Broadcasting system of an emergency alert protocol CAP-PER using the standard RDS

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Abstract—

This paper describes a proposal and implementation of dissemination system of an emergency alert protocol called CAP-PER (Common Alerting Protocol from Peru), through FM broadcasting using the RDS (Radio Data System) standard.
The insertion of the emergency information uses groups 9A and 11A of the RDS, in which the bytes of the emergency protocol CAP-PER enter into the information blocks C and D of the baseband-encoded structure of the RDS, for a FM transmission.
In the case of reception, we have developed a module that decodes the received signal from groups 9A and 11A of the RDS to obtain the information of the emergency protocol CAP-PER. Finally, we successfully performed laboratory tests at the INICTEL-UNI and field tests at Arequipa city with the collaboration of TV-Peru broadcasting station.

Keywords – emergency messages; EWS; broadcasting; RDS/RBDS; FM; encoder

I. INTRODUCTION

Natural disasters can occur without warning and it is necessary to have emergency warning systems, for disseminating emergency information to the population as soon as possible. According to the European technical standard TS-102-182[1], emergency dissemination systems must communicate to 50% of the vulnerable population in the first 3 minutes and by the 5th minute, 97% of the population must be covered.

According to the ITU (International Telecommunication Union), there are three phases during any emergency in which information and telecommunications technologies are actively involved; the stages are: Prediction and Detection "," Alert "and" Assistance " [2]; in which we focus on the Alert area.
To be able to alert the population quickly and effectively without saturating any communication, you must use broadcasting technologies, such as Radio and TV, as specified by the recommendation ITU-R BT.1774-1[3].
In relation to broadcasting technologies, the radio FM has greater coverage for urban and rural areas compared to television and other technologies, being and important reason to use the RDS system [4], which allows including digital information on the FM radio signal. In this way, you can transmit the emergency protocol called CAP-PER on groups 9A and 11A. This will allow sending multiple warning messages for various types of emergency.
This article describes the proposal and implementation of an emergency alert dissemination system based on the CAP-PER protocol.

II. SYSTEM ARCHITECTURE

A. Overview of the Broadcasting System

The diffusion system of the CAP-PER emergency protocol consists of the transmission and reception of digital emergency information using groups 9A and 11A of the RDS standard. For this, we carried out a proposal and implementation of an emergency RDS encoder and a RDS receiver module, capable of coding and decoding respectively the signal of the emergency protocol CAP-PER. The emergency RDS encoder receives the CAP-PER emergency information from a remote server, next, the signal is inserted into the FM exciter and then the RF signal is amplified to start the FM transmission with the RDS groups. For the reception, the RDS receiver module read the emergency information to store it and obtain the emergency alert protocol CAP-PER communicating to the central control the activation of the sound speakers through the energy module shown in the (Figure 1).

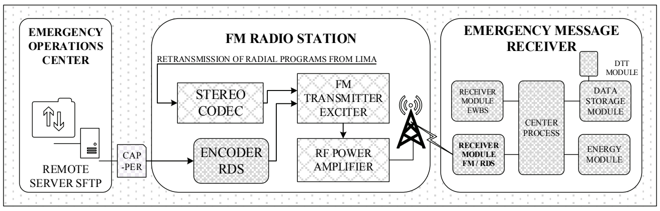

Figure 1. Scheme of the broadcast system of the CAP-PER emergency alert protocol through FM broadcast using the RDS standard.

B. Emergency Protocol CAP-PER

The emergency alert protocol CAP-PER emerges as a proposal to have a homogeneous protocol for supporting multiple types of emergency events based on the PLANAGERD-PERU [6] and the CAP protocol [7]. This protocol allows us to include different types of emergency information according to the natural disasters of the Peruvian reality generating a structured information in XML file [2] shown in the (Figure 2). In order to insert the proposed CAP-PER emergency protocol in the

