Earthquake early warning
Status and opportunities for massive sensing networks

Richard Allen
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The visible story

Earthquake Early Warning Summit
scientists, public and private sector, legislators and foundations

April 2011

ShakeAlert™ US early warning system using traditional sensors

White House Summit
scientists, legislators, responsible agencies and foundations

Feb 2016

MyShake Smartphone earthquake detection and warning

Public warnings in California
ShakeAlerts delivered to MyShake phones

Oct 2019

White House Summit
scientists, legislators, responsible agencies and foundations

Feb 2016

ShakeAlert™ US early warning system using traditional sensors

Public warnings in California
ShakeAlerts delivered to MyShake phones

Oct 2019
The other story

Dual-use geophysical networks and the scientific opportunities they present

2014: 575 stations
Today: 1143 stations
Planned: 1675 stations
What is earthquake early warning?

Magnitude 8 on the San Andreas
Why do we need earthquake early warning?

MyShake’s goal: Deliver earthquake alerts around the globe

Mexico City
M7.1 - September 19, 2017
Who could use earthquake early warning?

Reducing Falling hazards

Loma Prieta >50% injuries were linked to falls

if everyone received a few seconds warning

if everyone dropped, took cover, and held on

then early warning could reduce injuries by 50%

Northridge >50% injuries were non-structural (falling) hazards

Cost of injuries in Northridge: $2-3 billion

Strauss and Allen, 2016; Shoaf et al, 1998; Porter et al, 2006
Who could use earthquake early warning?

Big-box store

Photo Eduardo Miranda / Michael Rowe

M6.3 Christchurch, NZ - Feb 22, 2011
Who could use earthquake early warning?

Santiago airport terminal

Photo Eduardo Miranda

M8.8 Maule, Chile - Feb 27, 2010
Who could use earthquake early warning?

Kawasaki Concert Hall

Photo Eduardo Miranda

M9.0 Tohoku, Japan – Mar 11, 2011
Who could use earthquake early warning?

**Automated control**

- Slowing and stopping trains
- Isolating hazardous machinery and chemicals
- Data security

**Situation awareness**

- Preventing cascading failures
Elements of an Earthquake Early Warning system

Earthquake detection
Sensor network
- seismic networks
- smartphones
- internet of things

Decision maker

Alert delivery
Broadcast network
geotargeted alerts
An Earthquake Early Warning Platform

Earthquake detection
Sensor network
- seismic networks
- smartphones
- internet of things

Decision maker

Allen et al., Pure Appl. Geophys. 2020
The MyShake team

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User Experience Designer

Stephen Thompson

Steve Allen

Akie Mejia
Developer team
Realtime earthquake information around the globe

Detailed damage information reported by users

Preparedness and safety tips

Early warning delivery (ShakeAlerts in CA)

Realtime earthquake information around the globe
MyShake 2.0 release

Gov. Newsom

The New York Times

California Launches Earthquake Early Warning System It Calls Best in World

October 17, 2019
MyShake Platform
An Earthquake Early Warning Platform

Earthquake detection
Sensor network
- seismic networks
- smartphones
- internet of things

Decision maker

Alert delivery
Broadcast network
géotargeted alerts

Allen et al., Pure Appl. Geophys. 2020
MyShake 2.0
Alert delivery

In specific regions as possible depending on availability
Where do the alerts come from?

Alerts are available for use...

...by technical and industrial users

...the public in California - Oct 2019
Earthquake sequence: Magnitude vs. time

Ridgecrest sequence

M6.4 - July 4th 10:33 am local
M7.1 - July 5th, 8:19 pm local

Los Angeles ~200 km

First big test

Courtesy of Doug Given, USGS
M7.1 Ridgecrest earthquake
8:19 pm - July 5th, 2019 local
An Earthquake Early Warning Platform

Earthquake detection
Sensor network
- seismic networks
- smartphones
- internet of things

Decision maker

Alert delivery
Broadcast network
g-evented alerts

Allen et al., *Pure Appl. Geophys.* 2020
MyShake
Also turns your phone into a seismic sensor

Try it out:
Open the sensor page

-1.0g = gravity
Vertical vibration (z-axis)

Horizontal (x-axis: side-to-side)
Horizontal (y-axis: up and down on the desk)
MyShake
Crowdsource sensing

Earthquake detection and alert

Seismic waveform data

Block-by-block shaking

Response of buildings to shaking

Global event detection

Microseismicity detection and fault monitoring (network-wide recording)
Distinguishing earthquakes from other shakes on a phone

- Identify key characteristics measured from 2 second windows of data
- Neural Network trained to classify activity

93% success rate on the phone

Then send earthquake trigger into the MyShake cloud

Before
MyShake 2.0
Already a global seismic network

MyShake 1.0 downloads: 300,000
MyShake Earthquake detection

Borrego Springs

M5.2
June 10th 2016

Time(UTC) 2016-06-10 08:04:38
Time(Local) 2016-06-10 00:04:38
Triggers 1

M5.2 Borrego_Springs
Depth 12.3 km

Kong et al., SRL 2020
Alert delivery: Borrego Springs re-run using MyShake detections

Time(UTC) 2016-06-10 08:04:38
Time(Local) 2016-06-10 00:04:38
Triggers 1

M5.2 Borrego_Springs
Depth 12.3 km

Kong et al., SRL 2020
Some successes...

Detecting earthquakes and generating alerts in California, Oregon and Washington

Our earthquake models (for rapid detection) are performing well for M4 through M~7.0 earthquakes i.e. for most quakes ...but not the biggest

Delivering ShakeAlerts to the public in California Oregon & Washington expected 2021

Massive new source of seismic data from around the globe

Testing MyShake-generated alerts

Goal: provide earthquake early warning around the globe
A virtuous circle?

- block-by-block shaking
- earthquake rupture physics
- microseismicity
- fault detection
- shallow basin structure
- building response

...that we hope will grow
Where might DAS/cabled observatories fit in?

1. Earthquake detection

Lots of stations **onshore**

The biggest earthquakes are **offshore**
What’s shaking? Earthquake detection with submarine cables

Valey Kamalov
Google Global Networking

Mattia Cantono
Google Global Networking

July 16, 2020

Lots of cables…

…access?

https://submarinecablemap.com
Where might DAS/cabled observatories fit in?

1. Earthquake detection
   Few seismic sensors offshore
   The biggest earthquakes are offshore

2. Ground motion prediction
   Current alert region based on
   • Generic ground motion prediction equations
   • Estimated magnitude
   • Distance to epicenter or fault

Can DAS observations in urban areas provide better ground shaking predictions?

Either better models ahead of time, or in real-time