IIIT, HYDERABAD

EARTHQUAKE FORECASTING

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Group Leaders	**Subgroup Leaders**
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	Rohan Bhatial (Himachal)

1. SYSTEM:

- Earthquake prediction by analysing past data.

2. SCOPE OF THE SYSTEM:

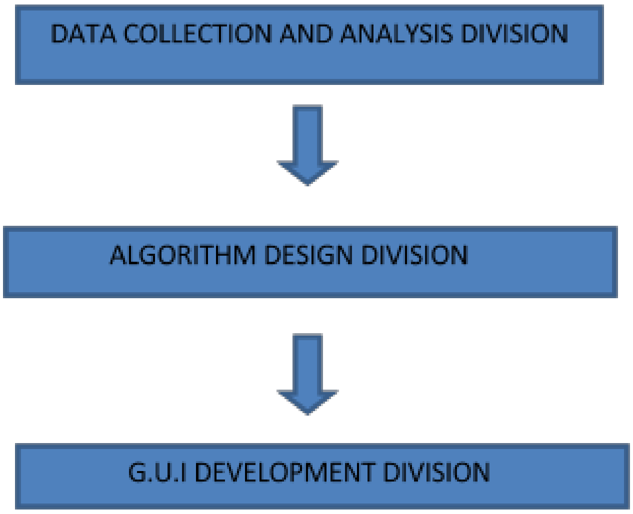
- To predict the earthquakes that may occur in future in a user specified area using the database that is provided.
- In our project we will be dealing with the north east states (seven sisters), Gujarat and Himachal Pradesh.
- To predict and analyze earthquakes using the data from the database.
- Usage of basic programming languages like python, php for the implementation of the project.

3. PURPOSE OF THE SYSTEM:

- The goal of earthquake prediction is to give warning of potentially damaging earthquakes early enough to allow appropriate response to the disaster, enabling people to minimize loss of life and property.

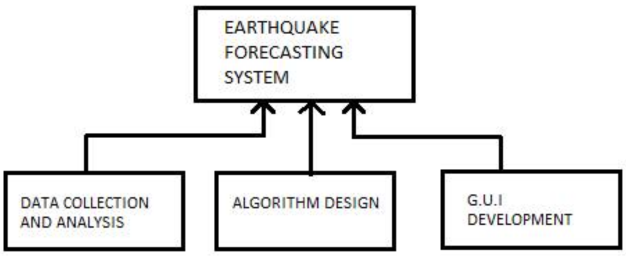
- To prevent the damage in terms of people, money, agriculture, property, etc due to earthquakes by forecasting accurately.
- To create awareness and enable people to effectively manage the disaster.
- To integrate technological tools with disaster management.
- To analyze and predict the pattern of earthquakes for efficient sewage and ground water pipe connections, building construction etc.

4. SYSTEM OVERVIEW AND FLOW:



This will be the work flow of the system.

Following is about sub-systems and their functioning.



SUBSYSTEM 1: DATA COLLECTION AND ANALYSIS DIVISION

INTRODUCTION:

1. **PURPOSE:**
    - To collect all the data that is required for prediction of the earthquake.
    - The data that is collected should belong to the states that we are dealing with.
    - To extract the collected data into a more meaningful form such that we can use it for predicting an earthquake using an algorithm.
2. **SCOPE:**
    - We will be dealing with the data of past 50 years.
    - We will also deal with the data that comes under the part of the country we are dealing with.

2.REFERENCES:

- http://10.4.3.123/Interactive_map/google_customize_4.php
- Open jump software for getting an idea about the faults, earthquakes and how we can use their latitudes and longitudes for calculating source for each earthquake.
- The basic data base files that were given regarding the past earthquakes and their magnitudes.

3.1 OPERATIONAL PERFORMANCE CHARACTERISTICS:

3.1.1 SYSTEM ENTITY DEFINITION:

This phase consists of 2 components : gathering and analysis of data of previous earthquakes of the region. Gathering of data is done from the EERC archives. This data has been derived from the readings of seismograph and Richter scale.

