# User Manual

## Real-time Geospatial Data Processor and Visualiser

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# Document History

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# 1 Introduction

The purpose of this document is to provide a detailed summary of the architectural requirements for the Real-time Geospatial Data Processor and Visualiser system in a technology neutral design specification. The specification shows how the system components will communicate with each other and through what means.

# 2 Software Architecture Overview

Figure 1 shows a high-level overview of the software architecture. In particular, it shows the decomposition of the system into layers with abstract responsibilities, the core architectural components of the system and the concrete frameworks to be used when realizing these architectural components.

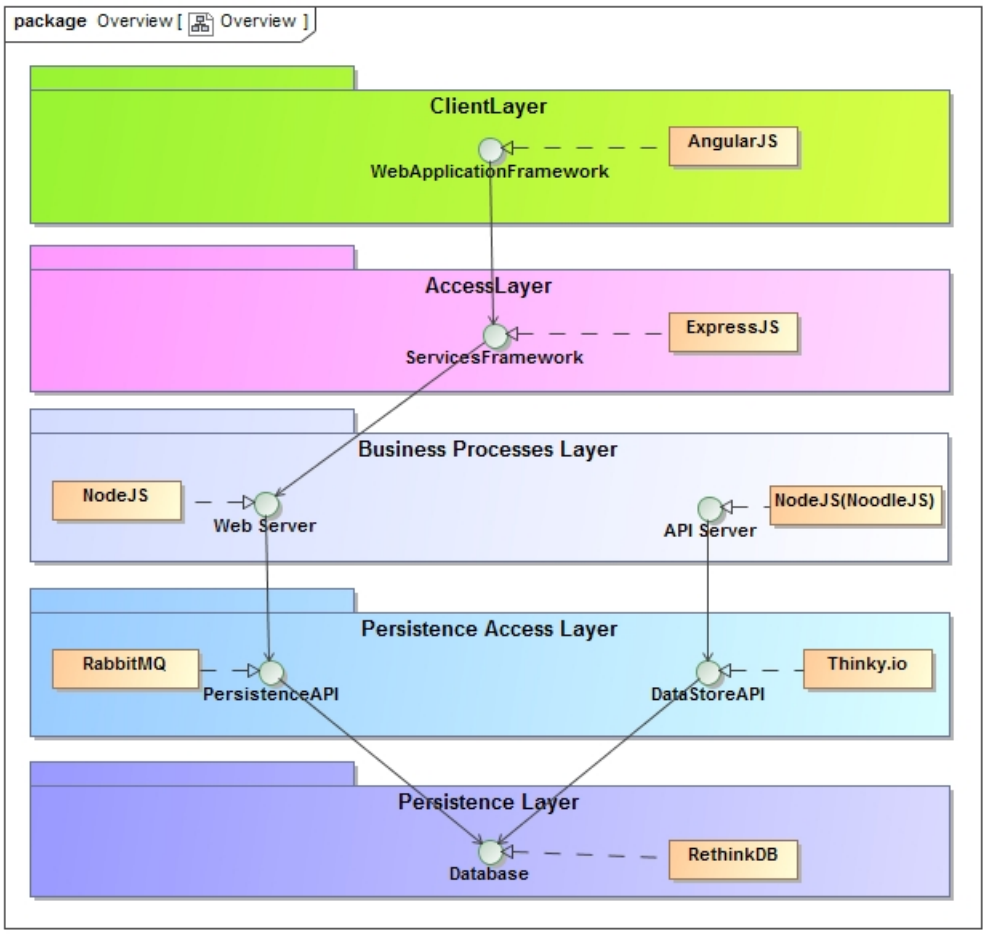



Figure 1: A high-level overview of the software architecture of the Real-time GeoSpatial Data Processor and Visualiser

# 3 Architecture Requirements

This section specifies the software architecture requirements and the software architecture design for the system as a whole. The output will be the high level software architecture components, the infrastructure between them and the tactics that will be used to realize the quality requirements for the system.

## 3.1 Architectural Scope

The architectural responsibilities that need to be addressed by the software architecture are as follows:

- A website that users will interact with to view weather and disasters occurring throughout the world
- A database that will be used to persist large amounts of real-time data as well user's detailsand preferences
- A web server that will allow for interfacing with the website and processing of requests
- An api server that will be used to collect data from various data sources and persist them to a database
- A persistence API that will allow for messages from the database to be accessed then queued

## 3.2 Quality Requirements

The quality requirements are the requirements around the quality attributes of the systems and the services it provides. This includes requirements like flexibility, maintainability, scalability, performance, reliability, security, auditabilty, testability, usability, integrability and deployability requirements.