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transmission system, we adapt the emergency information based on the RDS standard in the FM radio transmission.

```xml
<?xml version = "1.0" encoding = "UTF-8"?>
<alerta>
    <identificador>GobiernoLocal</identificador>
    <fechaHora>2018-03-15T18:40:23-07:00</fechaHora>
    <estado>Prueba</estado>
    <tipo_mensaje>Alerta</tipo_mensaje>
    <ambito>Privado</ambito>
    <referencia>Alerta de emergencia</referencia>
    <informacion>
        <idioma>Ingles</idioma>
        <categoria>Biologico</categoria>
        <evento>Huayco</evento>
        <tipo_respuesta>Evaluar</tipo_respuesta>
        <urgencia>Futuro</urgencia>
        <severidad>Moderado</severidad>
        <certeza>Improbable</certeza>
        <efectivo>2018-03-15T18:40:23-07:00</efectivo>
        <inicio>2018-03-15T18:40:23-07:00</inicio>
        <fin>2018-03-15T18:40:45-07:00</fin>
        <color_alerta>Verde</color_alerta>
        <parametros>Alerta de emergencia</parametros>
        <area>04-04-04</area>
    </informacion>
</alerta>
```

Figure 2. CAP-PER protocol generated from the web interface.

III. BROADCASTING EMERGENCY MESSAGES

A. Implementation

For the RDS transmission, we use a SmartGen mini RDS encoder [8], which is connected to a reduced-board computer Raspberry Pi 2 used to configure and control the RDS encoder shown in the (Figure 3). The CAP-PER emergency protocol (Alerta.xml file) is received by the Raspberry Pi 2 via Ethernet port using the SFTP transfer protocol [9]. Then, the Raspberry Pi 2 encodes the information contained in the CAP-PER emergency protocol to insert the data into the groups 9A and 11A of the RDS.

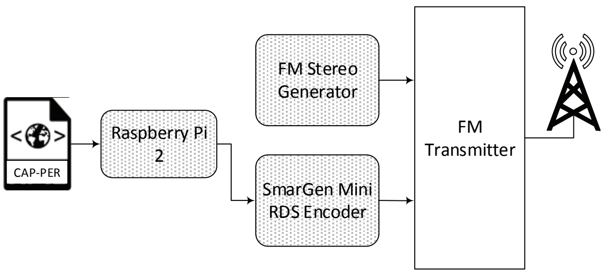

Figure 3. Interconnection diagram of the equipment used for the RDS transmission.

We have implemented three scripts developed in C in the Raspberry Pi 2 that fulfill the function of preparing the insertion of the CAP-PER protocol in the SmartGen Mini RDS encoder. (Figure 4) shows a tree diagram with the files and programs contained in the Raspberry Pi 2.

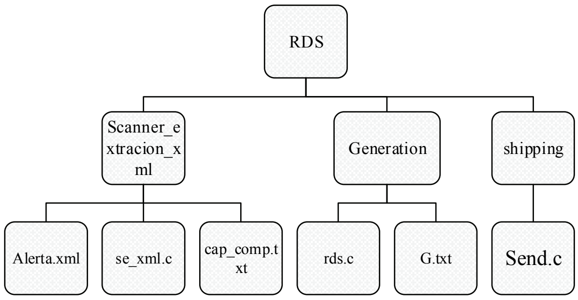

Figure 4. Tree diagram of the folders and files that be present in the Raspberry Pi 2.

B. Coding Emergency Information

The coding of the emergency information contained in the CAP-PER protocol is turned out in two tasks, called "Scanner_extraccion_xml" and "Generation", corresponding to the first two folders shown in the (Figure 4). First, the file Scanner_extraccion_xml obtains the Alert Emergency information contained in the file Alerta.xml and stores a file with compressed information in .txt format called (cap_comp.txt) shown in the (Figure 5).

```xml
<?xml version = "1.0" encoding = "UTF-8"?>
<alerta>
    <identificador>GobiernoLocal</identificador>
    <fechaHora>2018-03-15T18:40:23-07:00</fechaHora>
    <estado>Prueba</estado>
    <tipo_mensaje>Alerta</tipo_mensaje>
    <ambito>Privado</ambito>
    <referencia>Alerta de emergencia</referencia>
    <informacion>
        <idioma>Ingles</idioma>
        <categoria>Biologico</categoria>
        <evento>Huayco</evento>
        <tipo_respuesta>Evaluar</tipo_respuesta>
        <urgencia>Futuro</urgencia>
        <severidad>Moderado</severidad>
        <certeza>Improbable</certeza>
        <efectivo>2018-03-15T18:40:23-07:00</efectivo>
        <inicio>2018-03-15T18:40:23-07:00</inicio>
        <fin>2018-03-15T18:40:45-07:00</fin>
        <color_alerta>Verde</color_alerta>
        <parametros>Alerta de emergencia</parametros>
        <area>04-04-04</area>
    </informacion>
</alerta>
```

```
0
2018-03-15T18:40:23-07:00
0
0
0
Alerta de emergencia
0
0
00
0
0
0
0
2018-03-15T18:40:23-07:00
2018-03-15T18:40:23-07:00
2018-03-15T18:40:45-07:00
0
Alerta de emergencia
444
```

