Design and Implementation of a EWBS Gateway over an IP Telephone Network

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Abstract. Being part of the so-called "Pacific Ring of Fire" and "Belt of Low Pressure," Ecuador is located in one area most likely to suffer seismic, volcanic, and hydrometeorological threats, which make it possible to catalog as a country with a high vulnerability. For this reason, the use of alert systems such as Emergency Warning Broadcasting System EWBS is necessary for the face of one of these threats, which can be implemented in analog and digital broadcast signals such as Digital Terrestrial Television. In an emergency, the receivers compatible with the EWBS are currently the decoders or digital televisions that include this system. They turn on automatically and emit a visual and audible alert signal that gives time to the population to act more quickly to an event. This article presents the design proposal of a receiver that replicates the warning emergency alert EWBS for digital terrestrial television with the ISDB-Tb standard, through an institutional telephone PBX, implementing an IP telephony server that receives the EWBS system and replicates it to landlines, infocast systems, and mobile phones connected to it, thus avoiding a percentage of losses in the economic and human fields.

Keywords: EWBS · Spatial data infrastructure · Common alert protocol · Risk management

1 Introduction

Earthquakes, volcanic eruptions, floods, forest fires, and landslides are just a few examples of natural disasters for which humans must be prepared. Years ago, people could not predict the dangers mentioned above, so they felt vulnerable and unprotected. However, we have always been aware of the importance of alerting people as quickly as possible to an emerging event to reduce losses and increase opportunities for survival. Over time, with the growth of civilization and the evolution of technology and science, human beings as such have been developing various methods of warning for their protection, such as early warning systems, which are now in continuous change.

As a background to early warning systems or EWS, we had in 1998 the International Conference on EWS EWC 98 defined these systems as a prevention

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element within national and international strategies. In 2003, the Second International Conference on EWS EWCII 03 included that early warning systems should be integrated into countries' public policies. In 2005, the Hyogo Framework for Action 2005–2015 proposed identifying the risks to which each nation is vulnerable and strengthening early warning systems to reduce the percentage of disasters that natural phenomena can cause. It was also stressed that the development of early warning systems should be people-centered. In 2015, the Sendai Framework for Disaster Risk Reduction 2015–2030 proposed significantly increasing access to and availability of early warning systems for multiple natural disasters.

One of the most recognized early warning systems worldwide is that implemented on television and radio receivers with the Integrated Emergency Broadcast Warning System (EWBS), launched in Japan in September 1985 and first used in 1987 emergency experienced by the Japanese people due to a tsunami. In 2000, EWBS was implemented in the Digital Satellite Television (ISDB-S), and in 2003 in the Digital Terrestrial Television (ISDB-T) standard. Since then, the system has warned of natural disasters more than 15 times, giving the population some time to take protective measures [1].

Ecuador has experienced several natural disasters in recent years, the most serious to date being the earthquake that occurred on 16 April 2016 in Pedernales Manabí, which reached a magnitude of 7.8. Nine days after the event, 655 people died, 48 disappeared, and 1,663 were injured [2]. The active stratovolcano"Cotopaxi" has been monitored since 1976 because it is one of the most dangerous volcanoes in the world due to the frequency of its eruptions, with the last one occurring in 2015, and because of the number of populations exposed to its threats [3], including the community of the University of the Armed Forces - ESPE.

Due to events like the previous ones, the EWBS is being integrated into new devices that alert the population, as it is the case of Peru that in October 2015 with the JICA (Japan International Cooperation Agency) and the INICTEL-UNI (National Institute of Investigation and Training of Telecommunications - National University of Engineering), a module and an EWBS chip were used for the development of receivers incorporated in horns, which were used in a simulation of an earthquake of magnitude of 8.5° followed by a tsunami, which counted with the participation of approximately 10 million people. The purpose of this system is that the horns will be used as community alarms for future events that Peru may witness [4].