### 3.2.1 Flexibility

It is important that the system architecture is designed in such a way that one can easily add different access channels to the system as well as remove old unused or outdated access channels. Furthermore, persistence architectures are evolving at a great rate. The growth of NoSQL databases such as MongoDB and RethinkDB serves as proof of this. In this context it is important that the application functionality is not locked into any specific persistence technology and that one is able to easily modify the persistence provider.

### 3.2.2 Maintainability

Amongst the most important quality requirements for the system is maintainability. It should be easy to maintain the system in the future. To this end

- future developers should be able to easily understand the system,
- the technologies chosen for the system can be reasonably expected to be available for a long time,
- and developers should be able to easily and relatively quickly change aspects of the functionality the system provides.

### 3.2.3 Scalability

The purpose of this system is to be used in the business of disaster management, it should allow for easy scaling in all layers. The system must adhere to the following requirements

- The database should support high availability of data,
- messaging should succeed for every CRUD database operation,
- and front-end maps should be able to display the geo-spatial information queried by the user.

### 3.2.4 Performance

Performance is amongst the most important quality requirements for this system. The following requirements must be considered

- messages should be small and only supply the most important data, e.g. descriptions and primary keys that could be used by the client to pull data from the API,
- Front-end maps should react responsively without lag between frames,
- the information must be streamed to the user in real-time.

### 3.2.5 Reliability

A reliable system allows users to use the system with ease. Users should feel that the system is reliable, to this end

- client connections to messaging services should never break,
- server and client exceptions should be handled gracefully.

### 3.2.6 Security

Initially the system needs to support only

- Users simply logging in and seeing data relevant to their area of interest.
- HTTPS connections are optional.

In future the system is expected to also enforce confidentiality through encrypted communication and protection against man-in-the-middle attacks through hashing, protect against DOS and DDOS attacks that will stress the servers, and authentication against a chosen user repository (for users who will deploy troops)

### 3.2.7 Auditability

The system will log all messages processed by the system including all requests and all responses for all user services provided by the system. For each request and response entries the following will be logged

- Request entries:
  - an id for the log entry,
  - the userId of the user requesting the service,
  - the date/time stamp when the request was made,
  - the user service requested, and
  - the request object stringified as JSON with any sensitive information removed.
- Response entries:
  - an id for the log entry,
  - the id of the corresponding request entry,
  - the date/time stamp when the response is provided, and the response object stringified as JSON with any sensitive information removed.

The system will provide only services to extract information from the audit log and will not allow the audit log to be modified. Audit logs will be directly accessible to both, humans and systems.

### 3.2.8 Testability

All services offered by the system must be testable through

1. unit tests,
2. and integration tests

In either case, these tests should verify that

- all pre-conditions are met (i.e. that no exception is raised except if one of the pre-conditions for the service is not met), and
- that all post-conditions hold true once the service has been provided.

In addition to functional testing, quality requirements like scalability, usability, auditability, performance and so on should also be tested.

### 3.2.9 Usability

Usability is an important quality requirement to consider. The system should be intuitive and efficient to use. Computer literacy is assumed. The time it takes users to find the disaster they're looking for or query a specific disaster should be kept to a minimum. Error handling messages should be self-explanatory and as much as possible of the input validation should be done on the client side.

### 3.2.10 Integrability

The system should be able to easily address future integration requirements by providing access to its services using widely adopted public standards. All use cases which are available to human users should also be accessible from external systems.

### 3.2.11 Deployability

Deployability is an important requirement to consider when designing a system. The system should be able to run on any of the 3 most used platforms namely Linux, Windows and Mac OS. The system must:

- run on Linux OS,
- ultimately the system should be packaged as a Docker image which is deployable on a Docker container installed on a virtual or physical Linux server.

## 3.3 Integration and Access Channels Requirements

This section of the document outlines the operability of the system running on the server and demonstrates user access and the integration of different technologies. A Web interface will be the single access channel provided to the user. A detailed discussion follows.

