

# Early Earthquake and Tsunami Warning Viewer

Yicheng Shao (Eason)


September 14, 2024


## **Abstract**

Give a brief summary outline of your project.

©2024–2025 Yicheng Shao (Eason).

This work is licensed under a CC BY-NC-ND 4.0 license.

This work is formatted using Xe<sub>La</sub>TeX. The source code is available at  EasonSYC/nea-report.

The relevant program source code is available at  EasonSYC/EEETWV, licensed under the MIT License.

## Contents

<b>1</b>	<b>Analysis</b>	<b>4</b>
1.1	Background Information . . . . .	4
1.1.1	The Early Earthquake Warning System . . . . .	4
1.1.2	Earthquake Terminology . . . . .	4
1.2	Problem Area . . . . .	5
1.3	Client and End User . . . . .	5
1.4	Research Methodology . . . . .	5
1.4.1	Client Interview . . . . .	5
1.4.2	Existing Applications and Solutions . . . . .	6
1.5	Features of proposed solution . . . . .	8
1.6	Requirements Specification . . . . .	9
1.7	Critical Path . . . . .	10
<b>2</b>	<b>Design</b>	<b>11</b>
2.1	Hierarchy Chart . . . . .	11
2.2	Data Structures/Data modelling . . . . .	11
2.2.1	External Data Sources . . . . .	11
2.2.2	OOP Model . . . . .	11
2.3	User Interface . . . . .	11
2.4	Hardware Software Requirements . . . . .	12
<b>3</b>	<b>Technical Implementation</b>	<b>13</b>
3.1	Key Code Segments . . . . .	13
3.1.1	Data structures . . . . .	13
3.1.2	Modularity . . . . .	13
3.1.3	Defensive Programming/Robustness . . . . .	13
<b>4</b>	<b>Testing</b>	<b>14</b>
4.1	Test Strategy . . . . .	14
4.2	Testing Video . . . . .	14
4.3	System Tests (against original requirements specification) . . . . .	14
<b>5</b>	<b>Evaluation</b>	<b>15</b>
5.1	Requirements Specification Evaluation . . . . .	15
5.2	Independent End-User Feedback . . . . .	15
5.3	Improvements . . . . .	15
<b>6</b>	<b>Code Listing</b>	<b>17</b>

# 1 Analysis

## 1.1 Background Information

### 1.1.1 The Early Earthquake Warning System

Earthquake is one of the most common natural disasters in the whole world, and direct consequences of earthquakes include tsunamies which could be catastrophic.

Japan, sitting on the intersection of the Eurasian, the Philippine and the North-American plates, is the countries with most earthquakes. Historically, the Great Kantō Earthquake in 1923, the Great East Japan Earthquake in 2011 (a.k.a. the Tōhoku Earthquake) and the recent 2024 Noto Peninsula Earthquake all caused hundreds of deaths, both due to the result of the earthquake(s) and the resulting tsunami.

To provide protection to its residents, the Japan Meteorological Agency (JMA), together with the National Research Institute for Earth Science and Disaster Resilience (NIED) placed thousands of **earthquake sensors** across Japan (the Hi-net), with several lying deep in the sea bed, measuring displacement, velocity and acceleration, which are connected to multiple servers, including two located in Ōsaka and Tōkyo.

Using data obtained from the sensors, computers do some complicated algorithms (mentioned below) to send out **early earthquake warnings (EEWs)** automatically within milliseconds. There are two types of EEWs:

1. **EEW (Forecast)**. Sent out to **highly-dependent industries** (e.g. rail industry, power plants) and **subscribed users**, when maximum intensity level of more than 3, or a magnitude of more than 3.5 is expected.
2. **EEW (Warning)**. Sent out to **everyone** via TV, Radio, Mobile Phone, SMS, etc., when a maximum intensity level of more than 4 is expected.

After the earthquake, JMA staff will determine the location and severity of tsunami warnings to be issued, if necessary.

### 1.1.2 Earthquake Terminology

- **Intensity**. The intensity describes the intensity vibration of a point due to an earthquake. It is not unique to an earthquake - **different places can have different intensities** due to the distance to the epicenter, and intensity will also change over time. JMA measures intensity using **9 levels: 1, 2, 3, 4, 5-, 5+, 6-, 6+ and 7** in increasing order.
- **Magnitude/Scale**. The magnitude of an earthquake describes the energy released in the earthquake in a logarithmic scale. **It is unique to an earthquake.**
- **Epicenter/Hypocenter**. The epicenter is the surface point directly above the true centre of the earthquake.
- **Focal Depth**. The focal depth is the depth of the true center of the earthquake.
- **P-Wave and S-Wave**. These are seismic waves, sourced from the true center of the earthquake, travelling at different speeds, with Primary (P)-Wave travelling faster and Secondary (S)-Wave travelling slower.

