International Journal of Future Generation Communication and Networking
Vol. 9, No. 12 (2016), pp. 1-16
http://dx.doi.org/10.14257/ijfgcn.2016.9.12.01

Emergency Broadcasting over CATV Channel using FM Subcarrier Technology

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Abstract

Emergency broadcasting is of importance method to alert people when disaster happens, but the development of network is slow in Chinese rural areas. So it is necessary to propose an emergency broadcasting solution for Chinese rural areas based on the available network. In this paper, a method that adopts FM subcarrier technology over CATV channel to broadcast emergency message have been proposed. In the method, emergency program is transmitted by CATV channel and emergency order is carried in FM subcarrier. As usual, to communicate emergency message to the public efficiently and effectively, a complete emergency broadcasting system should have following functions such as parallel broadcasting, compatibility, robustness, security, and so on. In the context, to satisfy above requirements, corresponding system construction, communication scheme, and message transmission protocol have been proposed as well. To verify the practicability, the solutions have been test in Chinese rural areas MiYun and gain good results.

***Keywords**: Emergency Broadcasting, Cable FM Subcarrier, RDS, Transport Protocol*

1. Introduction

1.1. Background

Emergency broadcasting message can be transported by varies of ways, such as mobile network [1, 2], Internet network [3], FM network [4], digital TV network [5] and so on. In the article, we pay our focus on researching emergency transportation scheme for rural areas in China. In most parts of Chinese rural areas, the development of broadcast network still lags behind that in city areas, only FM network and Cable analog TV network can cover most areas efficiently. FM network is vulnerable to interference and can't keep the security of message, so we choose Cable analog TV network as emergency broadcasting transmission channel.

In usual, emergency message is comprised of emergency information and emergency order. Emergency information is program that will be communicated to audiences in audio or text format. Emergency order is responsible for when, how and where to transmit the program. Based on the situation, we choose FM Subcarrier in Cable (CFS) [6, 7] to broadcast emergency message. Emergency information can be transported by cable analog TV network, and emergency orders can be carried in FM subcarrier.

Considering that there is county, countryside, village three administration social estates in Chinese rural areas and each estate should be capable of broadcasting emergency message. The emergency broadcasting solution based on CFS should be able to solve following problems:

Data transmission: order data could be transported as subcarrier signal together with audio signal which is in cable analog TV network;

ISSN: 2233-7857 IJFGCN

Parallel broadcasting: because emergency information may be different in each area at the same time, so a platform should be capable of broadcasting more than one emergency message simultaneously.

Compatibility: keep the uniformity of transmission protocol and coding rules for future replacement and updating.

Robustness: broadcasting platform per estate can releases emergency message independently without rely on each other.

Sub-regional controlling: emergency message can be broadcasted to designated areas without affecting people receiving daily program in the other areas.

Priority: set based on the level of emergency message and broadcast agency, and used to decide which message should be broadcast firstly when terminal receives several emergency signals at the same time.

Security: system should be able to protect emergency messages with digital signature technology from being tampered and interrupted.

The structure of the paper is as follows: firstly, introduces the background and related works; then comprises several kinds of emergency broadcasting system constructions and technological routes based on CFS emergency broadcasting system (CFS-EBS); next, defines the transmitting protocol of CFS-EBS; after that, tests CFS-EBS in rural areas and analyzes the results; at last, summed the pros and cons of CFS-EBS and future works we will work on.

1.2. Related Work

FM subcarrier technology aims to transmit text, picture, or audio data with FM broadcasting program in spare frequency spectrum. To realize CFS, audio signal, which carries subcarrier message, should be modulated to FM signal in 87MHz-108MHz; then mixed with available cable TV signal, and transmitted to terminal by coaxial cable or optical fiber. There are lots of available FM subcarrier technologies, such as Subsidiary Communication Authorigations (SCA) [8], Radio Data System (RDS) [9, 10], Radio Broadcast Data System (RBDS)[11], Data Radio Channel (DARC)[12], High Speed Subcarrier Data System (HSDS)[13] and so on. These technologies have been widely applicate in traffic message, vehicle information and communication system [14], broadcast response system [15], warning system [16, 17] and other systems.

In Chinese rural areas and schools, FM subcarrier technology has been widely and simply used to realize regional broadcasting, spot announcement and call waiting. However, there is no system or transmission scheme designed to solve problems in emergency broadcasting. Therefore, the article adopts FM subcarrier technology for emergency broadcasting and proposes corresponding system construction, communication scheme, and message transmission protocol.

The comparison of prevalent FM subcarrier technologies has been shown in Table I.

Because in most parts of Chinese rural areas, available broadcast network infrastructure and equipment support RDS, so the paper proposes a scheme based on RDS to test the reliability and practicability of our CFS-EBS technological route and protocol.

Table 1. Comparison of FM Subcarrier Technologies

	SCA	RDS	DARC
year	1958	1986	1993
Subcarrier frequency	67KHz	57KHz	76KHz
Transmission Speed	slowly	1.1875Kbps	16Kbps
Transmission content	Audio Text	Text	Text

2. The Construction of CFS-EBS

In CFS-EBS, there are three levels of platform: county platform, countryside platform and village platform. All these platforms can release emergency message.