Figure 5. Obtaining and coding the information contained in the CAP-PER protocol.

Then the Generation file, based on the information obtained and stored in the file cap_comp.txt, generates a vector of 62 Bytes, which contains the coded emergency information. With the vector shown in the (Figure 6), a text file (G.txt) is generated and this one contains the console commands for sending the RDS groups, which enter of the RDS encoder terminal [9].

BYTE 1			*BYTE 2*				*BYTE 3*		*BYTE 4*		
Identificador	Estado	Tipo_ mensaje	Ambito	Idioma	Categoria	Evento	Tipo_respuesta	Urgencia	Severidad	Certeza	Color

BYTE 5		*BYTE 6*	
Codigo_ Area(1)	Codigo_ Area(2)	Codigo_ Area(3)	X X X X…

Figure 6. Coding example of the first 6 BYTES of the total of BYTES containing the emergency alert information CAP-PER.

The CAP-PER emergency protocol contains **62** bytes of information, perfectly fitting in our reception with 64 bytes of capacity. (Table 1) details the values in bits of the CAP-PER emergency protocol.

CAP-PER PROTOCOL		
N°	**VARIABLE**	**BITS**
1	identifier	2
2	date_hour	33
3	state	2
4	message_type	3
5	ambit	2
6	reference	160
7	language	2
8	category	3
9	event	5
10	answer_type	3
11	urgency	3
12	severity	3
13	certainty	2
14	effective	33
15	start	33
16	end	33
17	alert_color	2
18	parameters	160
19	area	12
TOTAL BITS		**496**
TOTAL BYTES		**62**

Table 1. Bit values of the fields of the emergency protocol CAP-PER.

C. Sending Emergency Information by RDS

Finally, start the configuration of the serial communication between the Raspberry 2 and the RDS encoder, which is set to 9600-baud, 8 bits of data and without parity bit [10]. Then, the commands contained in the G.txt file are sent line by line to be processed by the RDS encoder. These commands are shown in the (Figure 7).

```
G=97e000000000
G=97e14440e2be
G=97e27171f15e
G=97e338b838af
G=97e41c5c1c57
G=97e58c560068
G=97e66f6c616d
G=97e7756e646f
G=97e86f686f6c
G=97e9616d756e
G=97ea646f6f49
G=97eb6e756e64
G=97ec6163696f
G=97ed6e507565
G=97ee6e746547
G=97ef72617500
G=97e000000000
```

Figure 7. Screenshot of all necessary commands for sending emergency information to the 9A and 11A groups of the RDS standard.

D. RDS Encoder Generator

The RDS Encoder Generator of the emergency information protocol was developed from the SmartGen mini RDS encoder and the reduced-board computer Raspberry Pi 2, and it was thought for being rack mounted, as be shown in the (Figure 8).

Figure 8. Design and final prototype of the RDS encoder generator.

IV. Reception of Emergency Messages RDS

A. Emergency Information Bytes Received

The reception of the emergency information is selected from 9A and 11A groups of the RDS standard, because they are free RDS groups [12], which can be used to propose emergency communication solutions as is described in (Table 2).

GROUP	TYPE GROUP / VERSION				DESCRIPTION
	A3	A2	A1	A0	
9A	1	0	0	1	Emergency Warning System or ODA
11A	1	0	1	1	ODA "Open Data Application"

Table 2. Description of groups 9A and 11A of the RDS standard.

