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Review Article

DRM Emergency Information System Coverage Study Evaluation - An Educational Perspective

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Abstract

In emergencies, timely communication plays a crucial role in ensuring the safety and well-being of individuals. The ability to disseminate accurate information quickly can help prevent panic, provide necessary instructions, and coordinate effective response efforts. One key aspect of timely emergency communication is the rapid transmission of alert messages to the public. Therefore, the need for efficient Emergency Information Systems that accurately and rapidly broadcast emergency content is ultimate. Radio coverage studies can be conducted to indicate the maximum coverage of these systems. However, the coverage study's outcome must be evaluated to provide reliable results. This paper presents specific criteria to evaluate the coverage study in the case of DRM Emergency Information Systems. These criteria are applied to a specific DRM Emergency Information System, the UNIWA-EIS to prove its robustness. The UNIWA-EIS competency in each evaluation territory also proves that DRM Emergency Information Systems can be used by any Educational Institute to broadcast safety alert messages.

Keywords: Digital Radio Mondiale; Coverage Study; Optimal Broadcasting; Emergency Information System

Introduction

Natural disasters have necessitated the development of Emergency Information Systems aiming at broadcasting emergency content rapidly and efficiently [1-4]. The ability to disseminate accurate information quickly can help prevent panic, provide necessary instructions, and coordinate effective response efforts. However, timely communication must be achieved in terms of maximum radio coverage.

Radio coverage studies can be conducted to indicate the maximum coverage of Emergency Information Systems. There are a lot of studies related to Emergency Information Systems that achieve high radio coverage [5-11]. One study emphasizes the maximum radio coverage of DRM Emergency Information Systems [12]. In parallel, another study clarifies that the maximum radio coverage percentage typically drops when the system is enacted in different areas or when various factors (such as the distance from the emitter) come into effect (AIR-DRM). Therefore, ensuring that the maximum coverage will remain high is of utmost importance.

Competent DRM EISs can be used by educational institutions to transmit common safety alert messages. Such systems can be incorporated into the Integrated Warning Systems of Educational Organizations to answer this purpose. Some important studies referred to in Literature prove that Emergency Information Systems assume their communication role effectively [13-15]. Nevertheless, there are not many important studies that refer to DRM Emergency

Information Systems developed by Educational Institutes to transmit safety alert messages [16]. Moreover, there is not a solid framework to evaluate the findings of a DRM EIS coverage study.

In an attempt to cover these scientific gaps, this paper presents specific criteria to evaluate the coverage study outcome of DRM Emergency Information Systems. These criteria are applied to a specific DRM Emergency Information System, the UNIWA-EIS to prove its robustness. The experimental UNIWA-EIS was enacted to broadcast safety alert messages, informing students and the academic staff about an impending fire or earthquake. The set of the evaluation criteria is presented in Section 2. The UNIWA-EIS coverage study is presented in Section 3. The evaluation of the respective coverage study is presented in Section 4. The paper ends with concluding remarks.

Evaluation Criteria

Some important Evaluation Criteria that we meet in Literature are [17,18]:

1. Testing the audio quality: Clear and crisp audio transmissions enable authorities to broadcast important updates, instructions, and alerts with precision, ensuring that recipients receive accurate information promptly. This superior audio quality can help mitigate confusion and panic among the affected population, facilitating a more organized response to emergencies.

2. Indicating the Maximum Coverage Percentage: Digital radio broadcasting systems can reach remote or underserved areas effectively, ensuring that vital information reaches all corners of the affected region. By expanding the reach of emergency broadcasts, authorities can improve overall response coordination and enhance community resilience in the face of disasters [19].

3. Testing the effectiveness of the error transmission mechanisms: By utilizing sophisticated encoding algorithms, these systems can mitigate the effects of noise and fading, ensuring consistent audio quality for listeners across varying reception conditions [18].

4. Indicating receiver compatibility: Challenges may arise in terms of receiver compatibility when implementing DRM+ and DRM30 technologies for emergency communication. It is crucial to address this issue by educating the public about the need to upgrade their radio receivers to access digital signals during crises. Ensuring widespread adoption of compatible devices can help maximize the effectiveness of emergency broadcasts using these advanced technologies [20].