To build a CFS-EBS platform, we need following equipment:

Order controller: generates emergency order according to emergency broadcasting requirements from emergency organization.

Coder: Processes emergency order based on CFS-EBS protocol and modulates the order data on 57KHz as FM Subcarrier.

Modular: modulates audio signal and order data to FM signal on 87MHz-108MHz.

Receiver: receives and decodes emergency message, separates the message into audio signal and order data, and then judges whether broadcasts audio signal by order data.

Terminal: receives emergency information and broadcasts it according to requirements.

2.1. Types of CFS-EBS Construction

There are three kinds of CFS-EBS system constructions can be applicate in a project, and they are Serial CFS-EBS, Detached CFS-EBS and Centralized CFS-EBS.

Serial CFS-EBS

Figure 1 shows how Serial CFS-EBS works.

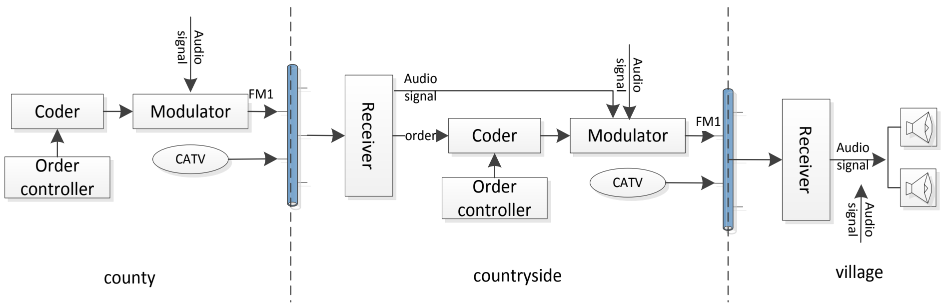


Figure 1. Serial CFS-EBS

Workflow: county platform modulates emergency message on frequency FM_1 and transmits it to countryside platform; countryside receiver demodulates and decodes emergency message from county platform, adds its own broadcasting requirements in the separated emergency order when it is need, then forms new emergency message and modulates it on frequency FM_1; village receiver demodulates and decodes the message from countryside platform, and broadcasts emergency information according to order.

Parallel broadcasting: supposes the number of emergency message that both of county and countryside platforms need to broadcast at the same time is N, then the number of frequencies in each platform should be N, and they are FM_1, FM_2,…, FM_N. In this way, receivers in countryside and village should be capable of receiving messages in all these frequencies. County and countryside platform can use same frequencies FM_1, FM_2, …, FM_N.

Robustness: relies on cable among county, countryside and village, as well as equipment on each platform.

Priority: should be judged by county, countryside and village platform.

Detached CFS-EBS

Figure 2 shows how Detached CFS-EBS works.

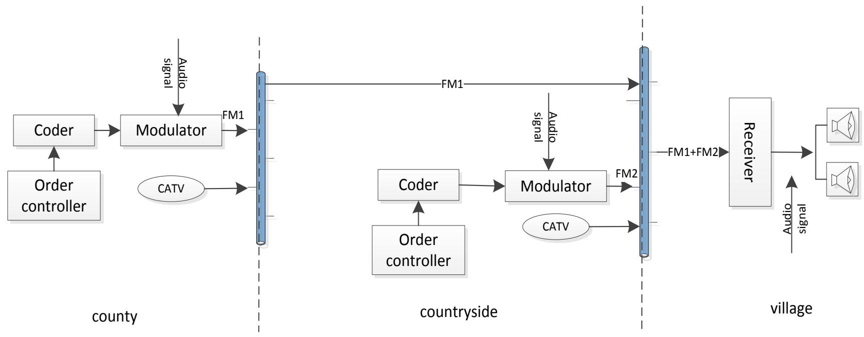


Figure 2. Detached CFS-EBS

Workflow: county platform modulates emergency message on frequency FM_1 and transmits it to village platform directly; countryside platform modulates emergency message on frequency FM_2 and transmits it to village platform directly; village receiver should be able to decode emergency message from county platform and countryside platform, and broadcasts emergency information according to order.

Parallel broadcasting: supposes the number of emergency message that both of county and countryside platforms need to broadcast at the same time is N, then the number of frequencies in county platform should be N, and they are FM_1, FM_2, …, FM_N. As well, the number of frequencies in each countryside platform from $countryside_{(1)}$ to $countryside_{(M)}$ should be N, and they are FM_{i1}, FM_{i2}, …, FM_{iN} (i=1,2,…,M) respectively. Frequencies between county and countryside platforms should be different, while frequencies from each countryside platform could be the same. In this case, the number of frequencies that a receiver in village should be capable of receiving is 2N, as shown in Equation (1).

$$N+N=2N \tag{1}$$

Robustness: each platform can work independently; the robustness relies on cable between county and village, cable between county and village, and equipment on each platform their own.

Priority: should be judged by terminal.

Centralized CFS-EBS

Figure 3 shows how Centralized CFS-EBS works.