Seismic waves are the vibrations from earthquakes that travel through the Earth; they are recorded on instruments called seismographs. Seismographs record a zig-zag trace that shows the varying amplitude of ground oscillations beneath the instrument.

The Richter magnitude scale (often shortened to Richter scale) was developed to assign a single number to quantify the energy that is released during an earthquake. The scale is a base-10 logarithmic scale. The magnitude is defined as the logarithm of the ratio of the amplitude of waves measured by a seismograph to an arbitrary small amplitude. An earthquake that measures 5.0 on the Richter scale has a shaking amplitude 10 times larger than one that measures 4.0, and corresponds to a 31.6 times larger release of energy.

3.1.2 SYSTEM MISSION:

- To collect the raw data from EERC archives .
- To prepare the schema for the database
- To normalize the tables of the database
- To identify and analyse the relationships among the tuples
- To maintain and upgrade the database with time

3.1.3 PHASES OF OPERATIONS

3.1.3.1 PRE MISSION PHASE OPERATIONS:

- At first, the team members need to know the basics of earthquake like its causes, effects, etc.
- Then, they are expected to know the use of some database

tools.

- Then, they must try to establish contacts with field-experts , research scholars, and data scientists for their valuable suggestions in due course of this project.

3.1.3.2 MISSION PHASE OPERATIONS:

- During this phase, the team will first collect the Richter scale readings of earthquakes from 1600-2010 from the EERC Archives.
- After that, the schema for the database is designed.
- After that, the primary key and relationships are identified appropriately.
- Then, the tables of the database are normalized for removing discrepancies and faster computations of queries.
- Finally, the tables of the database are written to a SQL file.

3.1.3.3 POST-MISSION PHASE OPERATIONS:

- The team regularly updates and maintains the database with time.
- Meetings are conducted regularly so as to discuss better schema as the size of the database grows with each year.

3.1.4: MISSION RELIABILITY:

- This mission's authenticity and reliability stands on the source of the data obtained. EERC is well-equipped with modern earthquake recording infrastructure and hence, the raw data is valid.
- Moreover, a proper schema design has ensured that there are

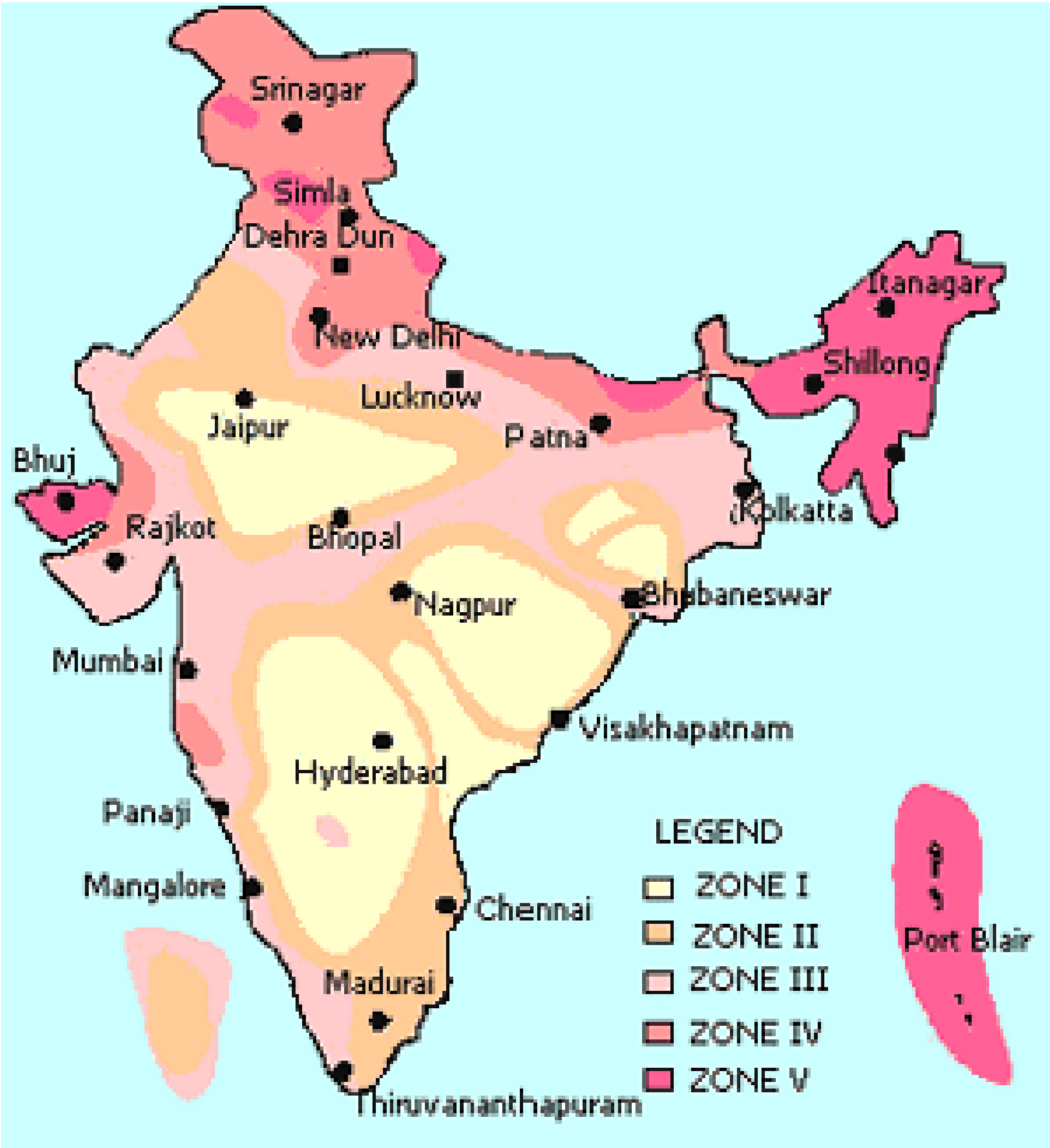
no errata while processing the data by the other teams.