5. Indicating the extent to which Multiple Communication Channels are used: Experts suggest that relying on a single communication channel may not be sufficient during emergencies. By utilizing a combination of channels such as text messages, social media, sirens, and radio broadcasts, authorities can reach a wider audience and ensure that critical information is disseminated effectively [21].

6. Testing the clarity of messages: Clarity is key when communicating vital information during emergencies. Experts recommend using simple language, avoiding jargon, and providing clear instructions to the public. Consistency in messaging across all channels helps prevent confusion and ensures that recipients understand the severity of the situation.

Testing the Uniwa-Eis Coverage Potential

The Uniwa-Eis

Our integrated system, with the additive units, is illustrated in Figure 1. As depicted in this figure, two principal units stand out in the UNIWA-EIS:

1. The Broadcast Model Selection System operates according to a specific algorithm (Figure 3).

2. A Remote Access Control System that is responsible for the control of the broadcast mode selection operation and the control of the content development process [16].

Our system is facilitated with fixed-line and mobile internet, complying with the standards for 4G and 5G, along with satellite internet. Additionally, our system uses alternative, environmentally friendly power sources.

The algorithm selects the optimal broadcast mode in case of communication loss or a power outage [22-24]. The algorithm's operation is illustrated in Figure 2.

As illustrated in Figure 2, if the electrical power goes out, a specific subsystem is activated, taking advantage of sustainable energy sources (Comfort et al., 2001; You & Kim, 2011) [16,18]. For this purpose, our algorithm is based on the Energy Management System (EMS) standard [22,25-29]. If the internet connection fails, another subsystem is activated, taking advantage of the satellite internet capabilities. The possible internet failure is addressed according to the failover technique [22-29]. Specific software, such as pfSense was used to execute failover algorithms.

A collinear dipole antenna, consisting of four (4) vertical folded dipole antennas in a line, fed in phase is selected since it contributes to a rapid and accurate broadcast. Using the appropriate software (Signal Pro EDX Wireless), the optimal antenna polarization was vertical, and the optimal transmitter power was calculated to be 977.24 watts. The antenna is depicted in Figure 2.

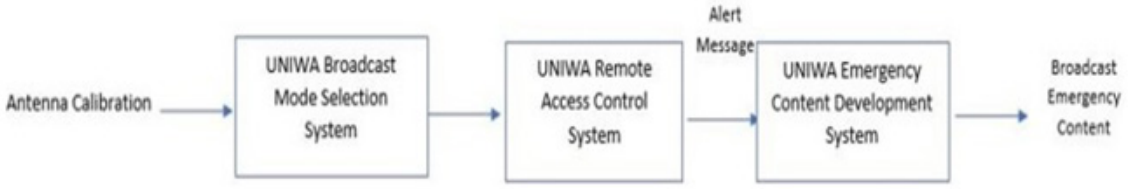

Figure 1: The UNIWA-EIS Integrated System.

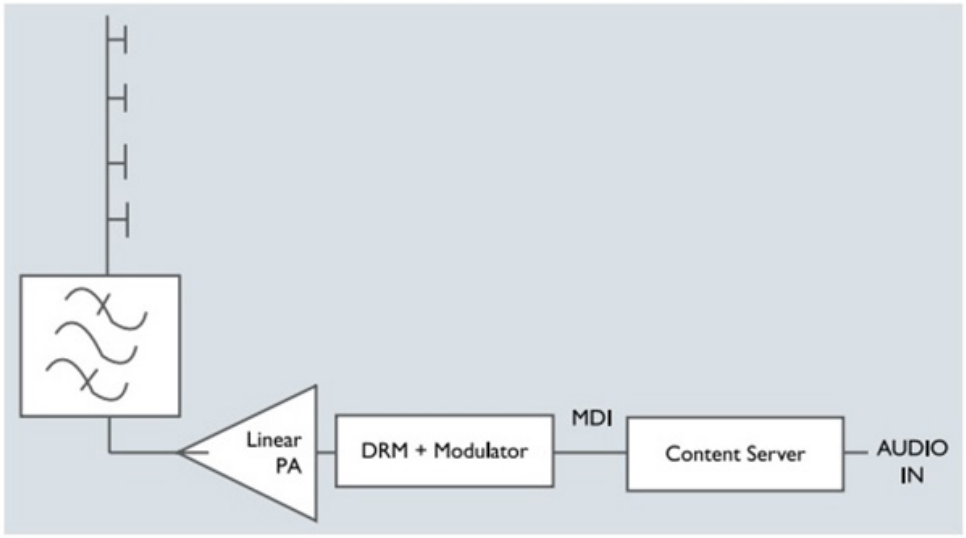

Figure 2: The UNIWA-EIS antenna features.