Since 2016, in Ecuador, the emergency alert system EWBS broadcast tests for digital terrestrial television have been carried out with the ISDB-Tb standard. In [5] the field tests of the Emergency Warning Broadcast System (EWBS) in Quito were presented, integrated into the international ISDB-T digital terrestrial television system. These field tests were made through the broadcasting signal of a commercial channel on 635,143 MHz frequency, in UHF band channel 41. An EWBS server was implemented in the transmitter, where the physical locations that will be alerted were configured, through 12-bit codes defined by cantons for Ecuador in the Harmonization Document Part 3 "EWBS" [6], as well as also the edition of the alert message that will be displayed on the television superimposed on the video and audio signal of the programming, under the ARIB STD-B14 standard [7]. The server reconfigures the PSI/SI tables. It generates a Transport Stream (TS) that is multiplexed with the content of the television channel is transmitted as Broadcast Transport Stream (BTS) together with the emergency bit of the physical layer through a microwave link to the modulator located on Pichincha hill and by broadcast transmission distributed throughout the city. The EWBS server configuration was performed using a remote desktop to the EWBS server located in the television station, activating the emergency alert signal in the receivers located in the city with a delay of less than one second.

The successful experience of testing the EWBS system generated the requirement for a single platform led by the National Service for Risk of Ecuador and Emergency Management that configures the codes of the country's cantons and the editing of the emergency message on the servers that will be installed on television channels, in an agile and dynamic way. In [8] the first results obtained from the integration of the emergency alert system platform that centralizes for EWBS servers were presented. In this platform, a Common Alert Protocol (CAP) [9,10] module in a Spatial Data Infrastructure (SDI) for risk management and integration of the EWBS System for digital terrestrial television were implemented. As a result of this work, a WEB service shown in Fig. 1 was obtained that contains the EWBS codes representing the cantons of Ecuador, selected through the use of a map viewer of the SDI UCuenca code generator system. The WEB service is consumed by the EWBS server developed by the ESPE University presented in [5], which is in charge of processing the information necessary to transmit an alert via DTT to the cantons that have been selected in the map viewer from SDI UCuenca [11]. The results of the latest EWBS tests carried out in Ecuador at the end of 2019 are presented in the following link: https://youtu.be/ZzBLg3oJbXU.

Increasing the availability of the EWBS systems depends not only on the generation of new transmission systems but also on all the utilities that can be derived from them. It is necessary to identify the transmission and reception protocols, where it is essential to define the transmission mode and the type of receivers. In the first case, it is required to define if a specific broadcaster will send the emergency alert or involve multiple broadcasters, which affects the type of receiver used. For this reason, the proposal of the present work is the adaptation of an EWBS signal taken from a set-top box to an IP Telephony Server that forwards or replicates the emergency alert in order to give the EWBS signal more excellent utility and better use.

One of the options of devices for the detection and emission of the EWBS signal is the IP telephone, which has a use in most companies and workspaces because the implementation of an IP telephony network has several advantages such as the simplification of infrastructure, advanced functions that can be developed employing software and additional services, which only this type of telephony can offer, so we based this work on the adaptation of an EWBS signal taken from a receiver (decoder) to an IP Telephony Server, thus giving the EWBS