3.1.5: SYSTEM MAINTAINABILITY:

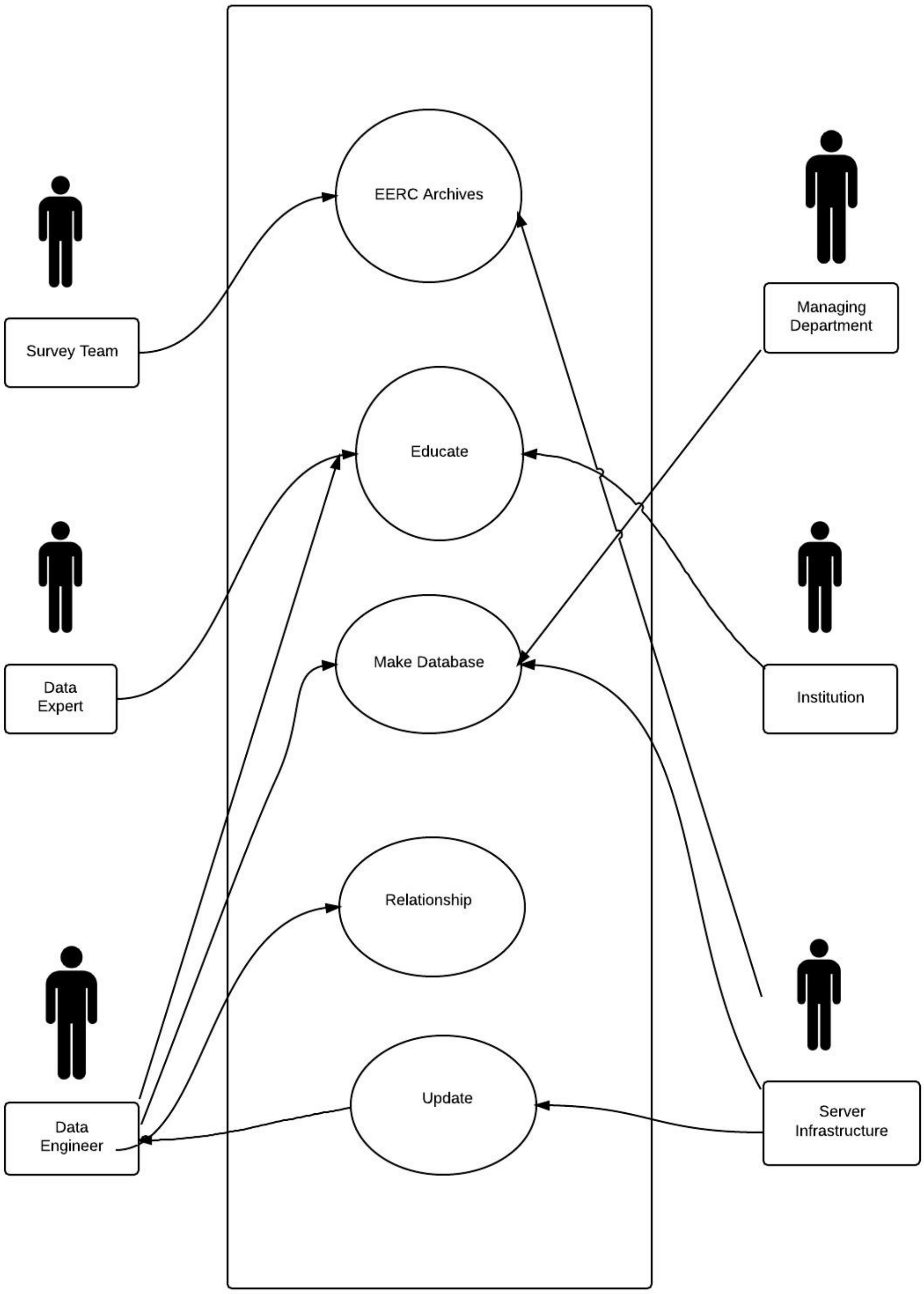
The system is maintained by updating the data regularly to ensure that all new occurrences of earthquakes are taken into account.

