# CISN Earthquake Early Warning: Implementation and Testing of the Tau_c-Pd Onsite Warning Algorithm

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We have implemented a test bed for real-time testing and enhancement of the Tau_c-Pd on-site warning algorithm (Kanamori, 2005; Wu et al., 2007) for earthquake early warning (EEW) in California using the infrastructure of the California Integrated Seismic Network (CISN). The CISN is a statewide network consisting of more than 300 seismic stations equipped with both broadband and strong motion stations. We provide an overview of our implementation and some recent testing results.

The purpose of the EEW test bed is to implement a processing system that provides low latencies for the EEW and superior performance when deployed in a dense network. We attempt to fulfill these requirements by optimizing both the current algorithm and the software implementation. In particular, quick access to waveform data is key to fast waveform processing and notification.

The first implementation relied on Waveform Data Areas (WDA) and message passing software communicating results between modules. This implementation was appropriate for debugging the various processing modules although processing was not being done at optimal speed.

The second implementation of the EEW test bed processes the waveform data provided by CISN. The test bed relies on our waveform packet capturing technology and rapid processing within one large code. Often, EEW results, i.e. Tau-c and Pd values and therewith estimates on magnitude and peak ground velocity, are available within 4 to 5 seconds after the P-wave arrival at a seismic station.

The Tau_c-Pd algorithm testing has been operational in Southern California for the last 2-3 years. During this time, we have gathered important performance data. In particular, we have learned that time of delivery of waveform packets can be highly variable and may adversely affect the production and delivery time of EEW messages.

We have recently deployed our on-site algorithm testing system at two additional processing sites in northern California (UC Berkeley and USGS Menlo Park). This enables us to process earthquake data statewide using multiple computer systems, databases and notification systems.

We are working on new tools and technologies to make our EEW development system more efficient.

To provide early warning as rapidly as possible is a high priority. A field processor called SLATE will be deployed at selected stations in the CISN network to calculate algorithm parameters on-site to make the system more distributed and fault tolerant. Using this approach, we also anticipate significant performance gains in terms of latency. We are also planning on developing iPhone application for providing prototype alerts to end-users.