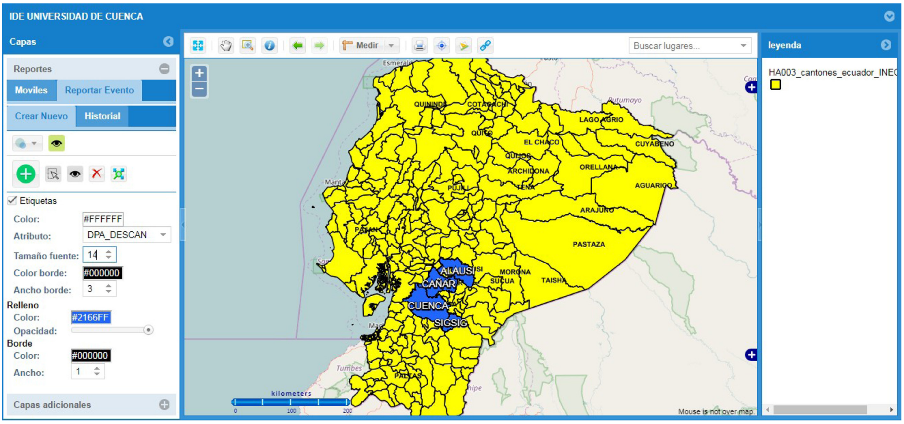

Fig. 1. EWBS code generator system of the SDI UCuenca

signal a more excellent utility and better use. For the project's development, the IP Telephony Network (managed by CISCO servers), of the University Campus of the University of the Armed Forces - ESPE, was used as a test scenario.

2 Methodology

For the project's development, the IP Telephony Network of the University Campus of the University of the Armed Forces ESPE was used as a test scenario. For the IP telephony system with signals coming from the outside as it is the warning emergency alert EWBS, the reason why we saw ourselves in the necessity to look for a way to make this integration, finding that most optimal, was to use a server of telephony IP like Asterisk since the programming language Python supports libraries coming from this Server. In this way, once an EWBS signal is detected under Python programming, the same program is responsible for transmitting the emergency signal through a kind of "call" from the Asterisk Server to the University Server.

For the development of this work, the following tools were used:

- Raspberry Pi 3 Model b+.
- Raspbian Buster with desktop and recommended software.
- Python version 3.7.3.
- Asterisk version 15.7.3.
- PIX-BT108-LA1 decoder from Pixela Corporation.

2.1 IP Telephony Server Under the Asterisk platform.-

For the installation of the server, initially, the Raspbian Operating System was updated, and all the necessary libraries for the Asterisk VPS (Virtual Private Server) were installed. After that, we proceeded to download and install Asterisk in version 15.7.3.

The operation of Asterisk is handled under the configuration of plain text files, so two files were modified, which were: sip.conf, because it contains the instructions for interaction with VoIP devices operating under the SIP protocol, and extensions.conf, it contains the configuration of phones, voice mailboxes, dialing plan, among others.

Plain Text File SIP.conf.- In the sip.conf file, we add the configuration of two users called [8640] and [TRUNK-CISCO]. The user [8640] was configured to execute tests of the correct functioning of the PBX in terms of incoming and outgoing calls. User [TRUNK-CISCO] was configured on the Asterisk PBX as a provider from the CISCO PBX. This user is used to carry out communication tests between the Asterisk Central and the CISCO Central. The configuration parameters are presented below, and the values used of both users in the Asterisk Central are shown in Table 1.

- type: Taking the friend of the value for the case of the user [8640], since this allows receiving and making calls internally in the Asterisk server, and peer for the case of the user [TRUNK-CISCO] since this only allows the authentication of outgoing calls.
- secret: If Asterisk is acting as a SIP Server, then this SIP client must login with an Authentication Password.
- qualify: Check if the client is reachable. Checks, in this case, are performed with a latency time of less than 2000 ms.
- port: UDP port on which the Asterisk Central will respond.
- insecure: Defines how to handle connections when the type parameter is set to peers.
- nat: This variable changes Asterisk's behavior for clients behind a firewall.
- host: This parameter is used to define how to find the client. The dynamic value serves to allow the user to connect from any IP address on the network.
- careinvite: This parameter indicates if the client can support SIP re-invite. The default value is yes.
- disallow: Allows to disable or enable a codec. The default value is all.
- allaw: Allows the use of codecs in order of preference. Usually, you must always define first the disallow parameter with the value all.
- context: This parameter depends on the value defined in the type parameter. In the case of the project, that value is friend, so this context is based on the calls that enter or leave through the definition of SIP entities.