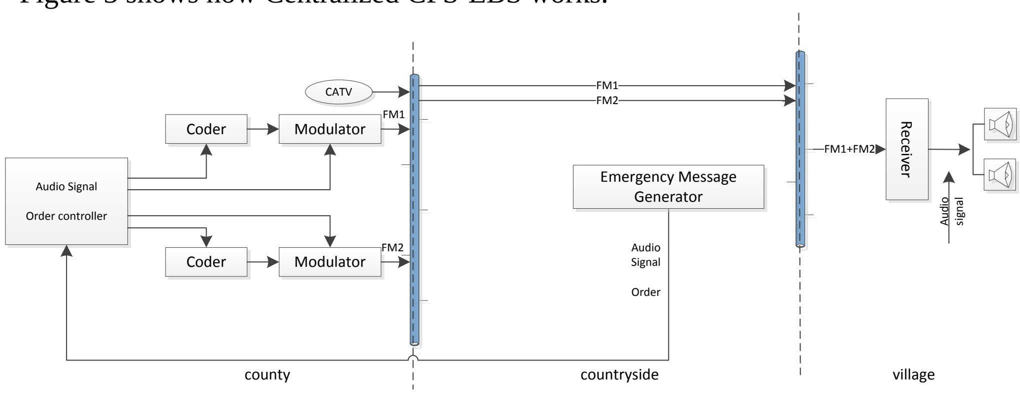


Figure 3. Centralized CFS-EBS

Workflow: countryside platform don't have broadcasting and transmission equipment. It only generates emergency message by mobile device or PC, and returns it back to county platform. County platform is responsible for receiving emergency messages from all countryside platforms (the number of countryside platforms is M), coding them based on CFS-EBS protocol, modulating audio signal and coded order data, and then transmitting emergency messages to village platform directly.

Parallel broadcasting: supposes the number of emergency message that both of county and countryside platforms need to broadcast at the same time is N, then the number of frequencies in county platform should be the sum of the following data. And they are N frequencies FM_1, FM_2, …, FM_N to send emergency messages generated by county platform, N frequencies FM_{11}, FM_{12}, …, FM_{1N} to send emergency messages from countryside No.1, N frequencies FM_{21}, FM_{22}, …, FM_{2N} to send emergency messages from countryside No.2, and so on. All these frequencies should be different, so the number of frequencies that a county platform needs is L, as shown in Equation (2),

$$L = N+M*N \tag{2}$$

Where M is the number of countryside platform in the county.

Robustness: relies on cable between county and village, as well as equipment on county platform.

Priority: should be judged by both county platform and terminal.

2.2. Comparison

From above analyses, Serial CFS-EBS needs the minimum number of frequencies to realize parallel broadcasting, has middle level of robustness, and requires complex operation; Detached CFS-EBS needs a little more number of frequencies to realize parallel broadcasting than Serial CFS-EBS needs, has high level robustness, and requires easy operation; Centralized CFS-EBS needs the maximum number of frequencies to realize parallel broadcasting, has low level robustness, and requires easy operation. In most cases, broadcasting two emergency messages at the same time can meet the parallel broadcasting requirement, so this index would not impact the performance of CFS-EBS so much. Therefore, Detached CFS-EBS would be the most efficient and convenient method to solve problem- parallel broadcasting and priority control-as mentioned in introduction paragraph.

3. CFS-EBS Message Packaging Protocol

This paragraph proposed CFS_EBS protocol based on data frame structure of RDS.

3.1. Protocol Architecture

Data frame structure of RDS

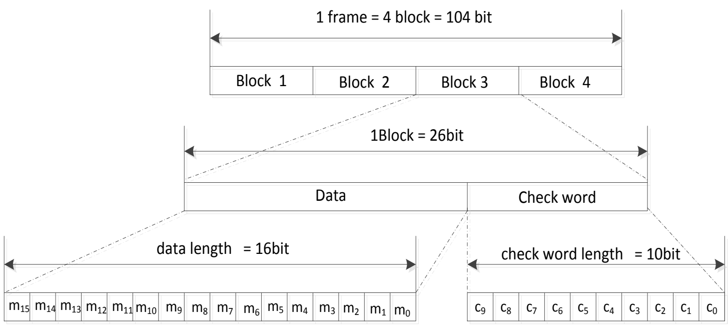


Figure 3. Data Frame Structure of RDS [10]

In Figure 3, it shows data frame structure of RDS, each data frame is comprised of 4 blocks, and each block consists of 16bits data and 10bits check words.

Data frame structure of CFS_EBS

Based on data frame structure of RDS, each frame in CFS_EBS protocol is still comprised of 4 blocks. However, because check words occupy too much bandwidth, which is not suitable for transmitting emergency message, so CFS_EBS protocol only add

2bytes check words in block D of the last frame not in each block. The data packet structure of CFS_EBS has been shown in Figure 4.

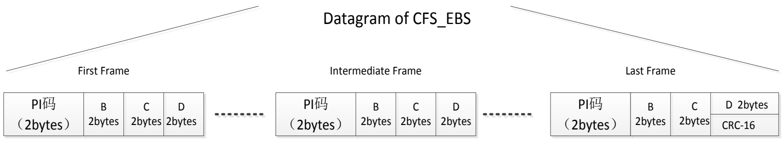


Figure 4. Data Packet of CFS_EBS

As well, CFS_EBS protocol redefines PI code and Block B, C, D according to the necessities of emergency broadcasting. The frame structure can be constructed as Figure 5. In Figure 5, letter means field name; number represents field length; frame serial number of the first frame is 0 in order to define the start of the whole data packet; the last two fields in last frame are CRC16 check data.