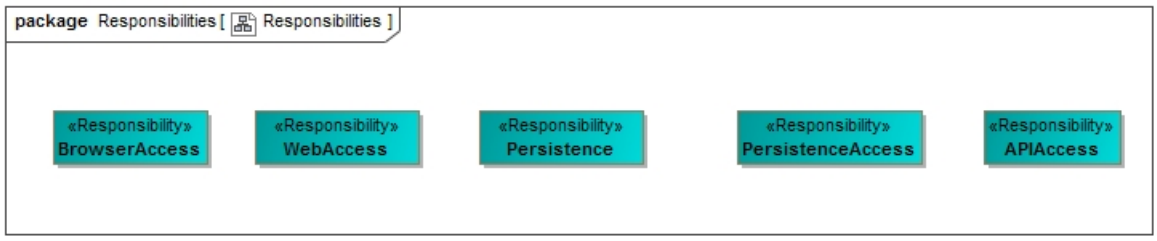
**Access Channel Requirements** The web interface will be accessed typically through a personal computer using a browser such as Google Chrome, Mozilla Firefox and Internet Explorer to name a few.
The system will be accessed in the following manner:

1. The user will open a web browser of their choice.
2. Click on the web page where the system will be hosted.
3. A login page will be displayed.
4. After user information validation, the user can then have full access to the information they wish to access, based on the privileges assigned to them during user creation.

**Integration Channel Requirements** Two servers would be used to achieve data persistence, one for interfacing with the website and a second for interfacing with the third-party API for data downloading. The system will also have to interface with a map database (Open Street Map) for downloading maps that will be overlaid with geospatial data. The web application will need to integrate with the services/business processes layer via a REST API.

## 3.4 Architectural Responsibilities

The architectural responsibilities for the system as a whole are shown below:



The system requires an environment within which the business processes realizing the services are executed. These services need to be made available to humans and systems over the web. Humans need to access the services via web browsers although it may be expanded to mobile devices. The business processes requires access to a persistence provider (a database).

### 3.5 Architectural constraints

The choice of architecture components and technologies is mostly unconstrained. The development team may choose the architecture and technologies best suited to fulfil the non-functional requirements for the system subject to:

1. the system must be deployable in a Docker container, and
2. the system must use only open source frameworks and tools.

## 4 Architectural Patterns

The architectural pattern that will be used for the Real-time Geospatial Data Processor and Visualiser system will be the Layering architectural pattern. (See Figure 1)
For the Layering pattern, the layers that will be used are

1. Client
    - This layer will use the lower layers to have data delivered to it so that it can display the different functionality the user requires in a user friendy manner, which could range from queries to just simply interacting with a map to view what is going on around it.
2. Access
    - This layer, which is a wrapping layer of the business processes layer, makes services available in a technology-neutral way over the Internet. ExpressJS, which is a NodeJS web application server framework, will be used.
3. Business Processes
    - The Business Processes layer will help process requests and will also contain an API server which will be used to extract data from Third Party APIs and/or other reliable data sources.

4. Persistence Access

    - This layer will be used to access data from the persistence layer, using RabbitMQ to queue messages from the database and it will also be used to write data pulled from public web APIs to the database using Thinky.io.

5. Persistence

    - The persistence layer will manage persistent real-time data which will have been acquired from Third Party APIs. It would in turn supply data, via the Persistence Access Layer, to the Business Logic layer upon request and when there are updates to the requested data.

The Layering pattern is used because:

1. it allows applications to be decomposed into groups of subtasks, each group of subtasks at a certain level of abstraction,
2. the layers are pluggable and replaceable,
3. complexity is reduced,
4. there is loose high-level coupling,
5. there is ability to mock out lower level layers, and
6. there is enhanced maintainability

# 5 Architectural Tactics

Architectural tactics by definition are design decisions that influence the control of a quality attribute response. For the quality attributes identified above, the following are the design decisions that were chosen for some of the quality requirements.

## 5.1 Maintainability Tactics

Maintainability tactics ensures that the system when modified will preserve its integrity.

1. Documentation has to always be up to date throughout the entire development process. It should also be self explanatory and be accessible to all who need it.

2. Another strategy is to localize changes by decomposing all the system elements with clear responsibilities.

## 5.2 Scalability and Performance

In order to ensure that resource demands are managed efficiently we would do so by:

1. Reusing resources through using thread pooling and caching. In our system we use thread pooling in the backend system to access and retrieve documents from the database.

2. Reducing the load using indexing and optimizing queries which will ensure efiiecient persistence and processing and will also greatly increase the overall speed of retrieving data from the database.

## 5.3 Reliability

Reliability will be ensured through:

1. Preventing faults using resourc locking and removing single points of failure. This will be done by thorough unit and integration testing throughout development.

2. Detecting faults using error/exception communication, in which case if a user wants to use a function/service that they are not authorized to use, an exception message will be communicated to them in a way that the user understands and is able to move forward from and through message integrity by checking that every message or input is valid and not malicious in anyway.