Plain Text File Extensions.conf.- In the extensions.conf file, we proceeded to declare the configuration for three numbers, the first being the Central's own in Asterisk, which was generated for testing. The second number is for the CISCO IP central of the University; this and the first number were also generated with the purpose of testing. The third number is the access code to the INFORMACAST of the CISCO IP Exchange of the University. This number

Table 1. User settings [8640] and [TRUNK-CISCO], in the sip.conf plain text file.

	[8640]	[TRUNK-CISCO]
Type	Friend	Peer
Secret	8640pass	Does not apply
Qualify	Yes	Yes
Port	Does not apply	5060
Insecure	Does not apply	Port invite
Nat	No	No
Host	Dynamic	IP of the CISCO Central
Canreinvite	No	All
Disallow	All	All
Allaw	Ulaw, Alaw	Ulaw, Alaw
Context	Public	Public

contains all the extensions of the University, in which at the moment that the EWBS signal is detected, the speaker of these extensions will be automatically activated. It is a mass emergency notification system that sends critical messages to local devices and mobile users belonging to an IP telephony network and can also send to other types of receivers or social networks, as shown in Fig. 2.

Fig. 2. INFORMACAST

Table 2 shows the configuration of the 3 numbers configured in the extensions.conf file.

2.2 EWBS Signal Detection

The designed receiver tests were conducted with controlled transmission broadcast in the laboratory. An ISDB-T Dektec DTU-215 modulator was used for the RF output and the EWBS server with the transport flow configuration presented

Table 2. Configuration of the numbers in the plain text file extensions.conf. Each number must have a line under the parameter (Dial), to establish a new outgoing connection on a channel, and then link it to the incoming channel of the call; and a line under the parameter (Hangup), to end the call.

	General context
exten	8640, 1, Dial(SIP/8640, 30, Ttm)
exten	8640, 2, Hangup
exten	1874, n, Dial(SIP/TRUNK-CISCO/${EXTEN})
exten	1874, n, Hangup
exten	7400, n, Dial(SIP/TRUNK-CISCO/${EXTEN})
exten	7400, n, Hangup

in Table 3, with different area codes of Ecuador based on the harmonization document. Part 3 of the Forum ISDB-T International [6].

Table 3. Transmitter configuration

Paramenters	Values	
Program Map Table (PMT)	PID: 1031	
Program number	59232	
Emergency information descriptor	0 × FC	
Country code (ecuador)	0 × 454355	
Area codes	Quito	168, 0 × A8
	Rumiñahui	172, 0 × AC
	Mejía	108, ×6C
	Latacunga	97, 0 × 61
	Pujilí	159, 0 × 9F
	Salcedo	173, 0 × AD
	Ambato	5, 0 × 05
Superimpose message in spanish	*"Alerta, evacuar el edificio"*	
PID message	278	

To integrate the EWBS signal to the IP Telephony Server, a PIXELA decoder receives the EWBS signal and activates an audible alarm according to the emergency code. The Raspberry card was used to monitor and capture the electronic signal that activates the alarm through a function implemented in Python. For the programming, we proceeded to perform the detection of the event (1 or 0 logical) coming from the decoder, followed by this, through the import of the *pycall* library, which is compatible with all the attributes of Asterisk call files, it was declared that at the moment the program detects a one logical automatically connects with the Asterisk server to initiate a call to the number designated for the INFORMACAST belonging to the CISCO Central.

2.3 Integration and Testing

In Fig. 3, can see the interconnection diagram between the interface and the network of the University of the Armed Forces ESPE, in which the first one has a CUCM Publisher module, which allows the reading and writing of the platform's database, where all the changes are made, that is to say, user declarations, extensions, among others. Furthermore, the second one has a CUCM Subscriber module, which only allows reading and saving the information that the Publisher replicates to the other subscribers of the solution and an INFORMACAST module. When the EWBS console emits a message, the system works as follows: it triggers an electrical pulse in the decoder, which the Raspberry detects through programming in Python. Once the detection process is done, the program in Python called detect.py calls the number 7400, which is the code assigned in the INFORMACAST, to activate the Speakers of the University's phones automatically.