## 1.2 Problem Area

The main goal of this application is to provide a visualisation of the earthquake/tsunami related data feed(s) provided by JMA's affiliated institution, Disaster Mitigation Data Send Service (DM-D.S.S). There are numerous separate apps providing a list of recent earthquakes, the real-time data measured by the sensors, and the real time earthquake warning displayed on a map, but rarely are there good apps that combine all those features together in a satisfying way, with just the necessary features the author needs.

Some applications are no longer being updated due to change in the user's policy of the related data feed. Furthermore, most of the apps available are only in Japanese, not in English or my home language Chinese, which can create trouble for the author to understand.

## 1.3 Client and End User

The primary target of this application will be passionate geographers and geologists who are interested in the study of earthquake observations and predictions. The age group of this vary all the way from primary-school students to adults, including the author who has been amazed by the technology since the age of 12. They could take any employment, ranging from students to full-time jobs. Their proficiency usually varies, since there are people new to this field who probably does not have much knowledge, so the interface of the application should be relatively user-friendly and understandable, hiding unnecessary technical complexities.

Another target client could be industries which highly rely on earthquake predictions due to the risk imposed by earthquakes. High-speed railway and nuclear power plants are good examples of this. Therefore, the staff in charge monitoring will usually have higher proficiency and would like more detailed data of the earthquake. However, they will only need the necessary data from earthquakes happening close to them and only require intensity data of the point in interest (e.g. the power plant). To put this into content, an earthquake happening 1000km away from them does not need to be fed into their system, while they would like to see the intensity of the shock and the arrival time of the seismic waves to decide the actions.

Table 1 compares relative features of these two target users/clients.

Feature	Primary Target	Secondary Target
Description	Passionate Geologists	Earthquake-Sensitive Industries
Age	Varies (Middle School – Adults)	Work Age
Reason	Monitor Live Latest Earthquakes	Monitor Risks to Infrastructure
Proficiency	Varies (Beginner – Amateur)	Trained Professional
General Requirements	Monitor Overall Movement	Alert about intensity and arrival time at specific points

Table 1: Comparison of target users and clients

## 1.4 Research Methodology

### 1.4.1 Client Interview

The author interviewed my friend Wesley Ma, who is a passionate geologist on earthquake studies and also monitor earthquakes regularly.

1. Which earthquake monitoring apps do you use?

2. Do you subscribe/pay to services such as DM-D.S.S. to use earthquake monitoring apps, and do you think it is worth the price?
3. Do you watch YouTube livestreams on earthquake monitoring?
4. Why do you use earthquake monitoring apps?
5. How often do you use earthquake monitoring apps (e.g. all the time/after school/only after big earthquakes)?
6. Describe the advantages and disadvantages of each of them, mentioning the specific features.
7. What features do you use the most/least?
8. What features are redundant in the earthquake monitoring apps you use?
9. What are the critical features of an earthquake monitoring app?
10. What additional features would you like to have in those existing apps?

TODO: Client Interview

#### 1.4.2 Existing Applications and Solutions

Based on the applications the author uses and the feedback from interviewee, there are the following commonly-used applications:

- JQuake <https://jquake.net>
- Scratch Realtime Earthquake Viewer (SREV)  
<https://kotoho7.github.io/scratch-realtime-earthquake-viewer-page/>
- Kyoshin EEW Viewer for ingen (KEV) <https://svs.ingen084.net/kyoshineewviewer/>
- Quarog <https://fuku1213.github.io/quarog-site/>

Supported platforms of those apps are listed in Table 2. In particular, note that SREV is a web-based and GitHub Pages-hosted application therefore supporting all platforms. KEV is written in .NET Framework and supports the second most platforms, with JQuake not supporting Linux and Quarog only supporting Windows.

Platform	JQuake	SREV	KEV	Quarog
Windows	✓	✓	✓	✓
macOS	✓	✓	✓	
Linux		✓	✓	
Android/iOS		✓		

Table 2: Supported platforms of existing solutions

An overview feature table of monitoring is analysed in Table 3. In particular, note that due to the nature of SREV being Scratch-programmed and web-based, it reached a special agreement with DM-D.S.S. to use the API without the need of all users paying for this, since it is hard to integrate such function into a web application.

Quarog is a relatively new application and only supports basic functionalities of EEW Viewing and past earthquake listing, as shown in Figure 2. JQuake is solely dedicated to earthquake and tsunami monitoring as shown in Figure 1, while KREV has features like rain clouds map and natural disaster warning which is beyond the scope of this analysis (which is a burden to users only requiring earthquake monitoring and a waste of storage space).