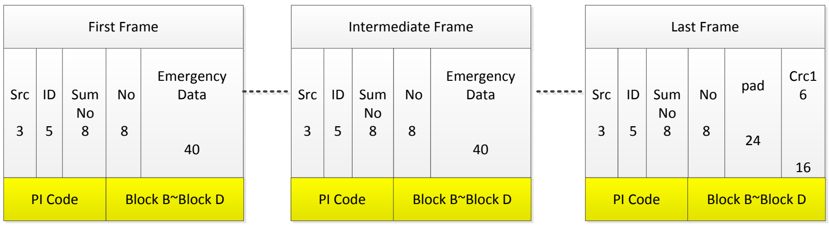


Figure 5. Data Packet of CFS_EBS

3.2. Protocol Data

Figure 6 is an extension of Figure 5, and shows the complete data frame structure of CFS_EBS protocol, including packet header, valid emergency data, and packet tail.

Table II, Table III, and Table IV descript details of each field.

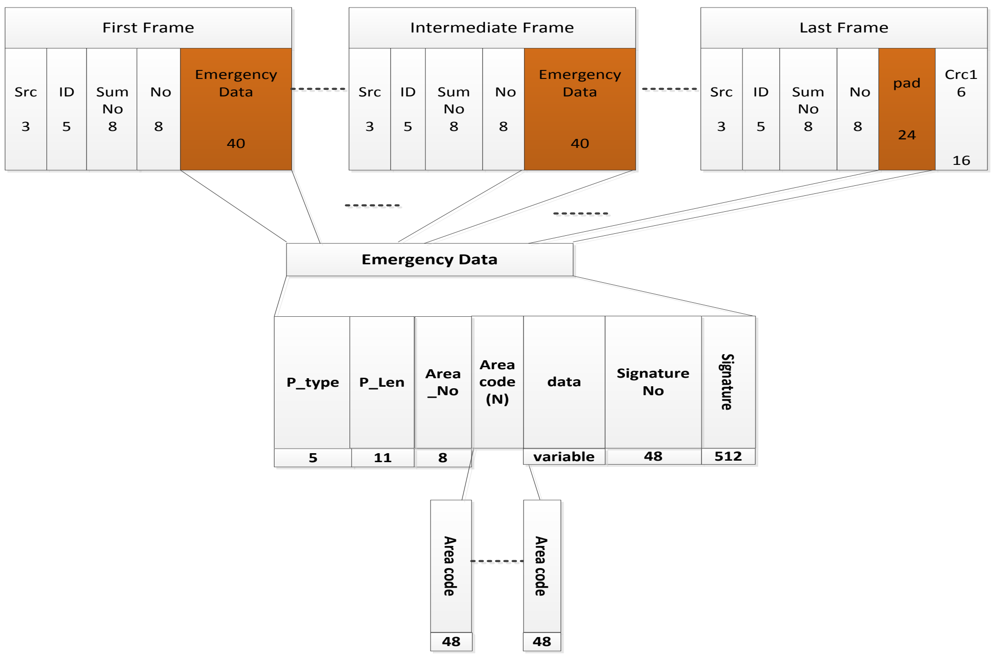


Figure 6. Data Frame Structure of CFS_EBS

Packet Header

Because it is impossible to guarantee that all data could be received by receiver at one time, it is necessary to transport data more than once. Sum_No. and No. fields in packet header are used to regroup emergency message data. Src is used for receiver to determine whether this packet should be analyzed.

Table 2. Packet Header

NO.	Name	Length(bits)	Field Description
1	Src	3	The level of emergency message, used for priority.
2	ID	5	Used to distinguish different type of data packet: 0x00: parameter setting; 0x01~0x0F: emergency data; 0x10~0x15: daily data; 0x16~0x1F: editable
3	Sum_No.	8	Total number of frame in the packet
4	No.	8	Serial number of current frame.

Emergency Data

Emergency data is consisted of valid data from each frame. Because the length of one frame is limited, so the emergency data should be separated into each frame in order to be transported, and spliced together after receiving.
Table III: Emergency Data

Table 3. Emergency Data

NO.	Name	Length(bits)	Field Description
1	P_type	3	0~15: type of emergency order; 16~31: type of emergency data;
2	P_Len	5	Data length from P_type to Signature.
3	Area_No	8	Value:1~255. Indicate the number of target area that this emergency message needs to cover. Suggestion: ≤16.
4	Area_code(N)	48	Defined based on GB/T 2260-2007[18] and GB T10114-2003[19]
5	Data	variable	Orders that terminal should obey, including: start broadcasting, stop broadcasting, update signature, and so on.
6	Signature No	48	
7	Signature	512	Used to protect the completeness, validity of current emergency message.

Packet Tail

Table 4. Packet Tail

NO.	Name	Length(bits)	Field Description
1	P_type	3	0~15: type of emergency order; 16~31: type of emergency data;
2	P_Len	5	Data length from P_type to Signature.

3.3. Problems Can be Solved

In this chapter, CFS_EBS protocol has been presented by redefining RDS protocol according to emergency broadcasting requirements. With this unified protocol, following problems in paragraph 1.1 can be solved:

1. Compatibility and extensibility of the system with unified coding standard;
2. Sub-regional controlling realized by defining area code.
3. Security can be kept by signature technology;
4. Terminal can judge priority with Src (in Table I).