3.1.6: SYSTEM AVAILABILITY:

The availability of the system is ensured by presence of relevant data whenever required.



3.1.7 USE CASE DIAGRAM


EERC Archives
Survey Team
Managing Department
Educate
Data Expert
Make Database
Institution
Relationship
Data Engineer
Update
Server Infrastructure

SUBSYSTEM 2: ALGORITHM DESIGN DIVISION

1.INTRODUCTION:

1. **PURPOSE**:
   - To implement the algorithm that can predict the future possibilities of the earthquake in a given area.
   - Here we will develop the algorithm given by the EERC people such that it predicts with more accuracy.

2. **SCOPE:**
   - We will just use the algorithm given by the EERC people and develop that only.
   - Any predictions that are done will be based on that algorithm only.

2.REFERENCES:

- Algorithm given by EERC and some normal formula from the internet.

- Basic Python programming.

3.1 OPERATIONAL PERFORMANCE CHARACTERISTICS:

3.1.1 SYSTEM ENTITY DEFINITION:

This phase involves the processing and querying of the database obtained from the previous subsystem.

Algorithm design is a specific method to create a mathematical process in solving problems. Algorithm design is identified and incorporated into many solution theories of operation research, such as dynamic programming and divide-and-conquer.

Successful forecasting of earthquakes is of primary importance for two complementary reasons. The first is practical: a reliable and skilful forecast is a fundamental component required to mitigate seismic risk. The second is more philosophical: forecasting is a cornerstone of scientific knowledge. Of course, although an accurate forecast suggests understanding, it might be accurate by chance, or for the wrong reason.

The basic problem in earthquake forecasting is to obtain the best model; to date, there is not a unique way to achieve this goal. One possible strategy is to apply a particular metric to a set of candidate models and select the optimal model. From a purely scientific point of view, this corresponds to evaluating the reliability and skill of each forecast (International Commission on Earthquake Forecasting for Civil Protection, 2010). In general, this is fairly straightforward if many data are available but fails when data is infrequent.