Feature	JQuake	SREV	KEV	Quarog
DM-D.S.S. Websocket Support	✓	✓ <sup>1</sup>	✓	✓
Real-time Sensor Data	✓	✓	✓	
Vibration Alert	✓	✓	✓	
Past Earthquake List	✓	✓	✓	✓
Past Earthquake Details		✓	✓	✓
Tsunami Warning	✓ <sup>2</sup>	✓	✓	
Realtime EEW	✓	✓	✓	✓
Calculated Seismic Wavefronts	✓	✓	✓	✓
User-Defined Key Monitor Point	✓		✓	
Sub-Map for the Okinawa Area	✓		✓	
Replay	✓		✓	

Table 3: Feature comparison in monitoring of existing solutions

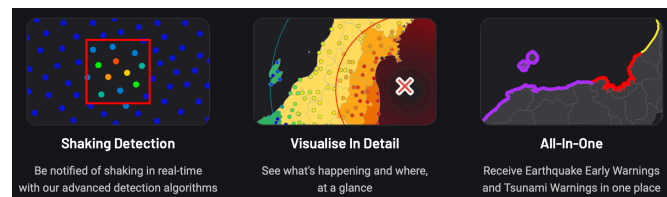


Figure 1: Feature introduction of JQuake, screenshot from website.

There are also a variety of configuration options available for all apps, as listed in Table 4. Both KEV and Quarog supports the adjustment of the colour theme, and Quarog even supports changing the style of how blocks are displayed and coloured as shown in Figure 3 and 4. Playing a sound on the speaker is also common among the apps to remind the user of earthquakes.

Feature	JQuake	SREV	KEV	Quarog
DM-D.S.S. Login	✓	<sup>3</sup>	✓	✓
Sound Alert	✓	✓	✓	✓
System Notification			✓	
Colour Theme			✓	✓
Map Colouring Style		✓		✓

Table 4: Feature comparison in configuration and customisability of existing solutions

<sup>1</sup>Integrated with no-login required.

<sup>2</sup>Tsunami forecast not available.

<sup>3</sup>Already integrated with special permission.



Figure 2: Feature introduction of Quarog, screenshot from website. Top-left: Past earthquake information; Top-right: Real-time EEW; Bottom-Left: Past earthquake list; Bottom-Right: Details of EEW.

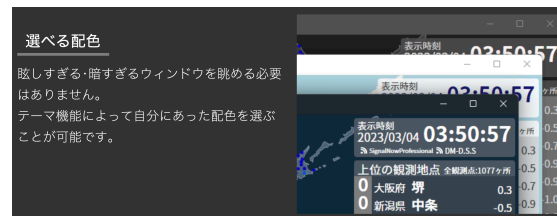


Figure 3: Customisable colour scheme of KREV, screenshot from website.

## 1.5 Features of proposed solution

Based on the potential user/client interview results, and the research into the existing solutions, the following key features should appear in the solution, since they are essential to earthquake monitoring applications:

1. DM-D.S.S. Login functionality (for the data source)
2. Real-Time Sensor Shake Intensity Data (w/ vibration alert)
3. EEW Visualisation (w/ Calculated Seismic Wavefronts)





Figure 4: Customisability of Quarog, screenshot from website.

4. Past Earthquake List (w/ Option to review details)
5. Tsunami Warning Visualisation (w/ Related Sounds)

However, due to the limitation of time and the difficulty of implementation, the following functionalities are not the key to implementation, which include mostly the customisation parts, ranked in decreasing importance:

1. User-Defined Key Monitor Point
2. Customisable Sound Alert
3. Customisable Colour Theme
4. Customisable Map Colouring Style

The following features might not be available due to the time constraints and the complexity behind such system:

1. Replay (due to a server needing to store past data)
2. Sub-Map for the Okinawa Area (due to the difficulty in implementatino)
3. Map Zooming Feature (due to the complexity in the map colouring functionality)

With those key features implemented, the application should mirror all essential functionalities of a earthquake monitoring application, as compared to the four existing solutions above.

## 1.6 Requirements Specification

The requirements specification is a document/contract with the client that outlines what you will deliver. The contents need to have SMART (specific, measurable, achievable, realistic, timely) goals.

After your system has been completed you will need to test against this.

Requirement №	Description	Success Criteria	Measurement Method

Table 5: Table of Requirements.

## 1.7 Critical Path

Order of development for the tasks that will need to be completed. This may reflect an iterative approach to software development. Software development will be undertaken using an *agile* methodology as opposed to a *waterfall* model of software development. It is expected that development will go through a number of iterations that will add increasing functionality to the system.