4. Experiment of CFS-EBS

4.1. Experiment Scenario

This experiment aims to solve problems proposed in 1.1 and practices emergency broadcasting solution proposed above. Therefore, CFS-EBS solution has been established in Miyun County, a rural area in Beijing. In the experiment, following assumptions has been put forward:

1. both county and countryside platform can broadcasting two emergency message at the same time;

2. the priority level from high to low is: county, countryside, and village.

4.2. Technology Scheme

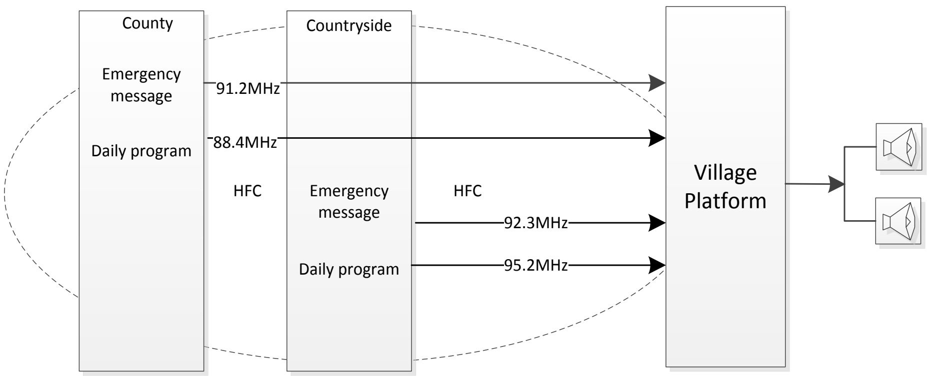


Figure 7. Parallel Broadcasting Diagram

As shown in Figure 7, to realize two channel parallel broadcasting concurrency, the test chooses frequencies 91.2MHz and 88.4MHz to transport emergency message and daily program separately in county platform; chooses 92.3MHz and 95.2MHz to transport emergency message and daily program separately in countryside platform. Once it is necessary, the frequency that broadcasts daily program will be used to broadcast emergency message, in this way two emergency signals can be parallel broadcast at the same time.

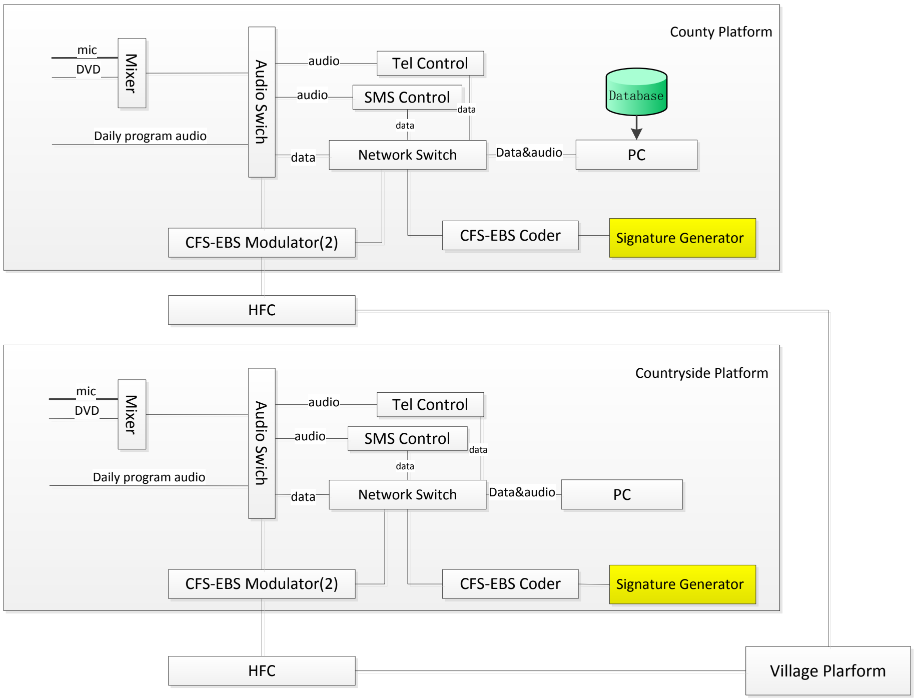
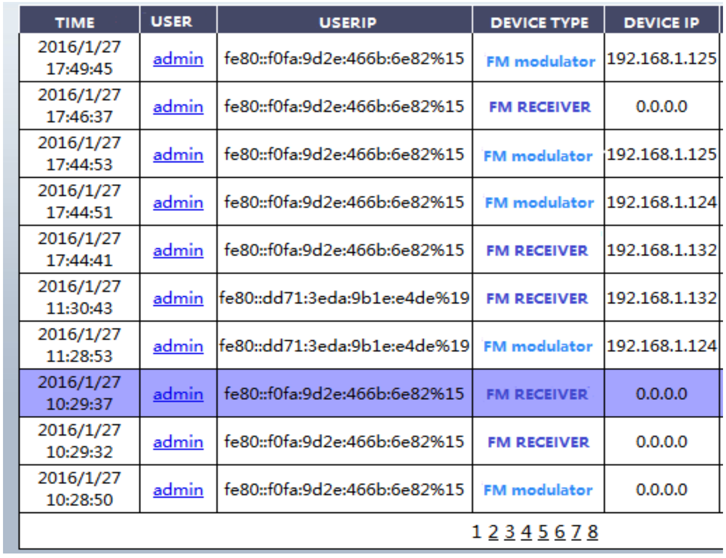


Figure 8. CFS-EBS Platform

Figure 8 shows details of CFS-EBS platform. Tel Control gets emergency message from telephone, and separates the message into audio signal and order data; SMS Control gets emergency message from SMS, separates the message into program data and order data, and then transforms program data to audio signal; Audio Switch is responsible for judging which audio signal should be broadcast first.