The chosen Bytes for the transmission of the emergency protocol correspond to the information blocks C and D [12] of the baseband code structure shown in the (Figure 9).

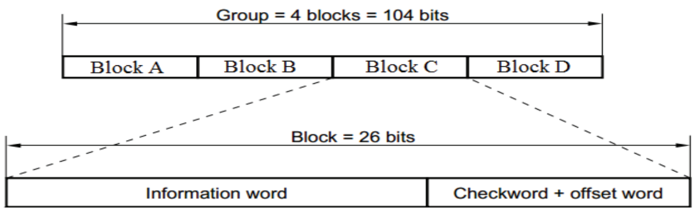

Figure 9. Baseband code structure of the RDS standard.

For the reception of the emergency information bytes an ordering was made with the last 4 Bits of block B [12] (Figure 10) called ***"address codes"*** which allow to have $[\mathbf{4^2 = 16}]$ different types of combinations. Therefore, for each address code there are 4 bytes of information from the blocks C and D, having the capacity to receive a total of $[16x4 = 64]$ bytes of emergency information transmitted by FM Radio as a cyclical transmission no matter when RDS signal is detected.

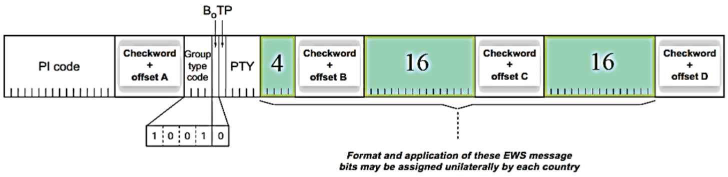

Figure 10 Group 9A of the RDS [12], where the 4 bytes of group B are the address codes and the others 32 bytes of groups C and D are to the CAP-PER protocol.

B. RDS Receiver Module

The RDS receiver module was developed from a breakout board Si470x FM SparkFun [11] shown in (Figure 11), capable of tuning FM stations and their respective RDS / RBDS data. The developed Hardware is constituted by an electronic board that has a serial connector for communication with the central control of the receiver of emergency messages and four indicator leds for board tests. The developed Firmware extracts digital information from the RDS 9A and 11A groups, which contain the CAP-PER emergency protocol. The operation of the receiver RDS module are based upon three operations: Activation of the emergency protocol, monitoring of the parameters of the receiver RDS module and Setting the operating frequency.

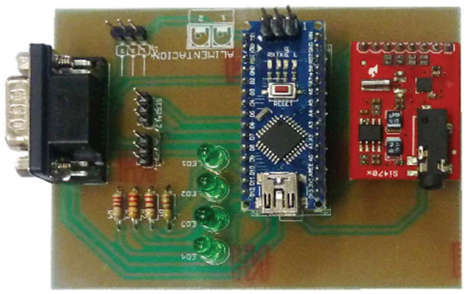

Figure 11. Developed prototype of the receiver RDS module with the Si470x FM SparkFun board serial connector and four indicator leds.

The RDS receiver module is part of the emergency message receiver [5] shown in (Figure 12). Which has the function of receiving the CAP-PER emergency protocol by FM and DTT (Digital Terrestrial Television) and being able to be monitored by the data storage module using the SNMP protocol [13].

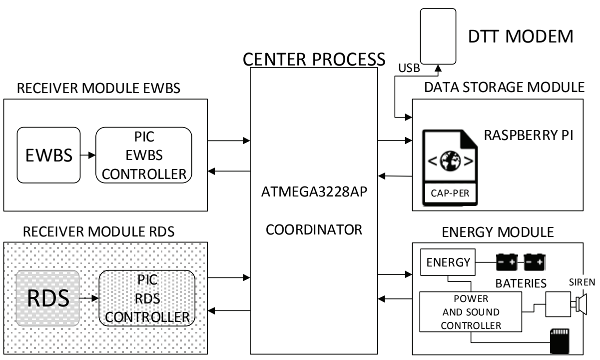

Figure 12. Diagram of the receiver of emergency messages, which has the receiver RDS module as one of its sub-modules.