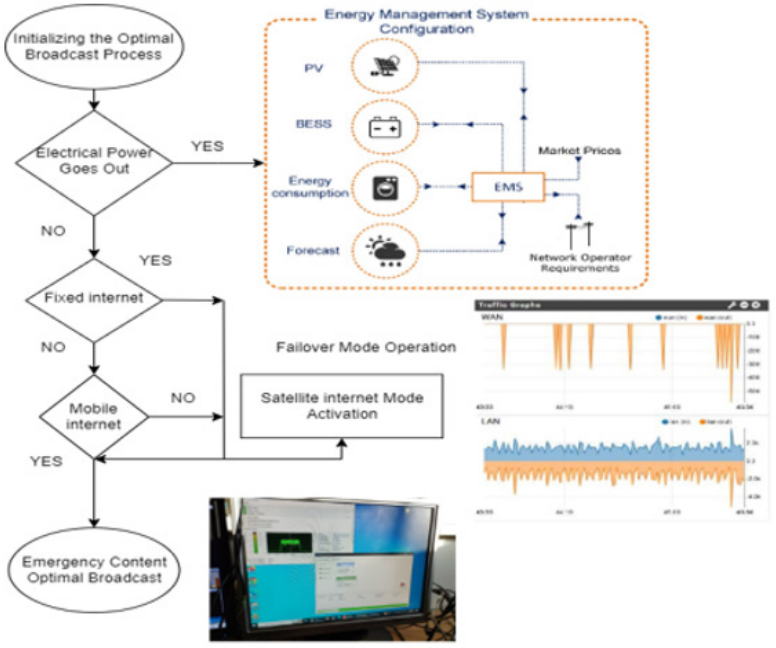

Figure 3: The UNIWA-EIS Broadcast Algorithm [16].

The Coverage Study

Our objective was to test the coverage potential of our system in areas featured by rough geographical terrain. For this purpose, our system came into effect in the region of Vigla, an area located on the island of Symi. The coverage study was based on a standard methodology called "LEGBAC" [30]. This methodology provides coverage results by analyzing valuable data such as site longitude, transmitter power, and carrier wave frequency. The area of Vigla is defined as the 'Site' in our case. It is important to point out that transmitter power and site longitude and latitude were parameters that were also used in one important study to test the coverage of a DRM emergency information system [12]. The six evaluation criteria described in section 2 were applied to our coverage study.

Results and Evaluation

Testing the Audio Quality of the Uniwa-Eis

According to studies, DRM+ offers audio quality comparable to CD (44.1 kHz, 16-bit), with a signal-to-noise ratio (SNR) that typically exceeds 30 dB even under suboptimal conditions. The "Dream" software was used to provide the SNR of the UNIWA-EIS. As indicated in Image 1, the average SNR value for the signal during the measurement phase was 20.1.dB. It is essential to underline that the maximum SNR value was 30.0 dB.

Testing the Maximum Coverage

The maximum coverage percentage of our system as shown in Table 1 was achieved in the case of antenna vertical polarization. As it is shown in Table 1, the field signal strength in the case of maximum coverage was 74.0 dBuV/m. The maximum coverage was achieved in the phases where the antenna central frequency value was 107.8 and 104.6 respectively. The following map (Figure 4) illustrates the field signal strength in the event of maximum coverage [31]. It is important to underline that our system achieved a great coverage percentage in any antenna setting. That is proof of our system's robustness, given that the system's coverage potential was not highly affected by antenna calibration.

