2 ShakeAlert: A Unified EEW System for California

Margaret Hellweg, Richard Allen, Maren Böse (Caltech), Holly Brown, Georgia Cua (ETH), Egill Hauksson (Caltech), Thomas Heaton (Caltech), Margaret Hellweg, Ivan Henson, Doug Neuhauser, Kalpesh Solanki (Caltech), Michael Fischer (ETH)

2.1 Introduction

Earthquake Early Warning (EEW) is a method of rapidly identifying an earthquake in progress and transmitting alerts to nearby population centers before damaging ground shaking arrives. The first few seconds of the initial P-wave arrivals at one or more stations are used to detect the event, and predict magnitude and peak shaking. Detections from several stations are combined to locate the event. A warning of imminent shaking can be used to activate automatic safety measures, such as slowing down trains, isolating sensitive factory equipment, or opening elevator doors. Warnings can also be sent directly to the public via cell phone, computer, television, or radio.

With support from the United States Geological Survey (USGS), the California Integrated Seismic Network (CISN) hosted a three-year proof of concept project for EEW algorithms in 2006-2009. Following that successful project, the Berkeley Seismological Laboratory (BSL) together with its CISN EEW partners, the California Institute of Technology (Caltech), and the Swiss Institute of Technology Zürich (ETH), are collaborating to build a single, integrated, end-to-end system for testing real-time EEW in California. The new system, called CISN ShakeAlert, will be capable of continuous long-term operation and rapidly provide alerts to test users across the state.

2.2 Project Status

The new ShakeAlert system combines the best aspects of the three methods from the proof-of-concept project. Caltech’s OnSite algorithm uses P-wave data from the single station nearest the epicenter to provide extremely rapid estimates of likely ground shaking. The BSL’s ElarmS algorithm and ETH’s Virtual Seismologist algorithm use data from several stations around an event epicenter to produce a slightly slower but more reliable estimate of magnitude and location. Combining these methods produces an algorithm which has the speed of a single-station method but is then promptly confirmed and adjusted by additional station data to form a more accurate description of the event. When an identified event exceeds a defined combination of magnitude threshold, ground shaking intensity and statistical likelihood, information is broadcast to system users. Currently, during the development phase, only project participants receive event information. By the fall of 2011, event information will be sent to a small group of test users outside the seismological community.

These tasks of the end-to-end system are accomplished in four primary software components (Figure 2.3). First, the Waveform Processing (WP) Module receives seismic waveforms from all early-warning capable seismic equipment in California. It identifies P-wave arrivals, and calculates the relevant P-wave parameters necessary for EEW magnitude estimation. Next, the Event Monitoring (EM) Module comprising the OnSite, Virtual Seismologist, and ElarmS algorithms recognizes events in progress and calculates event magnitude and location. It passes this information to the third component, the Decision Module (DM). The DM can receive event notifications from several systems, including the three algorithms of the EM module. It reviews events and determines whether to send warnings to users. The final component is the User Display (UD), which will be installed at an EEW user’s site. When the UD receives a warning from the DM, it sounds an alarm and generates an alert message, a map of expected ground shaking intensities, or other output, depending on the user’s settings.

The end-to-end system is now in operation. Caltech programmers developed the UD, while Berkeley programmers built the DM. The three CISN EEW partners (Caltech, BSL, ETH) are working together to jointly build a new, quicker and robust Waveform Processing Module.

2.3 Perspectives

During the coming year, the CISN EEW project members will continue to operate and improve the elements of the end-to-end system, including efforts to improve the speed and accuracy of alerts. We will recruit a group of test users outside of the seismology community and interact with them to develop improvements to the system, as well as to learn about the advantages of EEW to users and to society. Finally, results from the prototype system will flow into the CISN Testing Center (CTC) software, so that the results and output can undergo objective evaluation.

2.4 Acknowledgements

This project is supported at UC Berkeley by USGS Cooperative Agreement G09AC00259, at Caltech by Agreement G09AC00258, at USC/SCEC by Agreement G09AC00255 and at ETH Zürich by Agreement G09AC00256.
Figure 2.3: Components of the new ShakeAlert EEW System. From left to right the elements of the system are waveform processing, event detection, decision module (DM), CISN ShakeAlert user displays (UD), and the CISN testing center (CTC) software. Waveform Processing: Each data center processes telemetered digital waveform data collected from seismic stations throughout California. Critical waveform parameters are calculated from this data, then dumped into a statewide parameter pool. Event Detection: From the parameters, CISN’s EEW algorithms rapidly detect and characterize an event within seconds of its initiation. Several EEW detection algorithms run in parallel to provide the Decision Module with the best available source parameters. Decision Module: The DM combines earthquake information from each algorithm and delivers a “ShakeAlert” xml message about an earthquake in progress to subscribed users. CISN ShakeAlert User Displays: The ShakeAlert UD receives xml messages from the DM and displays their content in a simple and easily understandable way. CISN Testing Center Software: The CTC Software provides automated and interactive performance evaluations of ShakeAlert forecasts.