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Dr. Laurence Simon, PhD
Pawan K. Kamlesh
Sustainability and Innovation Program
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The Status of Japan's Earthquake Early Warning System With Comparison/ Recommendation for the Earthquake Early Warning System in California

Pawan Kamlesh

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Pawan Kamlesh
ENVR S-173
Dr. Lawrence Simon, PhD

Abstract:

In the after math of 1995 Kobe Earthquake, Japan implemented the most advanced early warning technology in the world. What can California can learn from Japan's advanced early warning system and their early warning app technology?. This paper will discuss the most seismic prone areas in the United States, the app technology relating to early warning system, and finally the recommendation for newly built early warning in California. I will illustrate many key points, specifications, and scientific terms along with providing a detailed analysis and articulating the importance of this environment- related technology. I will also specify potential challenges along with rational arguments. In conclusion, I will distinguish the core weakness and strengths of using this technology, along with proper policy-related recommendation to the government of California and the United States.

Will the West Coast have early Warning System Before or After the Next Big Quake?

Introduction: The Status of Japan's Earthquake Early Warning System and Recommendation for Earthquake Early Warning System in California

Environmental Natural disasters are inevitable. For thousands of years in our human history, we have experienced and coped with natural disasters and learned a great deal about it. In the past fifty years, many new scientific technologies have been launched to prevent all types of natural disasters.

Earthquakes and tsunami, two of the most destructive forces on earth, bring havoc and unimaginable destruction. On the other hand, safely drills, earthquake and tsunami prevention programs, and proper awareness and technology tools can save our precious lives and prevent billions of dollars in damage.

In 2011, Japan experienced one of the largest earthquakes and tsunamis in recorded human history. As we watched the horror of unprecedented calamity, the world's only and most advanced national earthquake warning system helped limit damage and loss of life. Fortunately, Japan was prepared to minimize the destruction due to the government law; many Japanese institutions are required to install the early earthquake warning system. Cell phone providers are required and equipped with earthquake, tsunami and other natural disaster warning system.

The Japanese earthquake warning system automatically issued alerts via television and cell phones shortly after the first, less harmful, shockwave was detected. This priceless technology gave millions of people enough time to prepare for the much stronger shock wave that followed. It also caused many energy, industrial, hazardous oil pipelines, gas utilities and transportation services e.g. high speed bullet trains, to shut down automatically.

Unfortunately, the United States is not fully equipped to handle any large mega thrust earthquakes. Here, especially in the west coast of United States, except for California (as recently as August, 2018) we don't have any such law or mandate to require the city or states to install these life saving devices.

My research paper will discuss how Japan implemented early warning technology and address what California can learn from Japan's advanced early warning system. I will discuss the most seismic prone areas in the United States, the app technology relating to early warning system, and finally recommendations for how to newly build an early warning system in California. I will also specify potential challenges of implementing this system in California. In conclusion, I will distinguish the core weakness and strength of using this technology along with proper policy related recommendation to the government of California and the United States.

Literature Review

One of the best guides to preparing for earthquakes was the United States Geological Survey's *Bay Area Earthquake Guide* (2011). The book provides seven steps to earthquake safety, explains why we should prepare for the next quake and provides simple geological explanations of plate motions and fault lines, and predicts the probability of future earthquakes in California, and describes the damaging effects of earthquakes. Another detailed analysis on the *feasibility study for earthquake early warning system* was created by ATIS (2015). It evaluates the feasibility of the commercial cellular networks in supporting public earthquake notifications as part of the proposed California Earthquake Early Warning System. Although this feasibility study was initially targeted to California, it is applicable to other earthquake warning systems that maybe deployed anywhere in the United States. The study clearly states that it will take minimum of 4 years to complete standards and fully deploy early warning wireless networks in California (by 2019) and it will take at least 7 years from the date of this report, before a substantial number of cellular users will have earthquake early warning alert app capabilities in their devices. Using the approach of normal market driven cell phone replacement cycles for providing the penetration of earthquake early warning app capable cell phones among consumers, it is estimated it will take an additional 2-3 years for early warning app capable cell phones to represent 80% or more of all cell phones in the state of California.