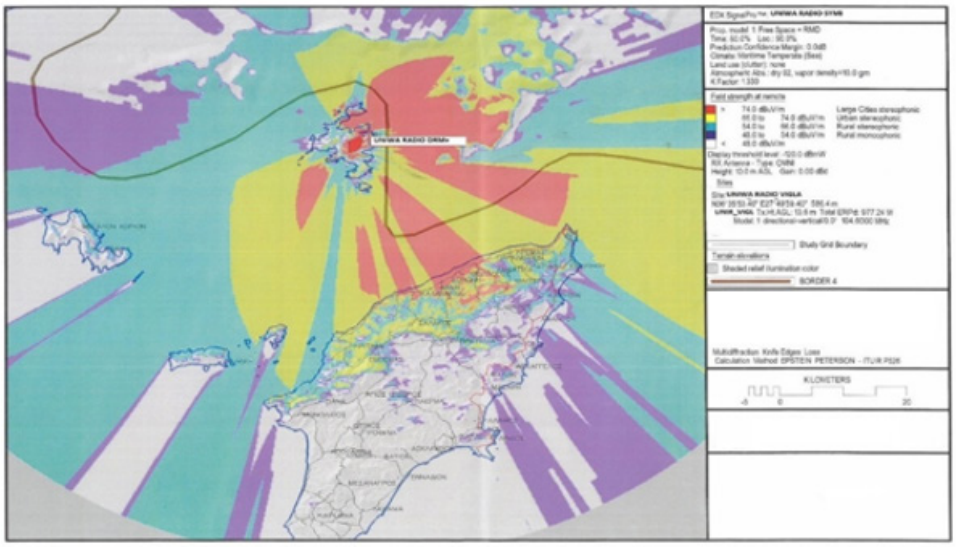

Figure 4: Radio Coverage Map (Field Signal Strength).

Table 1: Coverage Percentage.

Signal Strength	Antenna Central Frequency	Antenna Polarization
74	107.8	Vertical
74	104.6	Vertical

The field signal strength fluctuated between 74.0 (maximum) dBuV/m and 48.0 dBuV/m (minimum) at approximately 133 Km, indicating a great coverage range. In one relative study, the field signal strength drops at approximately 20Km and slightly increases at 28 Km (AIR-DRM, India). In parallel, the field signal strength didn't exceed 59 dBuV/m in the respective study. In the case of the UNIWA-EIS, the transmitter power was 977.24 watts whereas in the AIR-DRM study, the transmitter power was mentioned to be 300 watts. The increase in the transmitter power appears to account for our great coverage range.

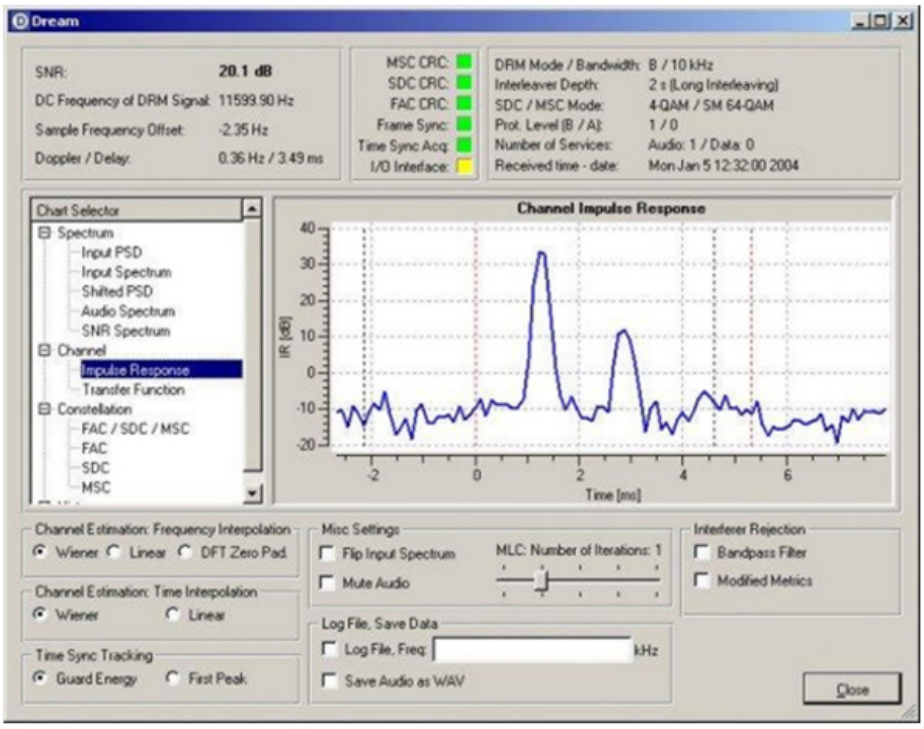

Image 1: The UNIWA-EIS SNR (https://sourceforge.net/projects/drm/).