Emergency audio signal can be generated by local equipment such as mic, DVD and PC, as well as can be gain by Tel Control and SMS Control which receive messages from mobile devices. Order data can be generated by local PC or separated out from emergency message in Tel Control or SMS Control.

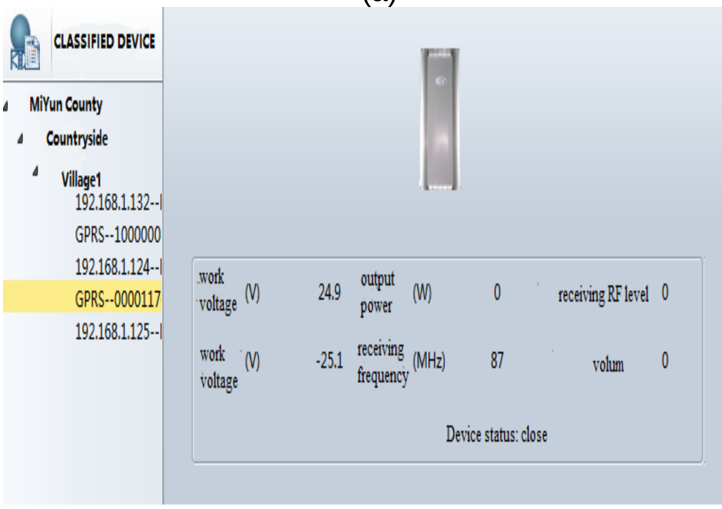
Audio Switch sends audio signal to CFS-EBS Modulator. CFS-EBS Coder signs and encrypts emergency order with signature data from Signature generator, and then sends signed order to CFS-EBS Modulator. CFS-EBS Modulator mixes audio signal and order, and then sends the mixed message to transmitter. Mixed message will be sent by transmitter to receiver via CATV network.



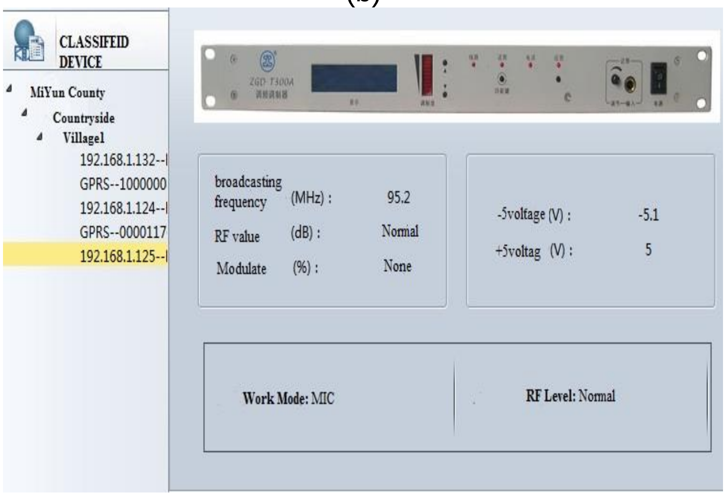
TIME	USER	USERIP	DEVICE TYPE	DEVICE IP
2016/1/27 17:49:45	admin	fe80::f0fa:9d2e:466b:6e82%15	FM modulator	192.168.1.125
2016/1/27 17:46:37	admin	fe80::f0fa:9d2e:466b:6e82%15	FM RECEIVER	0.0.0.0
2016/1/27 17:44:53	admin	fe80::f0fa:9d2e:466b:6e82%15	FM modulator	192.168.1.125
2016/1/27 17:44:51	admin	fe80::f0fa:9d2e:466b:6e82%15	FM modulator	192.168.1.124
2016/1/27 17:44:41	admin	fe80::f0fa:9d2e:466b:6e82%15	FM RECEIVER	192.168.1.132
2016/1/27 11:30:43	admin	fe80::dd71:3eda:9b1e:e4de%19	FM RECEIVER	192.168.1.132
2016/1/27 11:28:53	admin	fe80::dd71:3eda:9b1e:e4de%19	FM modulator	192.168.1.124
2016/1/27 10:29:37	admin	fe80::f0fa:9d2e:466b:6e82%15	FM RECEIVER	0.0.0.0
2016/1/27 10:29:32	admin	fe80::f0fa:9d2e:466b:6e82%15	FM RECEIVER	0.0.0.0
2016/1/27 10:28:50	admin	fe80::f0fa:9d2e:466b:6e82%15	FM modulator	0.0.0.0

1 2 3 4 5 6 7 8

(a)



(b)