Another great resource was United States Geological Survey's *ShakeAlert* (2017) and *California's Integrated Seismic Network* (2017) website. It gave a detailed survey, R &D, challenges, solutions and implementation of early warning system technology in the state of California . *California Earthquake Early Warning System Benefit Study* by Johnson, Rabinovici, Kang and Mahin for California Governor's Office of Emergency Services was an excellent benefit study to read for the environmental policy related matters. The research focused on ground motion, structural and geotechnical engineering, transportation, risk management, resilience and public policy. *Fujiwara & Noda* (2013) gave an excellent analysis on how earthquake early warning system app's education and efforts among citizens led 90% of people to take advance actions to save their own and others lives. This high rate of effectiveness was assured to be the result of education regarding the early warning system.

Earthquakes in the United States: The seismic prone west coast

According to geologists from prominent universities and the United States Geological Survey (USGS), a very large mega thrust earthquake on the west coast of the United States is likely (USGS 2018). The puzzling question is when and where. For example, one of the largest faults called "San Andres Fault" crosses California. Large cities Los Angeles, San Francisco, San Jose, Santa Barbara, and San Diego lie on the epicenter or the vicinity of this huge fault line. Without an excellent quality early warning system, as we have recently seen in Japan, the disaster would be unprecedented. According to The Federal Emergency Management Agency (FEMA) report, 84% of the average annual earthquake loss is located on the West Coast of the United States, with 74% concentrated in California alone (FEMA, 2018). With this in mind, the population of California, Oregon, Washington, Alaska and Nevada are acutely aware of the potential unprecedented future disaster and its outcome.

In California, seven fault lines are concentrated around the western part of the state, with twenty six counties are at very high risk. Within These 26 counties represent California's largest cities and more than 80 percent of the state's populations (FEMA, 2018).

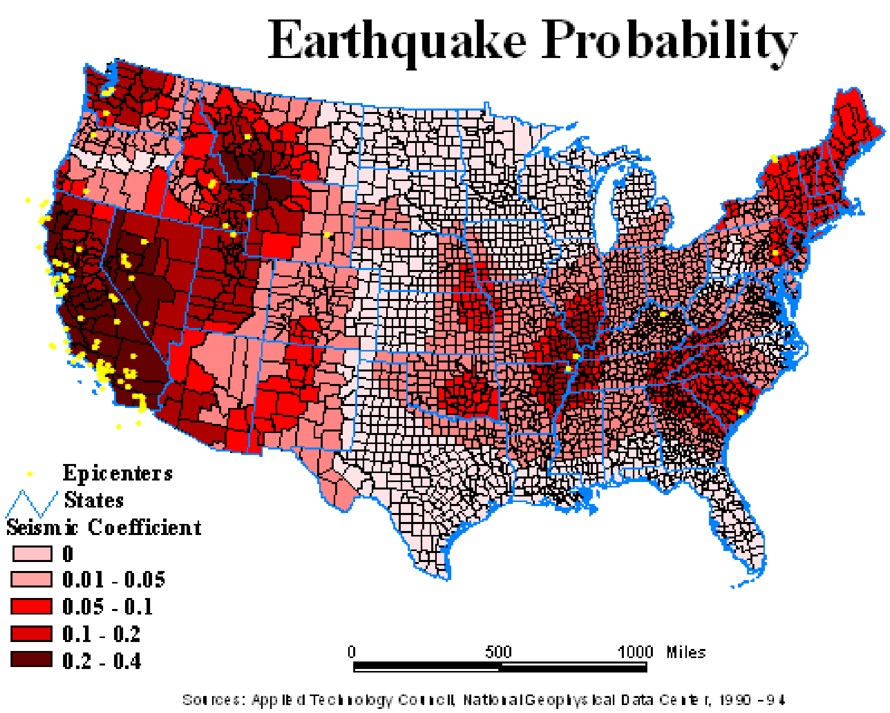
According to the USGS (United States Geological Survey) report released on April 14, 2008, California has a 99% chance of experiencing a magnitude 6.7 or larger earthquake in the next 30 years (USGS, 2014). If this occurs, California alone would experience damages that could amount to billions of dollars, both on the state and federal levels as well as for private enterprises.