Testing the Effectiveness of the Error Transmission Mechanisms

DRM+ uses advanced error correction techniques, such as Reed-Solomon coding and unequal error protection, to maintain audio quality even in challenging reception environments. These mechanisms ensure that the error rate remains below 1% in most cases, maintaining a high level of service continuity. Images 2 and 3 indicate that the OFDM mechanism (a feature of the Dream Software) worked well in our case.

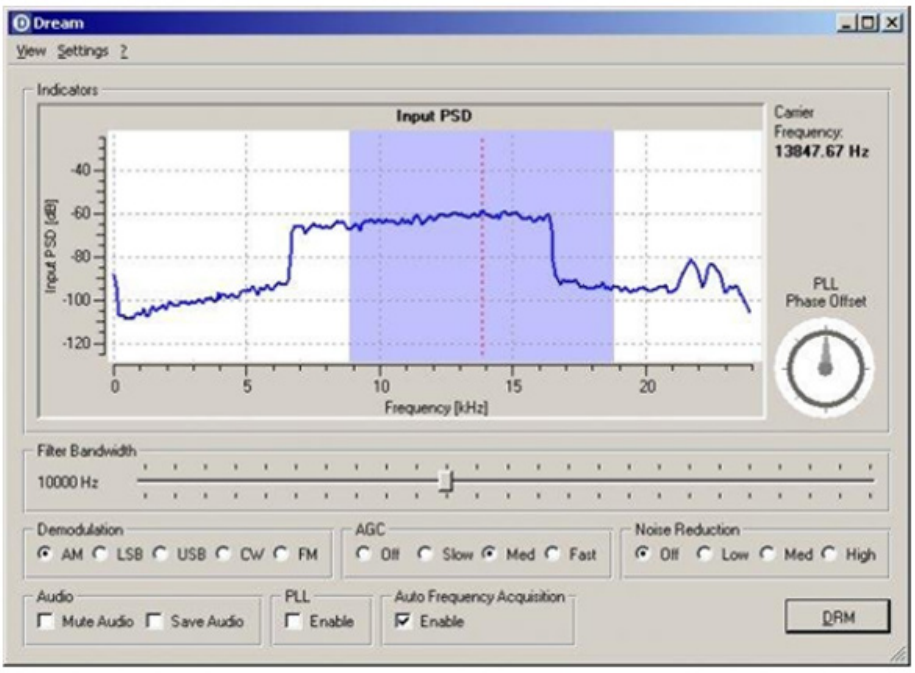

Image 2: Demodulation.

