network of Jiangsu Public Security Department.