USGS also indicated a higher estimate for catastrophic magnitude 9 earthquakes occurring along the Cascadia subduction zone. The Cascadia subduction zone fault ruptures, on average, every 500 years, and has the potential to generate destructive earthquakes and tsunami along the coasts of Washington, Oregon and northern California (USGS, 2018).

The earthquakes in the United States: Other unknown states

The perception that California or the west coast is the only areas in the United States predicted to have a major earthquake in the near future is not correct. What is shocking is that FEMA has recognized 39 States as having a significant earthquake risk. According to FEMA, 75 million people (one fourth of the U.S. population) face some earthquake risk.

Earthquake hazards are greatest in the western United States, particularly California, but also Alaska, Washington, Oregon and Hawaii. Earthquake hazards are also prominent in the Rocky Mountain region and the new Madrid seismic zone (a portion of the central United states), as well as portions of the east coast, particularly South Carolina (FEMA, 2018).



All 50 states and the District of Columbia are vulnerable to earthquake hazards, although risks vary greatly across the country. Alaska is the most earthquake-prone state, experiencing a magnitude 7 earthquake almost every year and a magnitude 8 earthquake every 14 years on average. Because of its low population and infrastructure density, Alaska has a relatively low risk for large economic losses due to an earthquake. In contrast, California has more citizens and infrastructures at risk than any other state because of its frequent seismic activity combined with its very high population (FEMA, 2018).

Four Risk Categories

The fifty states along with the District of Columbia are divided in to four risk categories: Significant, higher, medium and low risk states.

Significant risk states are Alaska, California, Washington State, Oregon, Hawaii, Nevada, Missouri, Arkansas, Kentucky, Tennessee, Illinois, South Carolina, Utah, Wyoming, Montana and Idaho.

Higher risk states are Colorado, Arizona, New Mexico, Oklahoma, Mississippi, Indiana, North Carolina, New York State, Vermont, New Hampshire, Maine, New Jersey, Georgia, Alabama and Texas.

Medium risk states are Massachusetts, Connecticut, Rhode Island, Delaware, Pennsylvania, Virginia, Ohio, South Dakota, West Virginia and District of Columbia.

Low risk states are Minnesota, North Dakota, Kansas, Nebraska, Iowa, Michigan, Wisconsin, Florida, Louisiana and Maryland.

New West Coast Integrated Earthquake protection Network and its implications

Japan launched nationwide public warning system on October 2007. Japan has two hundred early warning stations and 800 High network stations (JMA, 2013). Immediate steps are required to deliver an early warning system in California and the rest of the United States. As of August 2018, more than 850 earthquake sensing stations in California are online, but about additional 800 warning system stations are needed (Lin, 2018).

It would cost about $ 118 million over five years. University of California at Berkeley estimates that Pacific Northwest system would cost approximately $ $170 Million (UCB, 2018).

Role of Earthquake Early Warning App in a Deadly Environmental Disaster (Policy Considerations)

The early warning earthquake mobile app would be a life saver. The early warning earthquake app can play a vital role in protecting the citizens, and in protecting institutions, industrial and transportation services. The Japanese App/ system saved my own life and not to say countless millions, back in Japan when I experienced hundreds of + 5 earthquakes/ aftershocks after the major one on March 11th, 2011. The Early Warning Earthquake Mobile App is not only a very important product but it's a necessity for the survival of citizens in earthquake areas. Modern science has made great strives toward understanding and finding the solutions to earthquakes. Life is very precious for all of us. We all desire to be happy and peaceful. Sadly, sometimes our happiness and peace can be taken away, if we don't prepare ourselves earlier from disasters. If we have a choice, then it is more logical and in reality makes sense to prepare ourselves for it so that we can save our lives and those of our loved ones.