In earthquake forecasting, the problem that large events happen so infrequently is managed in two different ways. One strategy is to assume that the largest events sample the statistical distribution of small-to-moderate events. In this approach, the empirical distribution of small-to-moderate earthquakes is extrapolated to large-magnitude events. The other strategy is to assume that the largest events have some peculiarities that make them distinct from smaller events (e.g., a different distribution and/or different epistemic uncertainty). In this case, extrapolation is not useful and a specific statistical model should be constructed. Unfortunately, we do not have enough data to build a unique, robust model and, even if we did, we do not have enough data to check its reliability or skill in forecasting. To address this problem, some earthquake scientists abandon the common scientific practice of hypothesis testing and instead build consensus models based on expert opinion, or the so-called “best available science”.

An earthquake forecast is a basic prerequisite for planning rational risk mitigation actions. Recently, the term “operational earthquake forecast” has become popular as it emphasizes the primary goal of such research: “to provide communities with information about seismic hazards that can be used to make decisions in advance of potentially destructive earthquakes”.

A short-term forecast model may be used to reduce risk during a sequence of small to moderate earthquakes, which might be an aftershock sequence, a foreshock sequence, or a swarm that is not punctuated by a large earthquake.

Regardless of the forecast horizon, the nature of the forecast model, and the specific mitigation actions, a probabilistic model allows scientists and decision- makers to clearly distinguish their roles in risk assessment and mitigation: scientists provide probabilities to decision-makers who then compare them with pre-identified thresholds to choose the appropriate actions.

3.1.2 SYSTEM MISSION:

- To devise a mechanism for dividing the region of interest into grids with proper indexing.
- To extract the faults under the region from a reliable source like a plate-tectonics map.
- To be able to categorise the earthquakes based on the source faults by analysing the distance of each epicentre from all the available faults in that region.
- To assign ranks to each grid based on the probabilistic hazard calculations with proficiency.

3.1.3 PHASES OF OPERATIONS

3.1.3.1 PRE MISSION PHASE OPERATIONS:

- At first, the team members will decide the input parameters of a fault and how to specify a grid cell(i,j) on the selected region.
- Then, they categorise the earthquakes based on the range of their magnitudes.

3.1.3.2 MISSION PHASE OPERATIONS:

- During this phase, the team will categorise and establish the source fault of each earthquake in that grid cell(i, j) .
- After that, probabilistic calculations for each grid cell is done with a good run-time complexity.

3.1.3.3 POST-MISSION PHASE OPERATIONS:

- After the probabilistic hazard computations, the grid cells are assigned ranks ranging from safe to highly vulnerable in the years to come.

3.1.4: MISSION RELIABILITY:

- This mission's reliability depends on our model of probabilistic model of computation of hazard risks.
- The faults of that region are identified by using OpenJUMP software. OpenJUMP is an open source Geographic Information System (GIS) written in the Java programming language. It is developed and maintained by a group of volunteers from around the globe.
- A short-term forecast practically does nothing to inform development of building codes, but it might be useful for

deciding whether or not to call for an evacuation.

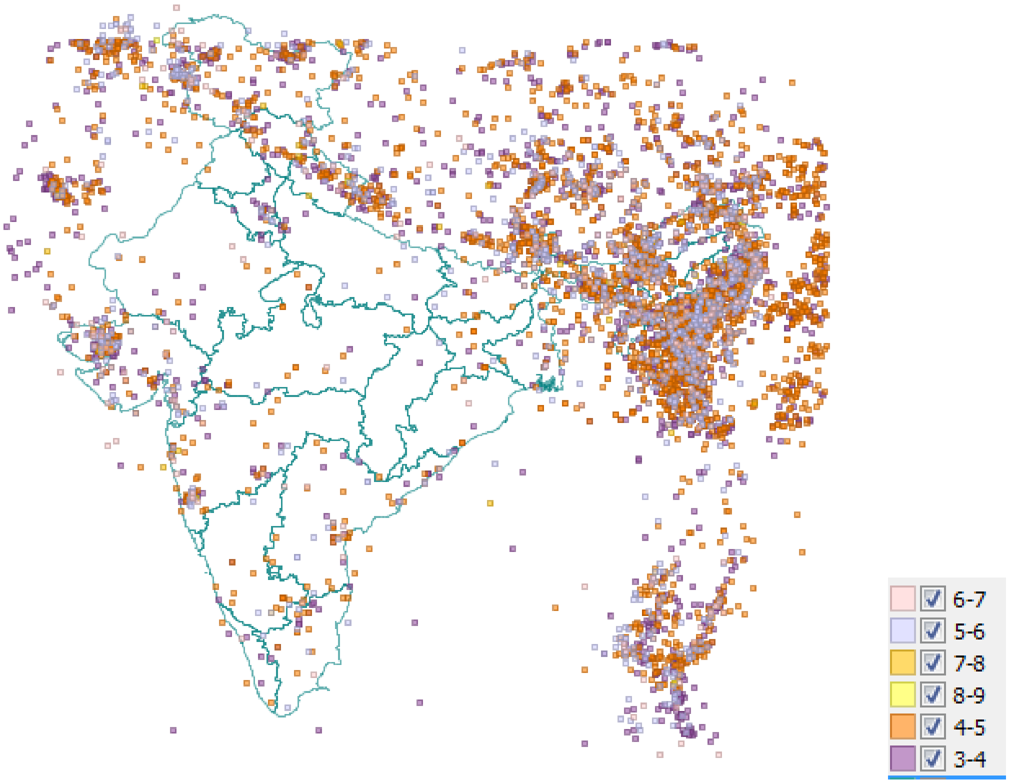
3.1.5: SYSTEM MAINTAINABILITY:

The system is maintainable in the sense that the algorithm used can be improvised upon as and when the need arises.

3.1.6: SYSTEM AVAILABILITY:

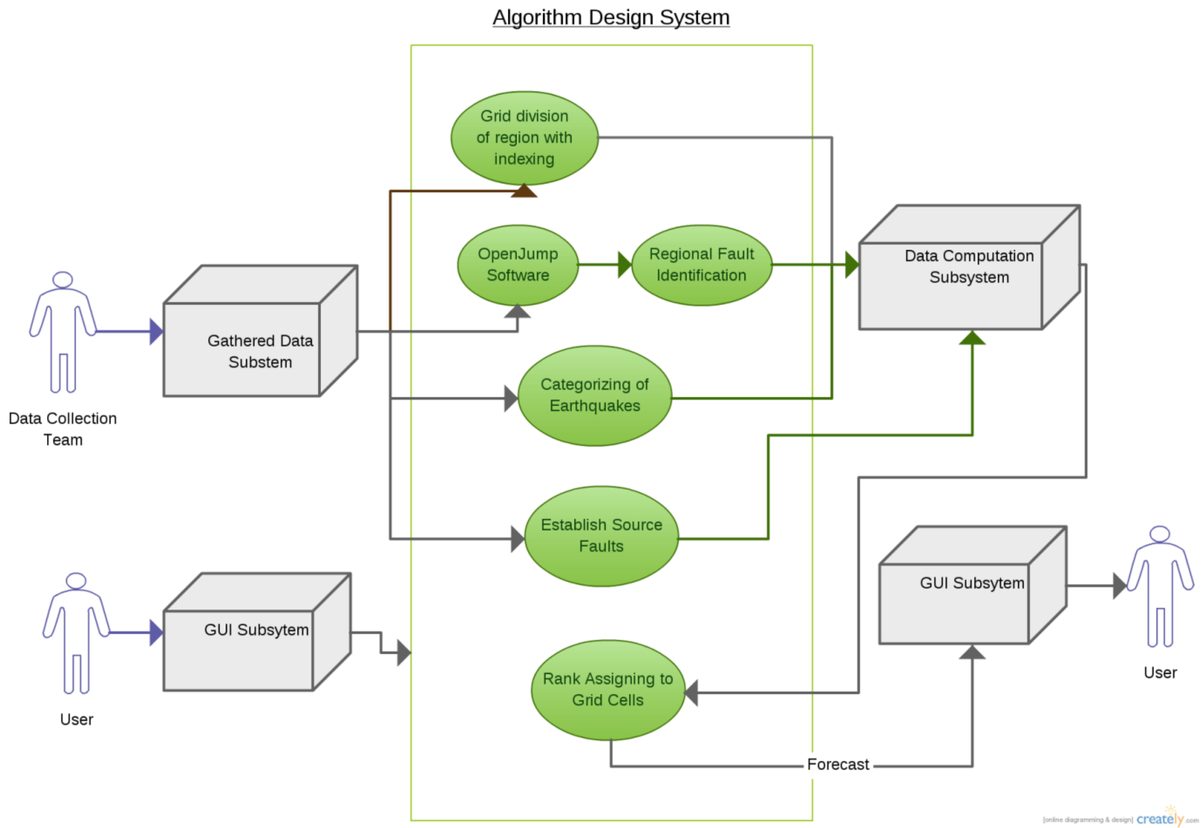
The system provides an efficient algorithm which is needed to predict the earthquakes using the data provided by other subsystems.