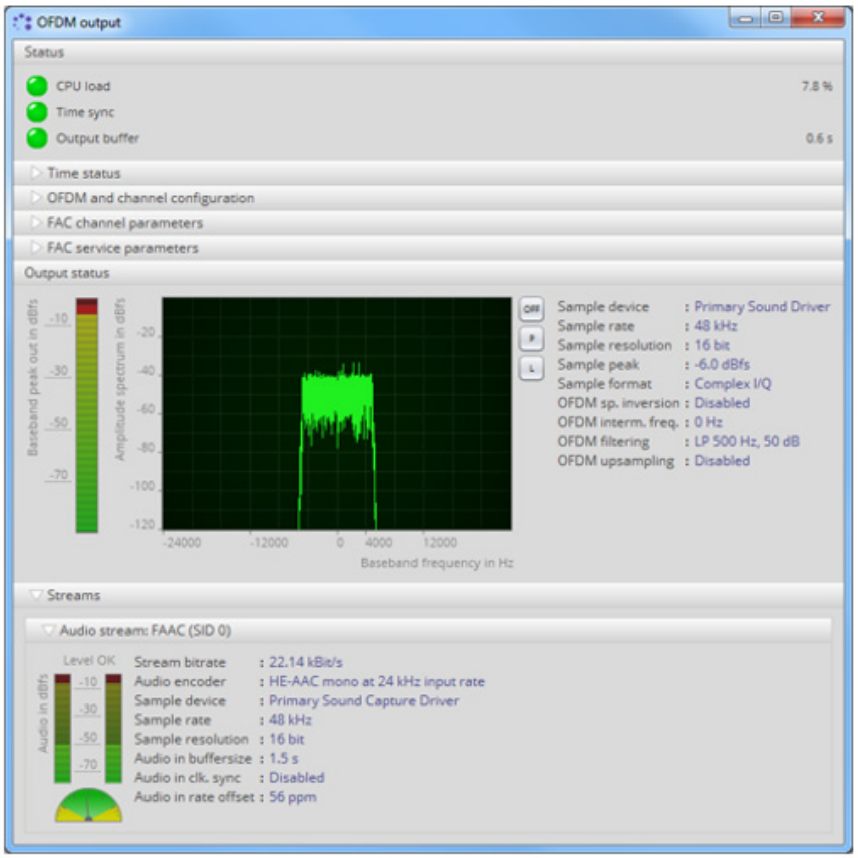

Image 3: OFDM Operation.

Testing the Receiver Compatibility

The adoption of DRM+ depends on the availability of compatible receivers. As of 2023, over 1 million DRM+ compatible receivers have been sold globally, with increasing adoption in countries prone to natural disasters. However, the penetration rate remains low in many developing regions. In our case, the SDR RTL 2832u receiver was used, offering compatibility in a fixed and mobile environment, as depicted in Image 4.

Image 4: The SDR Receiver (https://www.rtl-sdr.com/).

Testing the Multiple Communication Channels' Potential

Relying solely on radio broadcasts can limit the reach of emergency messages. Studies indicate that using a combination of communication channels increases the likelihood of message reception by up to 40%. DRM+ can complement other channels by providing robust, reliable radio coverage even when other infrastructures fail. The "SPARK" software was used in the UNIWA-EIS production studio to answer this purpose. As shown in Image 5, audio and data channels were provided.

Image 5: SPARK Multi-Communication Channels (https://www.drm- sender.de/?page=tools&lang=en#1).

Testing the Clarity of Messages

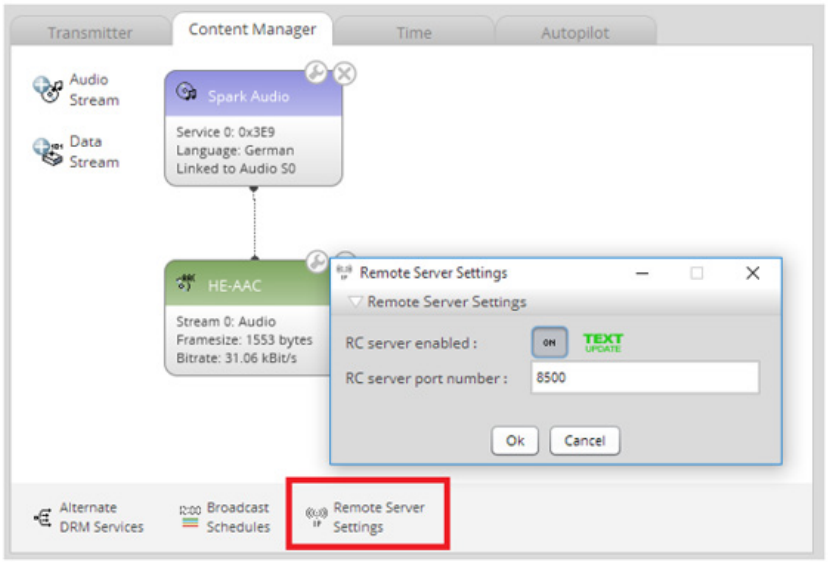

Image 6: The SPARK CONTENT MANAGER.