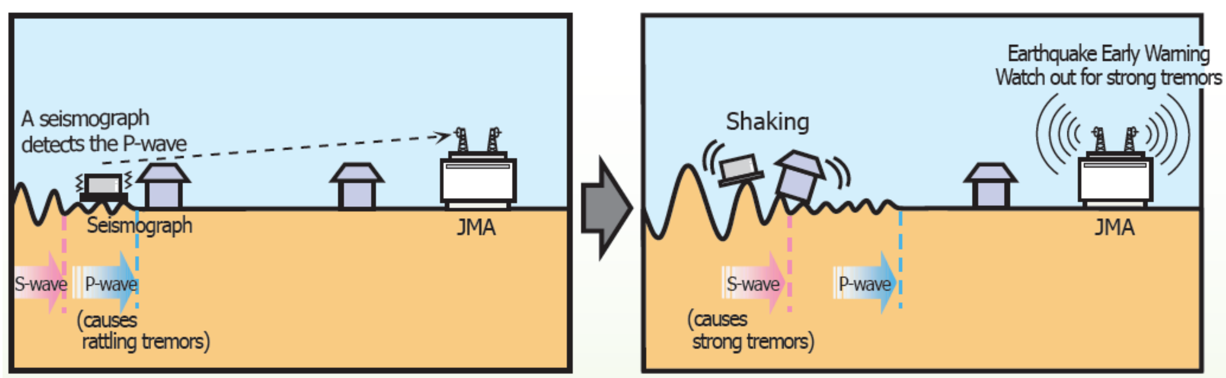
Having this great app not only will give citizens peace of mind, particularly in earthquake threatened areas. A personal Earthquake App would be a an easy-to-use high technology device that could be installed in any smart phone. It is that simple but highly valuable. It would monitor all the seismic waves (earthquake wave) with accuracy and high

Precision.

Future High End Technology For The App

All earthquakes produce a series of different types of shock waves, which travel at different speeds and carry different amounts of energy. The fastest shock waves, and the first to arrive, are called P waves. The next shock waves to arrive are called S waves. The final two waves to arrive are called Love or L waves and Rayleigh or R waves. These final two waves cause most of the damage.

Since the P waves arrive first, they provide advance notice of heavy shaking to follow. The early warning earthquake mobile app would follow and detect these first waves and give ample time warnings through cell phones, even personal computers and other media devices. The system would also give warning through very loud sirens and strong blinking red light.



C. Japan Meteorological Agency

With this in mind, The Japanese early warning earthquake app is unique. It provides an automated, programmable response through alerts and alarms that would warn populations in time to prevent human injury, loss of life and property damage.

The early warning earthquake mobile app is reliable. This app produces no false alarms. This app has multiple sensors and DSP (digital signal processing) algorithms to carefully and precisely deduct the P waves and seismological vibrations in case of an earthquake. This system is accurate only in the event of an earthquake that measures 5.0 on the Richter scale or higher. Depending on the geological terrain and the distance from the epicenter, a warning up to 60 seconds or more is possible.

Solutions (Policy Considerations)

The Japanese early warning earthquake mobile app system's extraordinary technology would send its emergency warning and automatic response system warning that would result in the following:

Emergency areas:

- Waking fire fighters and support personnel by triggering audible and red light alarms.
- Saves fire fighters lives.

Schools and educational facilities:

- Protects children and teachers.
- Turns on loud audible and red light alarms.
- For school children, plays programmable audio reminders to "duck and cover" beneath their desks.
- The App will announce "duck and cover" in two different languages. Japanese and English.
- Turns on automatic emergency light for protection and safety.

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Medical facilities:

- Promptly alerts ER's, ICUs and other surgical units so surgeons, physicians and other medical personnel can prevent surgical accidents.