## 5.4 Security

1. Resisting attacks by limiting access through:

    - Minimizing access channels, which at current the system can only be accessed through one access channel taht is the website
    - Authentication. In order to use any of the functionality in our system, one would need to be registered with the system so that they are able to login.
    - Authorization. Different users have different access control. A normal user would be able to view and query the system while an admin is able to modify any relevant system data.

2. Detecting Attacks through monitoring and logging events.

### 5.5 Auditability

Auditing will be ensured through

1. Monitoring and logging all messages processed by the system as well as all requests and responses for all the user services.

2. Authentication. Every action performed will be linked to the person who has performed it, whether it be a request from a user, a response from the system or admin modifying system data.

### 5.6 Testability

- Separate interface from implementation. That would allow for substitution of implementations for various testing purposes and would also allow the remainder of the system to be tested in the absence of the component being stubbed.

### 5.7 Usability

- Usability will be ensured by making the interface easy to use and having a system that is not cluttered but only has functionality that is necessary.

## 6 Reference Architectures and Frameworks

Frameworks that are incorporated within our software architecture:

1. AngularJS Description: AngularJS is a structural framework used for building dynamic web applications. Reasons for using it:

    - It is fully extensible, as it lets us extend HTML vocabulary for our application, and it works well with other libraries
    - It helps with communication between the client and server side, which is helpful fto us as the client and the server communicate regularly to ensure that all the requests made by the client are fulfilled. It tarns async callbacks with promises and deferreds.
    - It makes it easy and quick to develop.

- It offers two-way data binding between models and views. This data binding allows for an automatic update on both sides whenever there is a data change.

2. ExpressJS Description: ExpressJS is a web application framework that provides a set of features for web applications. Reasons for using it:
   - It is flexible and easy to use
   - It helps build back-end functions for web applications, which is important for our system as most of the system depends on the functions done in the back-end.
3. Mocha Description: Mocha is a JavaScript test framework which runs on NodeJS Reasons for using it:
   - It is easier to test async code usind in the back-end. It can run tests in series and also trace exceptions to the right test cases.
   - It allows for use of any assertion library. In our case we use Mocha with Chai, which is a TDD asertion library.
4. Jasmine Description: Jasmine is a behavior-driven development framework. Reasons for using it:
   - We use it to test our AngularJS application because it has a clean and obvious syntax that makes it easy to write tests for our front-end code.

# 7 Access and Integration Channels

## 7.1 Integration Channels

The Real-time Geospatial Data Processor and Visualiser system will integrate with:

1. different public web APIs using HTTP requests to pull data.
2. a database
   (a) The database will be used to store data which is pulled from the APIs.

(b) The technology that will be used for the database is RethinkDB because it is scalable and will be able to store the massive amount of data that is pulled from the APIs; it also allows for data from the APIs to be stored in real-time, meaning that the data stored would be the most up-to-date at all times (adding new data and updating data that already exists in the database) and it also allows the database to continuously push updated query results to applications in real-time.

3. a messaging service

   (a) Stores any messages to and from the web client, whether it is an update to the data the web client has already received, or is currently displaying or a new message consisting of different data to the one being currently shown.

   (b) In this case the system will integrate with technology, RabbitMQ, which will act as an intermediary for any incoming or outgoing data.

## 7.2 Access Channels

The Real-time Geospatial Data Processor and Visualiser system will be accessed by different users via the web interface. The web interface will be accessible through web browsers such as Google Chrome, Mozilla Firefox or any other standard web browser.
The system has two kinds of users, who are:

1. Any person interested in the data

   - A user is able to view or track disasters, view weather and they are also able to perform a point or detailed query. A user registered with the system is also able to add, view and edit disaster or weather preferences.

2. Admin

   - An admin user is able to add or modify disaster types as well as access and/or modify relevant system data.

# 8 Technologies

Technologies and frameworks that will be used to build the system are as follows:

- Front-end
  - AngularJS, provides good RESTFul services and easy integration with other technologies.
  - RabbitMQ listener as Message bus, to collect real time data from the backend feeder.
  - Leaflet.js, as our map framework that will use the openStreetMap as its map source.
- Back-end
  - NodeJS for server-side Web applications.
  - ExpressJS is a framework for node.js for building web-applications, supports RESTful services.
  - Bluebird for promises, to complete asynchoneous tasks.
  - RabbitMQ feeder as Message bus, to collect real time data from the database.
- Database
  - RethinkDB, supports "changefeeds", which allow you to subscribe to changes on a table. This goes hand in hand with the real-time feature of the system
  - RabbitMQ, a framework for RethinkDB; is a natural choice for distributing notifications of change events on RethinkDB.

# 9 References