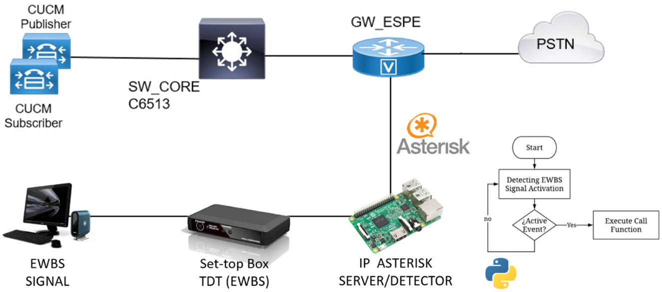

Fig. 3. Interconnection diagram between the interface and the IP network

In this scenario, what was finally executed was that, at the time of detecting the activation pin of the decoder, make the call to a number previously configured within the INFORMACAST of the Central CISCO, so that the speakers of the IP terminals of the Central are activated automatically emitting the signal of Emergency through audio.

Figure 4 represents the full implementation of the work, after that detecting the activation pin of the decoder, make the call to a number previously configured within the INFORMACAST of the Central CISCO so that the speakers of the IP terminals of the Central are activated automatically emitting the signal of Emergency employing audio.

2.4 Test Scenarios

To obtain the results, four test scenarios were performed. The first test scenario was implemented exclusively to validate the detection of the decoder's electric pulse under Python programming on the Raspberry, which in this case acted only as a detector once it received the EWBS signal from the Console.

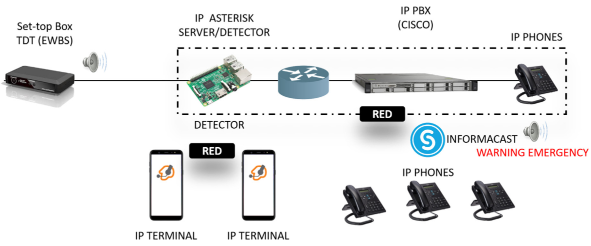

Fig. 4. Total work implementation diagram.

Figure 5 shows the implementation of scenario 1, in which once the detector identifies an electric pulse equal to 1.6 V, the time and day in which the electric pulse was detected is presented in the interface through a command window.

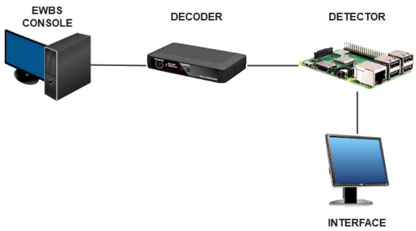

Fig. 5. Test scenario no. 1.

Scenario 2 was performed to test the operation of the Asterisk PBX implemented on the Raspberry after its installation.

The tests consisted initially of communicating two telephones previously registered in the PBX to determine that there are no errors in communication in the IP telephony system.

Following this, the detection system used in Scenario 1 was incorporated so that, instead of visualizing the detection through a command window, the detection is visualized through a telephone call to the IP Terminal. Figure 6 shows this scenario in Phase 2.

Scenario 3 was performed in 2 phases shown in Figs. 7 and 8, respectively. The first one, to execute communication tests between the Asterisk IP PBX and the CISCO IP PBX. When calling from extension 8640 (belonging to the Asterisk PBX) to extension 1874 (belonging to the CISCO PBX), successful communication was achieved due to the configuration of the Asterisk user as a friend type within the Asterisk PBX in which it was determined that it could make calls.

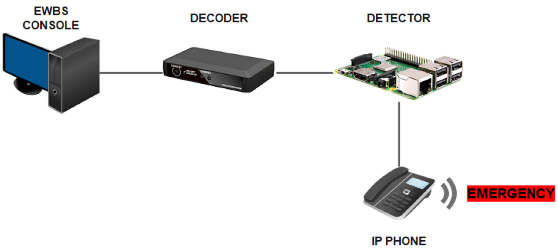

Fig. 6. Test scenario no. 2.