Water and Gas Utilities:.

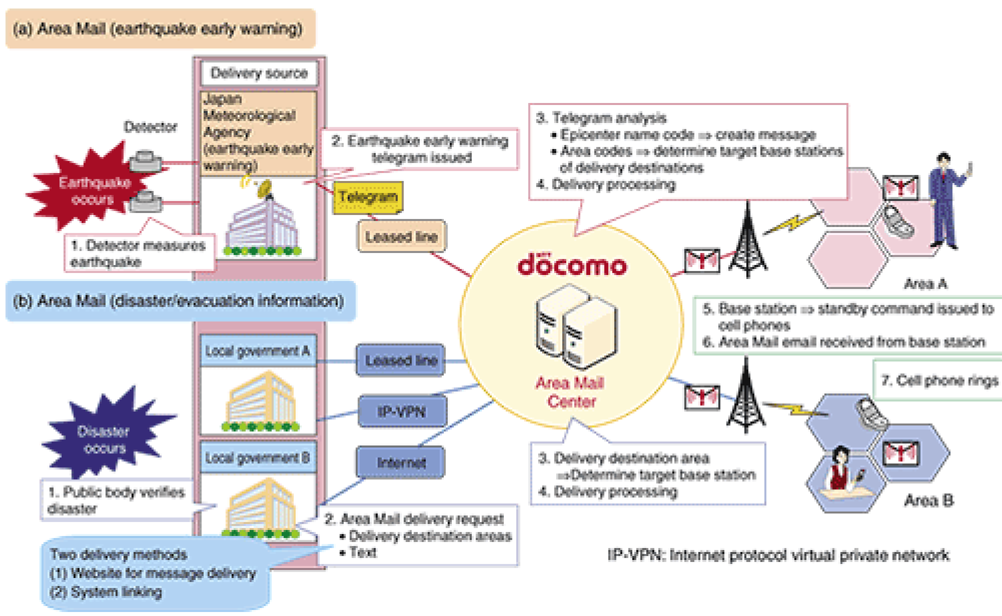
- Provides safety for other risks: fires, terrorism, intruders and other threats.

Transportation system

- At train and bus stations, provides audible and red light alarms.

- At airports, if downloaded at the control tower, it notifies control towers to warn pilots to not take off or land.

I had this technology in my Japanese mobile phone and found out that it is pre installed and is required by the government of Japan. We MUST implement this technology in all the phones in California.



C. Nippon Telecommunications, DOCOMO, Tokyo

Situation in California

The West Coast's earthquake early warning system known as "Shake Alert" is in the testing stage, although California plans a " limited public roll out" in late 2018 or early 2019 .The earthquake early-warning system is under development by the U.S. Geological Survey and is ONLY available to a limited array of testers. Depending on the location of a tremor, the earthquake warning time can range from seconds to minutes. USGS Scientist estimate that the public in Los Angeles could get about a minute warning if a major earthquake were to occur along with of the 800-mile California's

San Andreas Fault. Similarly, if the earthquake starts in the northern end of the fault, San Francisco Bay area would get about a minute's time of warning. If the earthquake occurs near the city, that means there would be less warning time (Allen, 2017).

The biggest challenge for late rollout is limited federal funding. President Donald Trump didn't provide funding for the earthquake early warning system in his 2018 budget proposal. In May of last year, the Trump Administration submitted a fiscal 2018 budget request that targeted the USGS with cuts. And it didn't include $ 10.2 million, the amount provided by Congress in fiscal 2017, to support development of the agency's early warning system.(Daniels, 2017) But last year in 2017, the house agreed to restore funding for an earthquake early warning system as part of a package of spending measures. It got a significant boost in the federal budget signed into law in March, 2018, defying an earlier proposal by President Trump to end federal funding for the program. As part of the $ 1.3 trillion budget bill approved by the Congress and signed by Trump, officials approved $ 22.9 million for the project. This is more than double the $ 10.2 million it got in the previous year's budget (Lin, 2018).