(c)

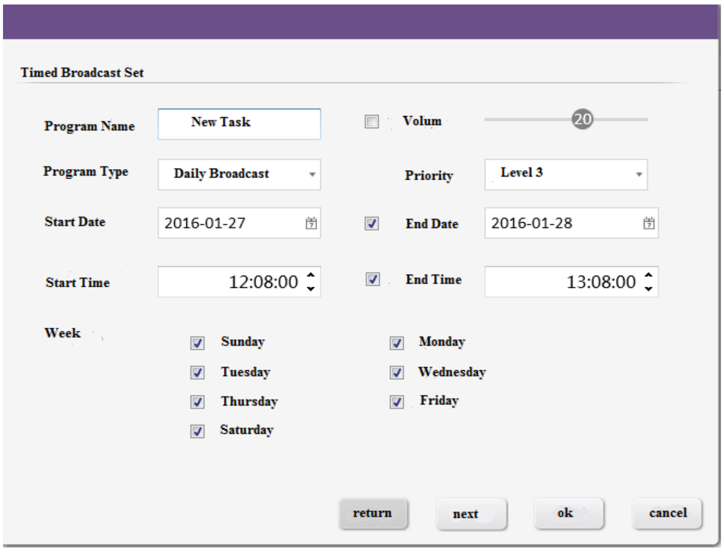
Figure 9. Emergency Message Monitoring Software

In CFS-EBS system, in order to supervise the working status of important devices in each platform, GPRS modules which can return equipment work statuses by SMS have been installed in CFS-EBS modulators and receivers. As shown in Figure 9, a monitoring software has been installed in county platform for watch these statuses from GPRS modules.

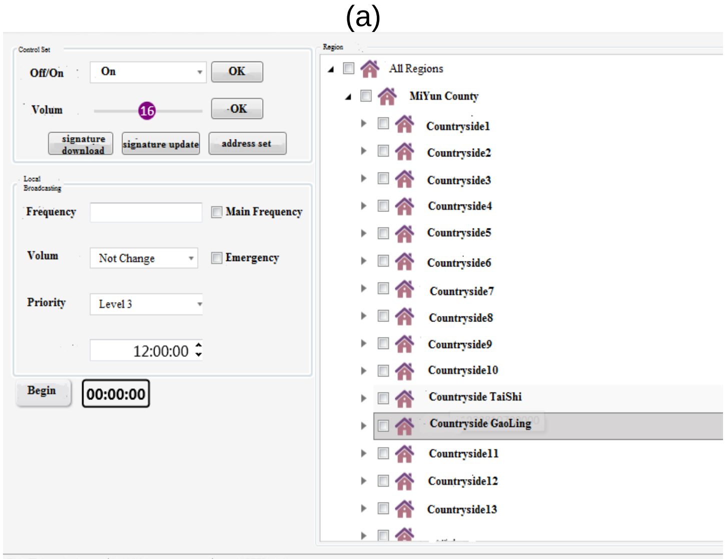
Figure 9(a) shows operation records of modulator and receiver, including operation time, operator ID, device name and status; Figure 9(b) shows status of receiver, such as working voltage, receiving frequency, receiving level, output power and so on; Figure 9(c) shows status of modulator, such as working voltage, broadcasting frequency, IP address, RF value and so on. With these statuses, we can carry on maintenance in time.

4.3. Result and Evaluation

As shown in Figure 10(a) and Figure 10 (b), CFS-EBS system can broadcast emergency message according to time, date, and area. Figure 11 displays a part of broadcasting operation records that we had done in Miyun County.



(a)



(b)

Figure 10 emergency message broadcasting

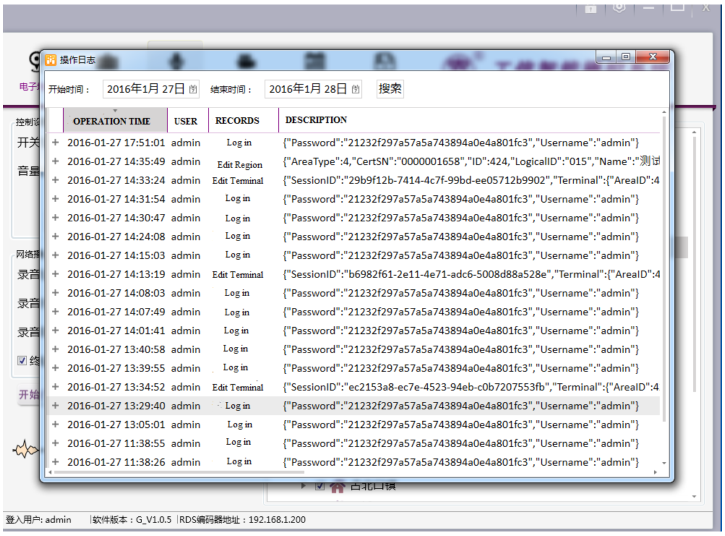


Figure 11. Operation Records

Figure 12 shows terminal status in a 2D map, including online rate, offline rate, terminal code and frequency. In the experiment, 1 county platform, 2 countryside platforms and 49 village platforms have been established. Receiver in each village platform has been set a GPRS module for returning statues of responding village platform. In Figure 12, there are 39 village platforms on line and 10 village platforms off line.