The (Figure 12) shows the receiver RDS module connected to the central control, which fulfills the function of sending all received emergency messages to the energy module, for a later sound reproduction through an electronic siren. For the communication between the receiver module RDS and the central control, a modeling of vectors was elaborated as shown in (Figure 13).

START	*ID*	*TASK*	*DATA 1*	*DATA 2*	*…*	*DATA N*	*CRC-8*	*END*
7E	1 BYTE		1 BYTE	1 BYTE		1 BYTE	XY	EF

Figure 13. Generic communication vector between the receiver module RDS and central control.

When the receiver RDS module receives the emergency information CAP-PER, automatically the firmware generates an emergency activation vector of 30 Bytes, which is sent to the central control to be verified and transmitted to the energy module; finally, the electronic siren generates a sound activation.

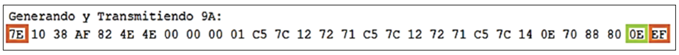
Generando y Transmitiendo 9A:
7E 10 38 AF 82 4E 4E 00 00 00 01 C5 7C 12 72 71 C5 7C 12 72 71 C5 7C 14 0E 70 88 80 0E EF

Figure 14. Activation vector of 30 bytes in hexadecimal format, generated from the information of the emergency protocol CAP-PER.

The second function of the receiver module RDS is monitoring of its operating parameters described in (Table 3), captured in a monitoring vector of 7 Bytes to be reported to the central control.

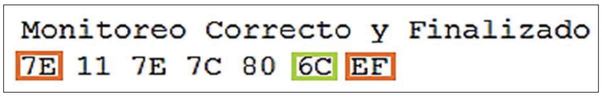
Monitoreo Correcto y Finalizado
7E 11 7E 7C 80 6C EF

Figure 15. Monitoring Vector, where bytes 7E, 7C and 80 contain the parameters of the RDS receiver module shown in Table 3.

N°	*PARAMETER*	*DESCRIPTION*
1	Frequency	Operation Frequency
2	Attach	FM Detection
3	RDS state	RDS Detection
4	2A RDS state	2A Detection
5	9A RDS state	9A Detection
6	11A RDS state	11A Detection
7	General state	Ok if Attach and RDS state are Ok

Table 3. Description of the receiver module RDS parameters.

Finally, the third function of the receiver module RDS is the configuration of the operating Frequency, This function is executed from a remote server to the breakout board Raspberry Pi 2, which sends a vector of 6 Bytes with the new operating frequency for the receiver module RDS.

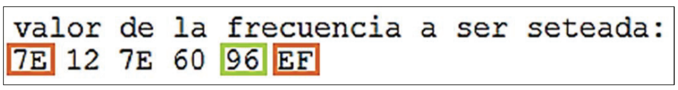
valor de la frecuencia a ser seteada:
7E 12 7E 60 96 EF

Figure 16. Setting Vector, which contains the new frequency to be configured in the receiver module RDS in bytes 7E and 60.

All communication vectors between the central control and the receiver RDS module use the error correction called **CRC-8** as seen in (Figure 14), (Figure 15) and (Figure 16). For avoiding information loss due to the signal degradation.

V. LABORATORY AND FIELD TESTS

A. Laboratory Tests

For the laboratory test, we used a special rack where we have our RDS encoder (Figure 17), able to insert the following RDS Groups: 0A, 2A, 9A and 11A. For verifying the RDS reception, we have used the RDS receiver module (Figure 10) shown on top of the laptop, which it was able to process the information sent in a frame of 64 Bytes. At the frequency of 107.9 MHz using 64 ASCII characters code transmitted by the 0A, 2A, 9A and 11A groups of the RDS standard shown in (Figure 18).

Figure 17. RDS Laboratory, where we tasted the Transmission and Reception of the emergency Protocol. At the bottom there is the RDS encoder and on top of the laptop the RDS receiver.

```
RDS heard: abcdefghijklmnopqrstuvwxyzabcdefghijklmnopqrstuvwxyzabcdefghijkl
```

Figure 18. Capture of ASCII characters with 64 bytes of information in a 2A RDS transmission.