When calling from extension 1874 to extension 8640, no communication was obtained because the CISCO user configuration within the Asterisk PBX was defined as a peer, allowing the CISCO PBX to receive calls.

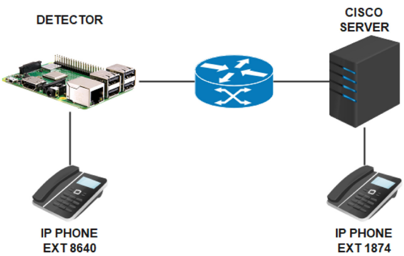

Fig. 7. Test scenario no. 3 (phase 1).

In the second phase, the call was made directly from the Asterisk Central to extension 1874, once the Raspberry detected the high pulse when the decoder obtained the EWBS signal coming from the Console.

In scenario 4 is shown in Figs. 9, when the decoder activation pin was detected, the call to a number previously configured within the INFORMACAST of the CISCO Central Station was automatically executed so that the speakers of the IP terminals of the Central Station were automatically activated, emitting the Emergency signal employing audio.

3 Results

The transmission was made from the laboratory ISDB-T transmitter through broadcast on channel 30 UHF at a transmission frequency of 569.143 MHz, activated the transport stream with the configuration for EWBS described in Table 3.

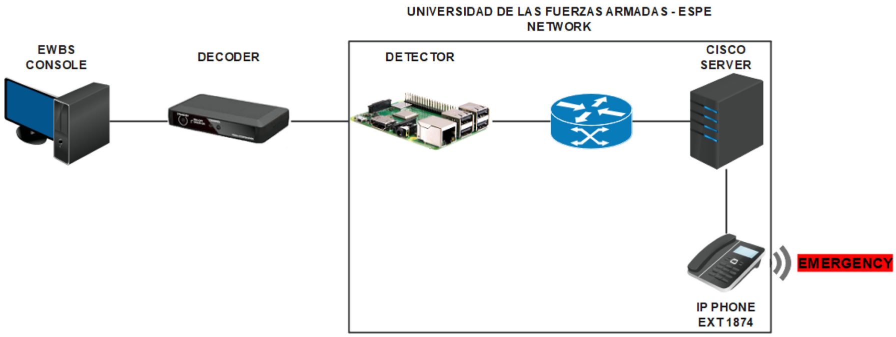

Fig. 8. Test scenario no. 3 (phase 2).

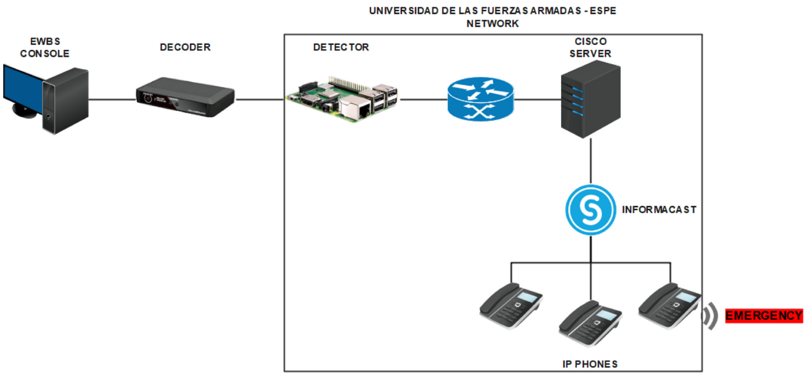

Fig. 9. Test scenario no. 4.

Three different city codes were evaluated with ten consecutive tests for each one. One hundred percent detection of the activated electrical pulse was obtained once the decoder received the EWBS signal. There were no false positives in any of the tests, which allowed us to ensure that there would be no false alarms in the operation process.

