Early Earthquake and Tsunami Warning Viewer

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Abstract

Give a brief summary outline of your project.

Contents

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 catastrauphic.

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 Meterological 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 visuallisation of the earthquake/tsunami related data feed(s) provided by JMA's affliated institution, Disaster Migitation Data Send Service (DM-D.S.S). There are numerous seperate 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 avaliable 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 obserations 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 applciation should be relatively user-friendly and understandable, hiding unnessary 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?

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 exsisting solutions

An overview feature table of monitoring is analysied 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

Feature	JQuake	SREV	KEV	Quarog
DM-D.S.S. Websocket Support	✓	✓[1]	✓	✓
Real-time Sensor Data	✓	✓	✓	
Vibration Alert	✓	✓	✓	
Past Earthquake List	✓	✓	✓	✓
Tsunami Warning	✓[2]	✓	✓	
Realtime EEW	✓	✓	✓	✓
Calculated Seismic Wavefronts	✓	✓	✓	✓
Replay	✓		✓	

Table 3: Feature comparison in monitoring of existing solutions

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.

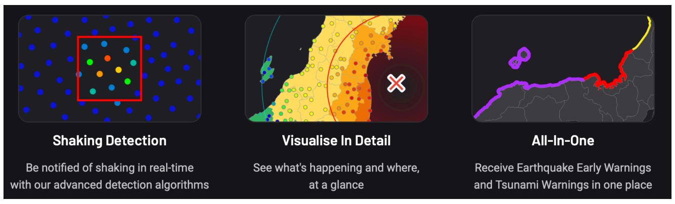

Shaking Detection
Be notified of shaking in real-time with our advanced detection algorithms
Visualise In Detail
See what's happening and where, at a glance
All-In-One
Receive Earthquake Early Warnings and Tsunami Warnings in one place

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

There are also a variety of configuration options avaliable 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	✓		✓	✓
Sound Alert	✓	✓	✓	✓
System Notification			✓	
Colour Theme			✓	✓
Map Colouring Style		✓		✓

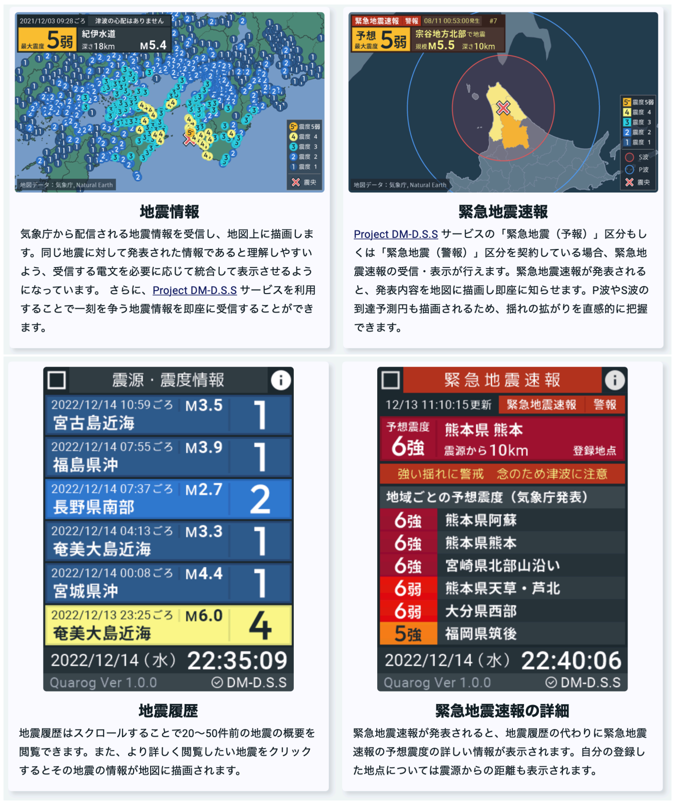
Table 4: Feature comparison in configuration and customisability of existing solutions

1.5 Features of proposed solution

As a result of research, you should identify the key features (in general terms) that your system will have:

- List of key features that will be Required
- Discussion of the scope and potential limitations to the system given the time constraints.

[1]Integrated with no-login required.
[2]Tsunami forecast not avaliable.



地震情報

気象庁から配信される地震情報を受信し、地図上に描画します。同じ地震に対して発表された情報であると理解しやすいよう、受信する電文を必要に応じて統合して表示させるようになっています。 さらに、Project DM-D.S.S サービスを利用することで一刻を争う地震情報を即座に受信することができます。

緊急地震速報

Project DM-D.S.S サービスの「緊急地震（予報）」区分もしくは「緊急地震（警報）」区分を契約している場合、緊急地震速報の受信・表示が行えます。緊急地震速報が発表されると、発表内容を地図に描画し即座に知らせます。P波やS波の到達予測円も描画されるため、揺れの拡がりを直感的に把握できます。

震源・震度情報

2022/12/14 10:59ごろ 宮古島近海	M3.5	1
2022/12/14 07:55ごろ 福島県沖	M3.9	1
2022/12/14 07:37ごろ 長野県南部	M2.7	2
2022/12/14 04:13ごろ 奄美大島近海	M3.3	1
2022/12/14 00:08ごろ 宮城県沖	M4.4	1
2022/12/13 23:25ごろ 奄美大島近海	M6.0	4