<u>VARIOUS EARTHQUAKES IN THE COUNTRT AND THEIR RESPECTIVE RANGES</u>



Open jump showing various fault lines in the country

3.1.7 USE CASE DIAGRAM



SUBSYSTEM 3: G.U.I DEVELOPMENT DIVISION

1.INTRODUCTION:

1. **PURPOSE**:
   - The final aim is to build an interface that will enable the interaction between the system and the user.
   - The interface will work in such a way that user can easily find the future earthquakes given his area.
2. **SCOPE:**
   - We will be developing the interface that will be simple and gives the future earthquakes list when an area is given.
   - A basic program will be running at the back end which gives output.

2.REFERENCES:

- We will be using python for coding the interface and PHP for the database.

3.1 OPERATIONAL PERFORMANCE CHARACTERISTICS:

3.1.1 SYSTEM ENTITY DEFINITION:

This phase involves the development of a web-based G.U.I tool that works with the database at the back end. The team is concerned with the following properties for a good user experience:

- Appearance
- Content
- Functionality
- Website Usability

- Search Engine Optimization

The G.U.I for the tool is simple yet valuable in its contents along with fast loading pages, descriptive link text and minimal scrolling.

3.1.2 SYSTEM MISSION:

- To deliver a consistent and compatible G.U.I for the back-end database.
- To provide important helpline links for the region of interest via the G.U.I.
- To aid in the efficiency of real-time earthquake risk mitigation methods.
- To motivate towards the development of time-dependent fragility functions for buildings, selected infrastructures, and utility systems.

3.1.3 PHASES OF OPERATIONS

3.1.3.1 PRE MISSION PHASE OPERATIONS:

- At first, the team members need to know the basics of web-programming and scripting.
- Then, the team members will ask for the desired layout of the G.U.I from the concerned faculty mentor.

3.1.3.2 MISSION PHASE OPERATIONS:

3.1.3.3 POST-MISSION PHASE OPERATIONS:

- The team regularly updates and maintains the database with time.

3.1.4: MISSION RELIABILITY:

- This mission is the design of the interface between the user and the system.
- The mission’s reliability is based on the error-free code and by outputting correct results even if invalid data is given by the user.
- Using php for database makes it highly responsive and also minimises server problems and hence it is easier for the user.