As I stated earlier, it would cost up to $ 110 million over five years plan. The USGS estimates that building a full system covering the West Coast will cost at least $ 38 million, with about $ 16.1 million annually to operate and maintain it (Lin, 2018). Funding for the earthquake early warning system has come from the federal government and the state of California, as well as other private sources. The federal government has spent more than $ 23 million already to improve "Shake Alert".

Will the West Coast have early Warning System Before or After the Next Big Quake?

It is interesting yet very sad to note that most countries build their early warning system after a devastating earthquake. Japan invested $ 600 million in such a advanced system after the 1995 Kobe earthquake which killed 6,400 people and injured hundreds of thousands. By 2007, Japan's system allowed every citizen to receive advance alert through their mobile app from the Japan Meteorological Agency. Thanks to this system, no trains derailed in the 2011 magnitude 9.1 Great Tohoku earthquake, and according to a government poll in Japan, 90 percent of the citizens think that the early warning app saved their life and the system is worth the investment (Fujiwara and Noda, 2013). Taiwan had built their warning system after the 1999 earthquake which killed 2,415 people and Turkey build their system after the 1999 Izmit earthquake killed 17,127 people. Our neighbor Mexico got serious building their early warning system only after the 1985 Mexico City earthquake killing 10,153 (USGS, 2018). So the question arises, will we be more serious after the next serious earthquake? I truly want to believe that we take faster action before any serious calamity happens.

Studies find that as an individual you can use a few seconds to move to a safe location: under a sturdy table, away from falling hazards like bookcases, ceiling lights and fans.One should run away from the weak structured building. In the 1994 Northridge earthquake more than 50 % of injuries were due to non-structural (falling) hazards.

The total estimated cost of just injuries in the not-so-large Northridge earthquake was $ 3 billion. If everyone took cover before shaking, those losses could be halved (Cal Berkeley Lab, 2017)

According to Richard Allen, director of University of California-Berkeley Seismological Laboratory "We're really behind here in the U.S. Mexico's warning System. Mexico's early warning system was installed in the 1990's and Japan has been running their system since 2007".

What is more alarming is that The California Governor's Office of Emergency Services, along with state legislation, felt the anticipated value of early warning system as late as 2013 and passed the bill in 2015 to develop early warning technology (CalOES, 2013).

Since the technology is under development, a few policy recommendations must be implemented:

1. Establish USGS as an "alert authority".
2. Develop a Smartphone app to receive early warning message on multiple platform (g. e-mail, SMS, voice call app, alarm system). This may be accomplished in cooperation with commercial developers.
3. Other technologies like Internet, Radio Broadcast Data System must be used as an platform
4. Private emergency alert systems (eg. Google Public Alerts) must work together for better result.
5. There should be public- private partnership to develop advanced app/ early warning system.
6. Existing cellular towers could be used to send alerts to smart phones.
7. For R&D, enhance performance in terms of speed, precision and accuracy similar to Japanese early warning system.

Challenges

There are challenges to a full public rollout, such as the ability to link up with people's mobile phones in a way that doesn't compromise the system. An extensive amount of data has to go through at one time in order to deliver this alert. But a solution is also on the way. The state of California is working with cell communication providers and the mobile phone developers to overcome the technology hurdle (Daniels, 2018).

Present Development

In California, facilities including airports, oil refineries, pipelines, schools, universities, city halls and libraries are already testing or planning to test the system. Hospitals in California are testing auditable notifications broadcasting from fire alarm equipment.

The only way for California and the United States to prepare for the next catastrophic earthquake is through greater collaboration and commitment. As we have seen, that commitment tends to be vague and collaboration weak and slow. Government policies towards early warning system (both from democrats and republicans) are not of priority. The cause of this problem lies in the lack of early warning system education for government officials leading to limited adoption and funding. Restructuring the contributions of all levels of government, including the private sector, will optimize the disaster governance and policy requirements. Another problem is our psychological assumption that another disaster will not occur for certain time being. This "cognitive dissonance" has to change our mindset through education, strategy, proper planning and implementation to mitigate the calamity and save millions of lives. With adequate funding and proper strategic vision together with deadline dates for completion of all required seismic networks, we can overcome the next disaster with resiliency and collaboration.