2022/12/14（水） 22:35:09
Quarog Ver 1.0.0 DM-D.S.S

緊急地震速報

12/13 11:10:15更新 緊急地震速報 警報
予想震度 6強 熊本県 熊本 震源から10km 登録地点
強い揺れに警戒 念のため津波に注意

地域ごとの予想震度（気象庁発表）

6強	熊本県阿蘇
6強	熊本県熊本
6強	宮崎県北部山沿い
6弱	熊本県天草・芦北
6弱	大分県西部
5強	福岡県筑後

2022/12/14（水） 22:40:06
Quarog Ver 1.0.0 DM-D.S.S

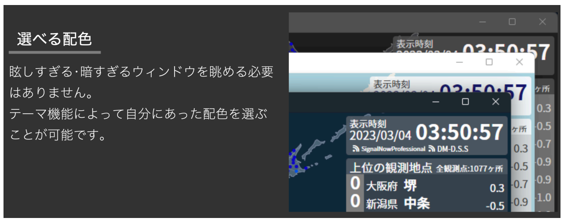
地震履歴

地震履歴はスクロールすることで20〜50件前の地震の概要を閲覧できます。また、より詳しく閲覧したい地震をクリックするとその地震の情報が地図に描画されます。

緊急地震速報の詳細

緊急地震速報が発表されると、地震履歴の代わりに緊急地震速報の予想震度の詳しい情報が表示されます。自分の登録した地点については震源からの距離も表示されます。

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.



選べる配色

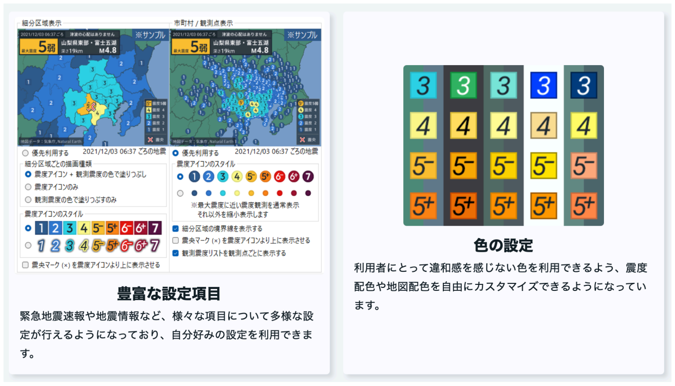
眩しすぎる·暗すぎるウィンドウを眺める必要はありません。
テーマ機能によって自分にあった配色を選ぶことが可能です。

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

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.



優先利用する 2021/12/03 06:37 ごろの地震

細分区域ごとの描画種類
- [✓ 震度アイコン + 観測震度の色で塗りつぶし]
- 震度アイコンのみ
- 観測震度の色で塗りつぶすのみ

震度アイコンのスタイル

☐ 震央マーク (×) を震度アイコンより上に表示させる

[✓ 優先利用する] 2021/12/03 06:37 ごろの地震

震度アイコンのスタイル

※最大震度に近い震度観測を通常表示
それ以外を縮小表示します

☑ 細分区域の境界線を表示する
☐ 震央マーク (×) を震度アイコンより上に表示させる
☑ 観測震度リストを観測点ごとに表示する

豊富な設定項目

緊急地震速報や地震情報など、様々な項目について多様な設定が行えるようになっており、自分好みの設定を利用できます。

色の設定

利用者にとって違和感を感じない色を利用できるよう、震度配色や地図配色を自由にカスタマイズできるようになっています。

Figure 4: Customisablity of Quarog, screenshot from website.

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.

2 Design

Algorithms + Data Structures = Programs.

2.1 Hierarchy Chart

A top-down approach to problem solving will lead to the identification of tasks with sub-tasks. i.e. modules and functions required. This shows how **decomposition** is applied.

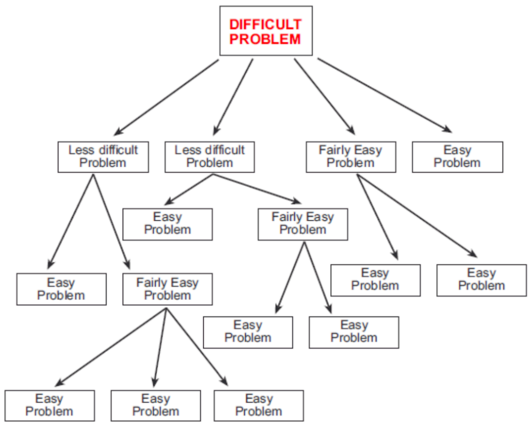


Figure 5: Hierarchy Chart.

2.2 Data Structures/Data modelling

2.2.1 External Data Sources

If you are scraping/gathering data from APIs from external sources you should define the relevant format/parameters.

2.2.2 OOP Model

OOP modelling (classes, methods, attributes, inheritance etc.). Class diagrams would be useful (these are covered in Bond book 1 page 185 onwards). Diagrams should follow conventions for inheritance/composition and private/protected/public methods/attributes.

2.3 User Interface

You will need to draw up a prototype for the user interface. You may do this within the software package you implement your solution in.

- Screen designs
- Menu options/sequences
- Buttons/keys/commands (command line)

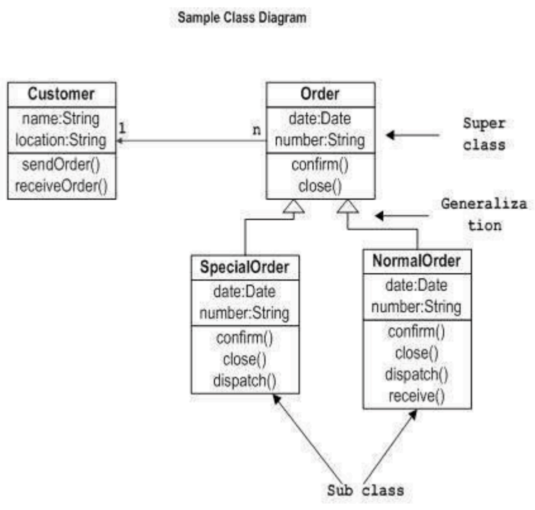


Figure 6: Class Diagram.

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 meet/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

List of Figures