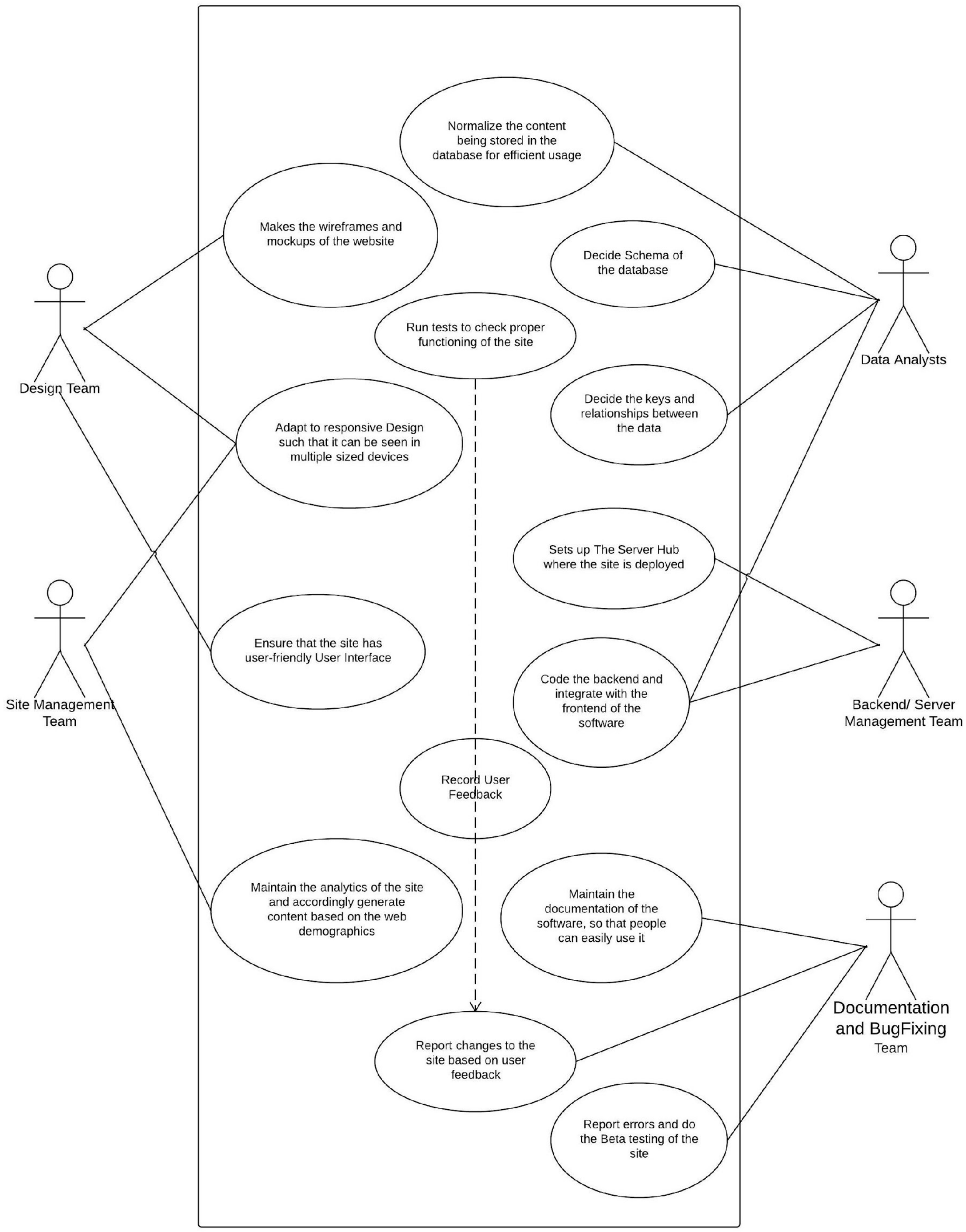
3.1.5: SYSTEM MAINTAINABILITY:

- The GUI of the system can be updated to ensure the absence of faults and to improve its usability and ease of access.

3.1.6: SYSTEM AVAILABILITY:

- GUI helps the users to interact easily with the system.
- System availability is ensured by the presence of responsive and efficient GUI.

3.1.7 **USE CASE DIAGRAM**



TIMELINE

Milestone	Due Date
Meeting with the respective TA/Mentor and division into subgroups.	**March, 6th**
Meeting with TA/Mentor for familiarisation with 'openjump' software and seismic hazard data analysis.	**March, 7th**
Meeting with faculty Mentor.	**March, 8th**
Sub Group Meeting to discuss project flow and PDR presentation for March10th.	**March, 8th**
Team Meeting to discuss project flow and PDR.	**March, 9th**
PDR Presentation	**March, 10th**
Received data analysis of three regions. (Himachal Pradesh, Seven Sisters and Gujarat)	**March, 15th**
Meeting with TA/Mentor and Faculty Mentor to discuss project progress.	**(By) March, 16th**
Commencement of CDR work in subgroups.	**March, 17th**
Complete pending tasks.	**March, 20th**
Integrate with subgroups, codes and complete CDR work.	**March, 25th**
Meeting with TA/Faculty Mentor for feedback and modification according to the	**(By)April, 2nd**

feedback.	
Finalize Project Work and upload CDR.	**April, 5th**

End of PDR