B. Field Tests at Arequipa City

For the RDS transmission and reception tests at Arequipa-Peru city we had the collaboration of the TV-PERU broadcasting station, where we adapt our developed encoder to insert the CAP-PER emergency protocol in groups 9A and 11A of the RDS standard. This was verified satisfactorily with our RDS reception module in different points of the city shown in (Figure 19). We captured the following parameters: the Potency parameter in dBµV, state 2A, state 9A, state 11A, time in seconds of the reception of the CAP-PER protocol, verification of the emergency message-received and the height measurement as is shown in (Table 4) with T, NT and EMR which means: Transmitted, Not Transmitted and Emergency Message-Received.

Figure 19. Map of Arequipa city, showing the blue points where the emergency information was captured contained in groups 9A and 11A of the RDS.

PLACE	*TV-PERU Broadcasting Station*					
Potency [dBµV]	57	58	58	60	54	55
2A RDS GROUP	T	T	NT	T	NT	NT
9A RDS GROUP	T	T	T	NT	T	NT
11A RDS GROUP	T	NT	T	T	NT	T
EMR	OK	OK	OK	OK	OK	OK
HEIGHT [m]	2	2	2	2	2	2
TIME [s]	4	4	3	6	2	2
PLACE	*UCSP University*					
Potency [dBµV]	39	39	38	38	39	39
2A RDS GROUP	T	T	NT	T	NT	NT
9A RDS GROUP	T	T	T	NT	T	NT
11A RDS GROUP	T	NT	T	T	NT	T
EMR	OK	OK	OK	OK	OK	OK
HEIGHT [m]	50	50	50	50	50	50
TIME [s]	6	6	5	4	2	1

Table 4. Results report of RDS groups.

Conclusion

Our proposal to send the CAP-PER emergency protocol through groups 9A and 11A RDS is a solution of low-cost and simple to implement, because the developed encoder can be adapted to the broadcasting station to insert 64 Bytes of information in the RDS groups. The transmission in the field tests did not present problems of FM broadcasting, being able to elaborate our test itinerary without major inconvenience. We also corroborate that the reception of the CAP-PER emergency protocol did not present errors in the CRC-8 algorithm. Proving that we can use FM Radio to send emergency signals RDS.

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References

[1] ETSI TS 102 182 V1.4.1 (2010-07)
Technical Specification Emergency Communications (EMTEL); Requirements for communications from authorities/organizations to individuals, groups or the general public during emergencies.

[2] ITU. 2007. Compendium of ITU's work on Emergency Telecommunications. International Telecommunication Union.

[3] Recommendation ITU-R BT.1774-2(10/2015)
Use of satellite and terrestrial broadcast infrastructures for public warning, disaster mitigation and relief
BT Series Broadcasting service (television)

[4] Study of Emergency Warning Broadcasting System.
IEEE Xplore: 06 August 2015, ISSN Information: Electronic ISSN: 2155-5052, DOI: 10.1109/BMSB.2015.7177255

[5] Automatic novel system for sending emergency alert and alarm for multi events through radio broadcasting transmission system in Peru
IEEE Xplore: 20 July 2017, ISBN Information: Electronic ISSN: 2155-5052, DOI: 10.1109/BMSB.2017.7986155.

[6] SINAGERD, PCM, SGRD, CENEPRED, INDECI. PLAN NACIONAL DE GESTIÓN DEL RIESGO DE DESASTRES PLANAGERD 2014-2021. LIMA: s.n., 2014.

[7] OASIS: Common Alerting Protocol Version 1.2; OASIS Standard 01 July 2010

[8] Maintenance and Operation Instruction Manual, SmartGen Mini RDS Encoder, DEVA, 2017.

[9] Simple File Transfer Protocol, https://tools.ietf.org/html/rfc913

[10] Minicom User Guide v1.0, 2010

[11] Broadcast FM Radio Turner For Portable Application, SILICON LABS

[12] EUROPEAN STANDARD NORME EUROPÉENNE EUROPÄISCHE NORM EN 50067.

[13] Management Module based on SNMP for a Warning message receiver considering DTT and FM.
IEEE Xplore: 05 October 2017, ISBN Information: Electronic ISBN: 978-1-5090-6264-5, DOI: 10.1109/IHTC.2017.8058181.