The IP Terminal was automatically called when the detector obtained the active electrical pulse once the EWBS signal was emitted. Since the detector's sampling time was 1 s in the programming, while the electric pulse was high, calls were made every 1 s, which allowed us to define a sampling time of 30 s.

When calling from an extension belonging to the Asterisk Central to an extension belonging to the CISCO Central, successful communication was achieved due to the configuration of the Asterisk user as a friend within the Asterisk Central in which it was determined that it could make calls.

INFORMACAST replied to the emergency alert through audio messages to both fixed and portable telephones of the Asterisk central and the CISCO central.

With the results obtained, it was possible to validate that there are no delays in the reception of the emergency alert in the IP Telephony network. As soon as the EWBS signal is activated, the speakers of the IP terminals are automatically activated, emitting the pre-recorded alert message.

The tests can be seen in: https://youtu.be/QWw8UaWGRQQ.

4 Discussion

To implement the EWBS system is necessary to define the complete structure of its transmission system through Digital Terrestrial Television under the ISDB-T standard, so it was essential first to develop a server that inserts the codes of each of the cantons of the country and the superimpose message that will be sent for the emergency alert in the transport stream of the television channel that is structured on the programming sent. In addition, a system was designed that allows the control of the emergency terminal to work in a centralized way to activate the signal to the television channel stations remotely.

Field tests were carried out in the city of Quito through a single television station, but the question of implementation remains since the EWBS system will only work when it is tuned to this channel or if it is on Standby. Some receivers receive the signal by tuning to a specific channel for Standby mode, making it dependent on a single television channel. For the possibility of increasing the emergency alert to the entire population, it would be if all the television channels that have digital transmission activate the EWBS system, which makes the centralized control send to several stations and not necessarily the entire population receives this signal.

On the receiving side, it is essential, on the one hand, that digital television receivers with the EWBS emergency alert system for the international ISDB-T standard should enter the market of each country and, on the other hand, that they also have audible alarms, text superimposes message and the standby output support, which affects all televisions and receivers that have entered the country since 2014 with the international ISDB-T standard that do not necessarily have the EWBS system.

To start the process of implementing the EWBS system in the country that supports coverage and reaches the entire population is necessary to find a way to take advantage of technology, thinking differently, giving support to a few television stations in the country destined to send the emergency alert that they have a centralized system that includes a backup and redundancy network, operating under an international communication protocol.

It is important to take advantage of the broadcast television signal coverage throughout the country to send the emergency alert and not necessarily receive it on the television and have reception equipment tuned to the television channel in charge of EWBS that retransmits that information, be it in the form through communal alarms on speakers, or through internal or external networks, either through the Internet or other means of communication.

In this article, we present the option of taking advantage of receivers already available in the market with the EWBS system, which replicates the emergency signal in an internal network through a telephone exchange, for which a telephone exchange was designed through a Raspberry Pi card IP that was connected to a corporate telephone exchange, in this case of the university, which allows that through its massive information system INFORMACAST, it can replicate all the telephones contacted to the corporate center and also to the individual central.

Similar projects have been developed for communal speakers through the cooperation of JICA and INICTEL of Peru using a specialized chip for receiving EWBS in one segment, which has proven to be a good solution for coastal areas that warn of Tsunami emergencies, which to at the same time it includes an audio message that comes out of the speakers, all sent through the television signal.

The tests we carry out on our prototype consider that we control the transmission and reception process, so the text message is sent to both a television receiver and is the same as the one sent by the telephone exchange. However, when conducting field tests through television channels, the EWBS receiver will continue to present the message sent over the television. However, the IP control panel will only receive the emergency activation, so the development of complete receivers that fulfill the role of Gateway has continued. We have developed a second phase based on a receiver designed with Software Defined Radio (SDR) that thoroughly reads the transport stream and can also detect the activation of the emergency message through the physical layer and decode the area codes and the message from text transmitted over the air, as well as the possibility of sending the replica of all this information to the network.

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