

Development and Operation of Early Earthquake Warning System for Radio Broadcasting

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The Earthquake Early Warning (EEW) service of Japan Meteorological Agency (JMA), which started in October 2007, provides seismic information possibly several seconds before the destructive shake arrives. We developed an EEW auto-broadcasting system for commercial AM/FM radio stations to quickly announce to the public that strong tremors are coming. The radio stations that the authors belong to started their operations in September 2008. The specifications of this system were decided considering the system generality that other ordinary radio stations can introduce our system without change.

The features of the developed system are as follows:

- (1) An EEW message is automatically broadcasted, interfering the broadcast of current program even if in the middle of a commercial.
- (2) The auto-interrupt broadcast is performed only when the coverage area of the radio stations includes the region where the destructive shaking is expected.
- (3) The broadcast message is dynamically generated including the epicenter location and the expected region names of strong shaking. The messages using multiple languages are possible.
- (4) The reliability for the system is emphasized as well as multiple functions.

(1) EEW, which is positioned as one of the weather warnings of JMA, is issued for the region where seismic intensity is estimated to reach intensity 4 or greater on the Japanese scale. A fully automatic broadcasting system requiring no manual operation is necessary to provide the information before strong tremors arrive to the public needing the alert the most. Manual operation may spread the region where EEW cannot be provided in time because of its loss of time. When the developed system receives EEW from JMA, it automatically interrupts the broadcast of current program even if

in the middle of a commercial, and provides the alert messages for the listeners to secure their personal safety.

This system consists of instruments shown in Figure 1. The main control server receives EEW telegrams from JMA servers which are parallel redundancy designed. The server is connected to JMA using digital leased circuit or IP-VPN. The server controls the audio reproducer and the broadcast interrupt equipment through the built-in I/O (input/output) board. The audio reproducer has short segments of broadcast sentences such as announce messages, epicenter locations or regional names, and plays phrases in sequence ordered by the command using 13 contact signals (11 of them are used for phrase selection and the others are 'start' and 'stop' commands.) from the server. When the broadcast interrupt equipment receives both the interrupt contact signal from the server and the audio output from the audio reproducer, the equipment interrupts the current program to bring the EEW messages. The customers can connect up to 5 network signal lights and one EEW display terminal on LAN connection as an optional extra. Network signal lights inform system failure detections other than the execution of EEW interrupt broadcasting. The EEW display software named ASU-QUICK runs on standard Windows PC. When EEW telegrams are received, ASU-QUICK estimates the arrival time of S-wave and the seismic intensity at the target location (the radio station) based on focal parameters and displays the estimated results and the focal information on the monitor as shown in Figure 2.

(2) EEW radio broadcasting also has a risk of secondary disasters; for instance, some drivers traveling along the expressway could overreact to the alert message to cause accidents. That is why Japanese commercial radio stations have their own seismic intensity thresholds to judge whether the interrupt-broadcast is performed or not. The EEW broadcast is performed only when the intensity in the coverage area is expected to be the threshold intensity or greater. The radio stations the authors belong to in Tokai area commonly set the threshold to intensity 5 upper, though their coverage area are different. In constant, NHK (Japan Broadcasting Corporation), which is the public television and radio organization and is obliged to broadcast EEW by law, broadcasts every EEW on TV and radio throughout the nation.

(3) The broadcast message is dynamically generated joining up to 2,000 segments recorded in the compact flash memory card. The message format is structurally defined in advance, and the epicenter location and the region names of strong tremors are properly inserted by analyzing the EEW telegrams. Our system can adapt to the cases that the regions where strong tremors are expected become widespread by the renewal of the EEW and that another EEW about another earthquake which occurs nearly simultaneously is issued during the interrupt-broadcasting.

An example of EEW broadcasting message is now introduced used in Aichi International

Broadcasting Co., Ltd., nicknamed RADIO-i. RADIO-i offers information services to foreigners in Tokai area. Alarm sound for EEW composed by NHK is firstly played for attention-calling. Then the alert messages shown as below are repeated two times both in Japanese and in English.

This is an Emergency Earthquake Warning.
 An earthquake has just occurred in (epicenter location name).
 Please be aware that strong tremors may occur at any minute.
 Please remain calm and evacuate immediately to a safe place.
 Drivers should slow down and stop their vehicles safely on the side of the road.

(4) EEW broadcasting is a rare event. The system now in operation may have no chance to broadcast EEW messages except trainings or system checks until the renewal time (about 5 years after). Therefore, usual condition monitoring is a very important function. The main control server checks its I/O control functions using telegrams received from JMA servers on the hour every hour.

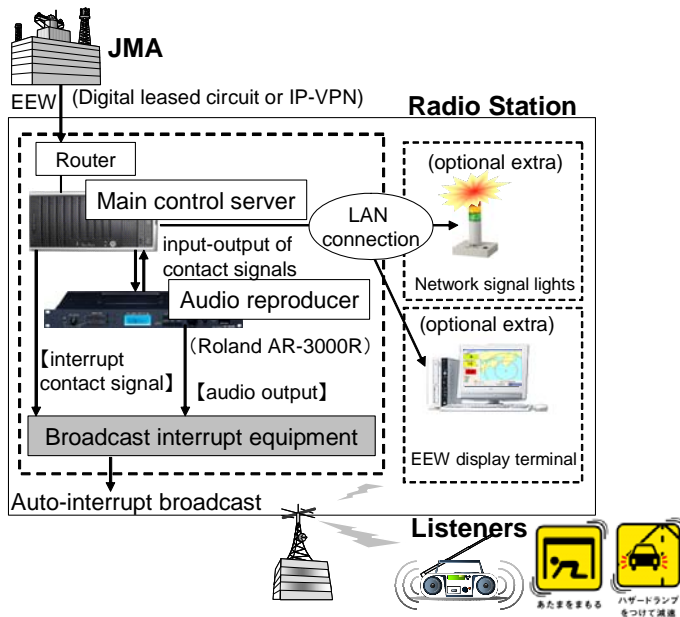


Figure 1: System configuration of EEW radio broadcasting system. The auto-interrupt broadcast is provided by inputting both the interrupt contact signal from the main control server and the audio output of EEW message from the audio reproducer into the broadcast interrupt equipment.

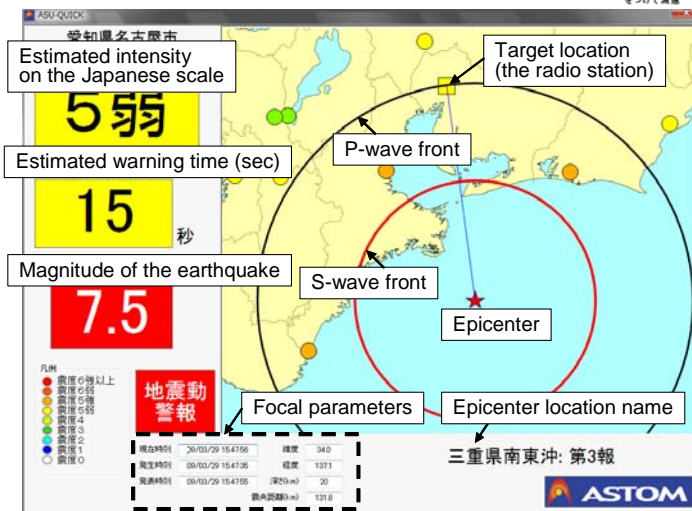


Figure 2: An example of PC screen by EEW display software, ASU-QUICK. Estimated seismic intensity and focal parameters are shown in left ends. The map indicates the location of the site, the epicenter and a moving image of P-wave and S-wave spreading.