Conclusion

A bold statement of USGS (the United States Geological Survey) Director and distinguished scientist Marcia McNutt to House Appropriations Committee summarizes the treat earthquakes pose to our species and environment.

"*Japan was hit by a tragic and devastating 9.0 earthquakes and tsunami, and shame on us if we do not learn from their misfortune. Japan is the most advanced nation in terms of seismic hazard, and their earthquake early warning system saved thousands of lives.*"

We urgently need a systematic network of early warning systems across the United States, at least in the western part of the U.S.The early warning earthquake mobile app and system can provide its technology to fill the gap and protect the citizens. I strongly urge the policy makers, institutions and the consumers to innovate, produce, and install this life-saving product on their mobile phones along with creating new environmental and sustainable policies to mitigate the forthcoming disaster.

This research proposal is dedicated to all the people who lost their lives at the 2011 Japan Earthquake and Tsunami, 2010 Haiti Earthquake, 2015 Nepal/ India Earthquake as well as any other disaster.

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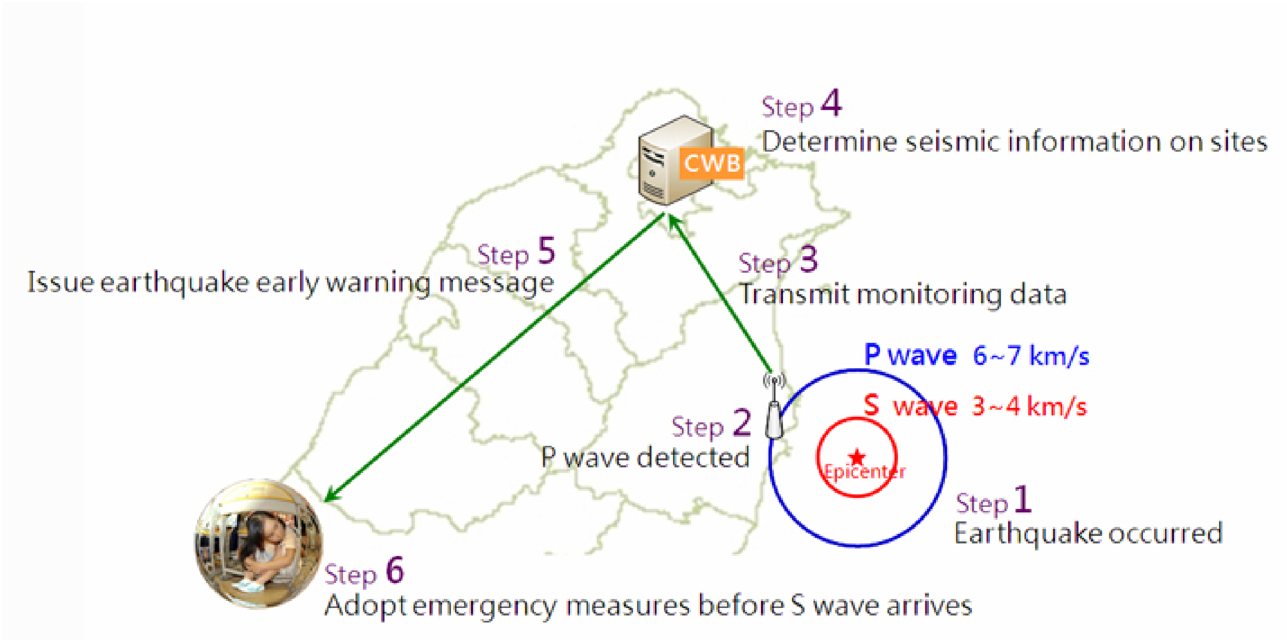

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