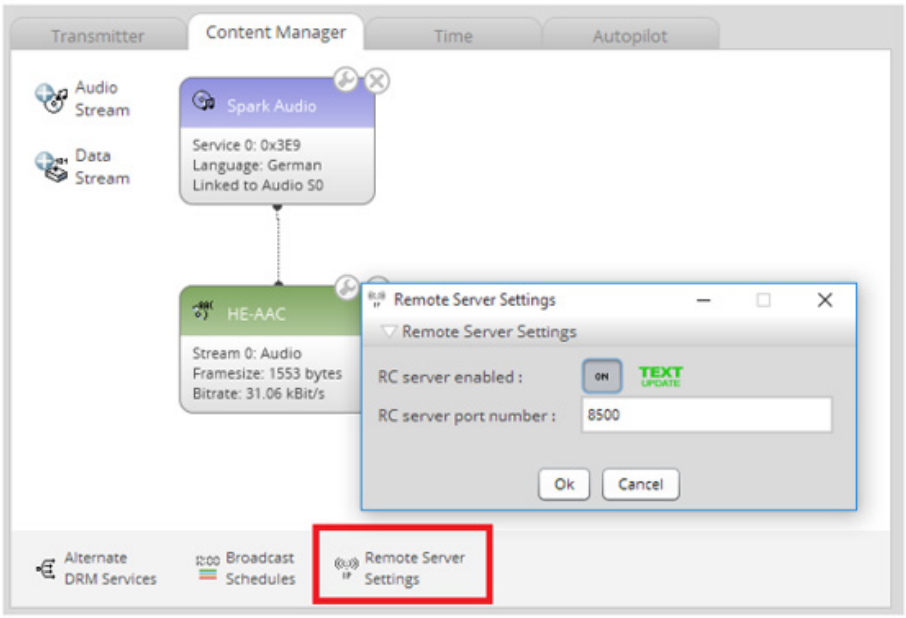

Image 7: The SPARK MESSAGE EDITOR.

Clarity in communication is critical for ensuring that the public takes appropriate action during emergencies. DRM+ supports text and image transmission along with audio, which can be used to reinforce key messages. The "SPARK" software used in the UNIWA-EIS Production Studio ensured the clarity of messages. The "SPARK" content manager along with the "SPARK" message editor offered the respective utility in the way shown in Images 6 and 7:

The clarity of the UNIWA messages is based on the fact that the Civil Protection Service can interfere with the emergency content in the production studio to ensure the clarity of the warning messages. It is essential to underline that after the UNIWA EIS enactment, listeners on the island of Symi reported a clear emergency content transmission, proving the clarity of the warning message.

The Educational Added Value

The UNIWA-EIS proved to be a competent DRM Emergency Information System that excels in each evaluation territory. Therefore, UNIWA-EIS can be used to broadcast any emergency content. In this sense, the UNIWA-EIS can be connected to an Integrated Warning System, informing specific target groups about an impending emergency. Hence, UNIWA-EIS can broadcast alert messages relating to the safety system of the University.

It is essential to underline that the experimental UNIWA-EIS was enacted to broadcast alert messages in case of a fire and an earthquake. During a preordained test, the UNIWA-EIS informed the students and the academic staff about the respective disasters. The UNIWA-EIS studio developed the alert message, and the UNIWA-EIS broadcast system ensured the rapid and safe transmission of the emergency content.

As a result, DRM Emergency Information Systems can be incorporated into the Integrated Warning Systems of Educational Organizations to broadcast alert messages in case of specific emergencies. However, such systems should be tested before being enacted. A coverage study is needed to ensure an accurate emergency content transmission.

In parallel, the emergency content development studios of DRM EISs like the UNIWA-EIS studio, can use competent software like "SPARK" to create any alert message. In light of the studios' capabilities, DRM EISs can efficiently transmit alert messages regarding common safety issues, such as wire heating, power outages, excessive electromagnetic radiation and other disasters. The UNIWA-EIS was not used to transmit such messages. Nevertheless, the UNIWA-EIS studio's competency and the UNIWA-EIS broadcast system's efficiency vouches for an accurate and rapid transmission of common safety alert messages.

Conclusion

This paper presents a set of evaluation criteria for a reliable coverage study in the case of DRM Emergency Information Systems. In parallel, the paper demonstrates a competent DRM Emergency Information System, the UNIWA-EIS. The application of the evaluation criteria to the UNIWA-EIS coverage study proves that the UNIWA-EIS excels in any aspect of the respective metrics, proving the UNIWA-EIS robustness. These evaluation criteria can be used in any DRM EIS coverage study to ensure its reliability. Moreover, robust DRM EISs such as the UNIWA-EIS, can be used by Educational Organizations to transmit safety alert messages.

Finally, our team is working on connecting the UNIWA-EIS to a Student Performance Prediction Model to transmit alert messages

to specific non-achievers (students who are about to fail their courses).

Acknowledgment

None.

Conflict of Interest

No conflict of interest.

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