Figure 13 shows CFS-EBS emergency order in hexadecimal, which captured from terminal. These emergency orders including start broadcasting, stop broadcasting, setting sound volume, set frequency and so on.

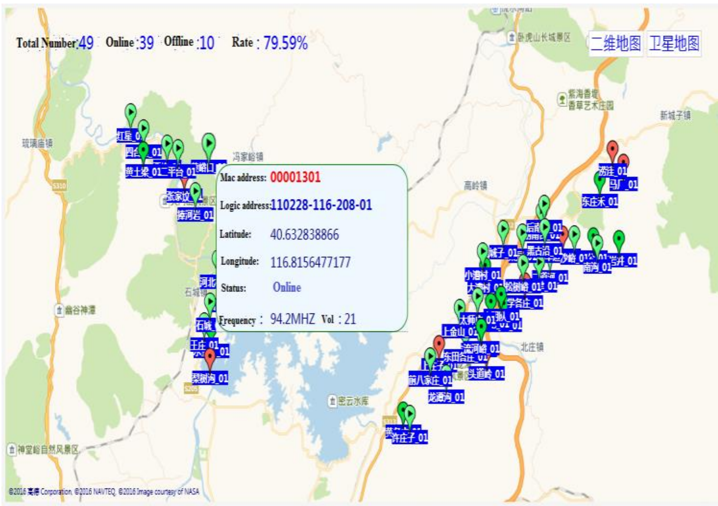


Figure 12. Terminal Status

```
08
54 [P_Len]
01 [Area_No]
00 00 00 00 00 00 [Area_code]
06 12 34 56 78
44 44 44 44 44 44
85 b7 3c 2e 7d 04 d8 f5 7d bb
2d 89 b4 95 ee e3 d7 cc 1c df 81
9c 67 b2 8e 1e b9 ed a0 01 97
20 d5 83 05 7b 32 b2 0d f1 2d fd
57 9c66 41 69 d2 60 82 ca 73 fd
ed 33 33 37 f5 96 e6 d7 ca
[Signture]
d3 b6 [CRC]
```

(a)start broadcasting

```
08
54 [P_Len]
01 [Area_No]
00 00 00 00 00 00 [Area_code]
02 12 34 56 78
44 44 44 44 44 44
2f 33 f4 a3 38 aa 43 39 ce 31
cd 22 cc bf f9 81 2e 96 2a 34 9e
d4 77 b5 9d 21 27 b8f2 d6 8f ea
93 d0 5b 18 33 a6 47 98 26 80
b7 6a a3 6a 4a e0 7e 83 c0 58
a3 12 f6 83 cc bd 33 8c f9 0e
[Signture]
f4 42 [CRC]
```

(b) stop broadcasting

```
10
55 [P_Len]
01 [Area_No]
05 71 88 00 00 00 [Area_code]
03 00 12 34 56 78
44 44 44 44 44 44
9d 45 fb 38 d5 ae ac 38 9c 41
36 ef 9a c8 b4 ad 26 98 ab f1 c5
27 5a eb af 44 a8aa 28 ee a3 75
d0 f2 f1 68 22 97 82 61 61 ba 3a
ac 21 27 b3 fd 26 ba 87 14 a0 69
6f a6 48 d0 b1 ec c8 a4
[Signture]
df 5c [CRC]
```

(c)setting sound volume

```
00
63 [P_Len]
01 [Area_No]
05 71 88 00 00 00 [Area_code]
03 01 00 01 63 78 02 01 01 86
a0 03 02 01 9a 28 12 34 56 78
44 44 44 44 44 44
3f d8 98 70 97 bf ae 10 ec 54
dd 31 3a 19 98 a4 d3 1c 82 97
46 2a 78 b0 7f 39 0f 06 50 65 8a
38 7a d9 39 fb 8c 31 be e9 7c 85
1e bd ce 20 8e 79 2b ea 3c 53
e6 9a 9e 3c 0d 33 df 1e 50 70
[Signture]
16 f3 [CRC]
```

(d) setting frequency

Figure 13. Emergency Order in Hexadecimal

In sum, the experiment constructs a Detached CFS-EBS in Chinese rural area, and tests CFS-EBS protocol on the system. The system can start emergency message broadcasting based on time and area, stop broadcasting in time, and realize parallel broadcasting.

5. Conclusions and Future Work

In conclusion, the article introduces a communication solution, which is called CFS-EBS, to transport emergency broadcasting message over CATV channel with FM subcarrier technology. The solution includes system framework, technology route, and transmission protocol. As well, a field experiment to test the effectiveness and practicability of CFS-EBS construction and protocol has been conducted in real rural areas, and gain expected results. The solution solve following difficulties in an emergency broadcasting system: parallel broadcasting, sub-regional controlling, priority controlling, safe transmission and so on.

However, because code rate of RDS is low and data size of signature is large, it needs a little long time for terminal to response emergency message, which will impact the timeliness of the whole system. Therefore, in future, we would test CFS-EBS protocol on more effective FM subcarrier technology and optimize our signature technology.

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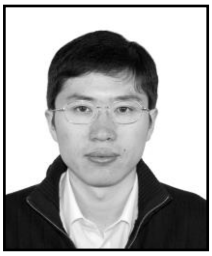

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