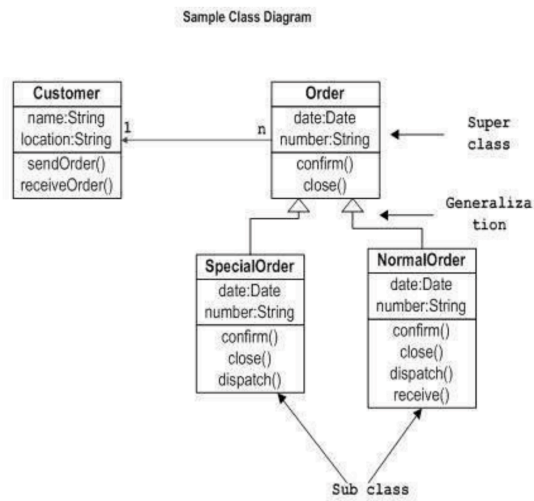


Figure 6: Class Diagram.

## 2.4 Hardware Software Requirements

Draw up a hardware and software specification for items that are required.

## **3 Technical Implementation**

### **3.1 Key Code Segments**

#### **3.1.1 Data structures**

Implementation of ADTs and OOP Classes to be demonstrated.

#### **3.1.2 Modularity**

Code should be created and tested in separate modules that are integrated later. Use sub-headings for each module, define the purpose of the module, and show unit testing of the module.

#### **3.1.3 Defensive Programming/Robustness**

Exception handling

## 4 Testing

Consider how you will test your project. You should devise a test strategy that encompasses a range of methods.

### 4.1 Test Strategy

- Unit testing (of individual functions)
- Integration testing (e.g. different modules/class files)
- Robustness (demonstrating defensive programming skills/exception handling)
- Requirements testing (against your initial requirements - a table with test number, description, test data, expected result, evidence (screenshot/video time link) would be suitable)
- Independent end user beta testing (this will assist with your evaluation)

### 4.2 Testing Video

- You can include a video to assist (but you will need to reference the timepoint at which relevant evidence appears)
- If you include a video you will need to have it publicly available.
- It is suggested that you include a QR code in your testing to give a link to it the video (for the moderator) rather than just giving a long URL on its own.

### 4.3 System Tests (against original requirements specification)

You need to give evidence in support of requirements that have been met e.g. reference to a relevant test/screenshot/relevant code.

Requirement №	Description	Success Criteria	Tests + Evidence

Table 6: Table of Tests.

## 5 Evaluation

### 5.1 Requirements Specification Evaluation

Personal evaluation

- Copy and paste your original requirements from your project analysis
- You need to review each requirement and comment objectively on whether it was *fully met/partially met/not met*.

Requirement №	Description	Success Criteria	Fully/Partial/Not met (Reflective Comment)

Table 7: Table of Evaluation.

### 5.2 Independent End-User Feedback

End user/client evaluation

- there **must** be meaningful end user feedback
- You should hold a review meeting with your end user
- Write down any key feedback that they give you. E.g. Agreement that a particular requirement has been met/comments as to aspects that they find sub-optimal/comments as to additions they would like to see

Requirement №	Description	Acceptance Y/N	Additional Comments

Table 8: Table of Feedback.

### 5.3 Improvements

You need to give consideration to a number of potential future improvements that could be made. They may arise from either your experience or from feedback given to you by your end user. Ideally at least one should be in response to end user feedback.

- Write a paragraph for each potential improvement/change
- The improvements/changes could result from additional functionality that has been identified as being beneficial or could be as a result of required efficiencies if some processes are clunky or require faster run-times

- You should then comment on how the proposed change could be implemented moving forward. i.e. what would need to be changed/developed and how? You are not expected to actually make any changes; just comment on the possibilities.



## 6 Code Listing

List of Tables

1	Comparison of target users and clients . . . . .	5
2	Supported platforms of exsisting solutions . . . . .	6
3	Feature comparison in monitoring of existing solutions . . . . .	7
4	Feature comparison in configuration and customisability of existing solutions . . . . .	7
5	Table of Requirements. . . . .	10
6	Table of Tests. . . . .	14
7	Table of Evaluation. . . . .	15
8	Table of Feedback. . . . .	15

List of Figures

1	Feature introduction of JQuake . . . . .	7
2	Feature introduction of Quarog . . . . .	8
3	Customisable colour scheme of KREV . . . . .	8
4	Customisablity of Quarog . . . . .	9
5	Hierarchy Chart. . . . .	11
6	Class Diagram. . . . .	12