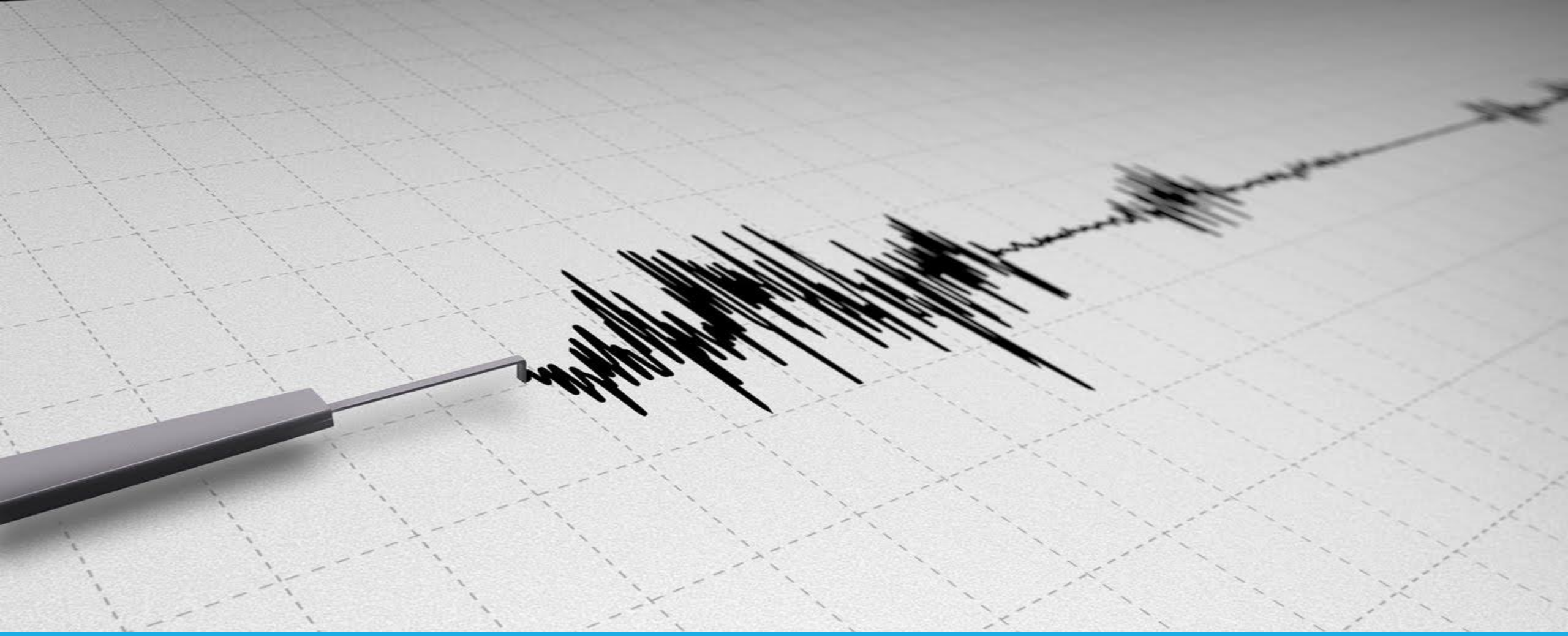


EARTHQUAKES

Shaking and vibration of the Earth’s crust.

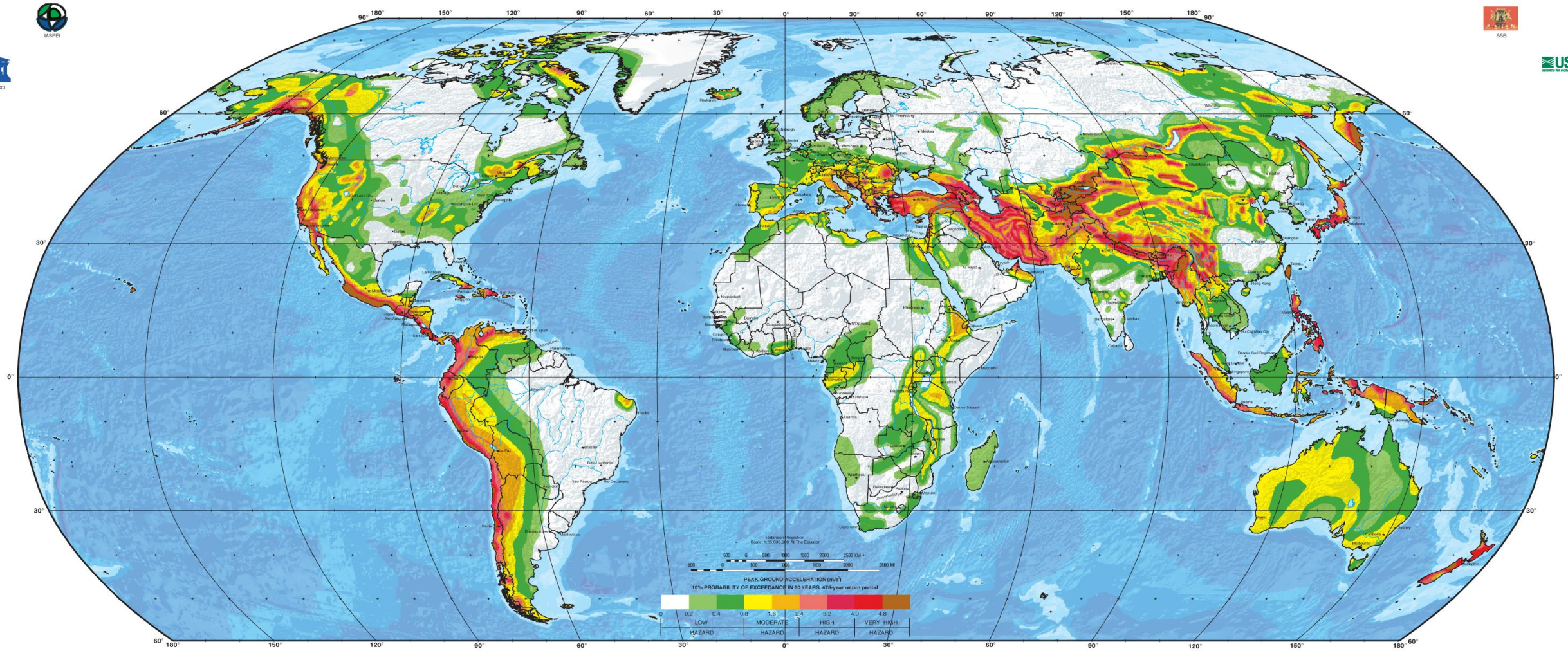
SICHUAN EARTHQUAKE, 2008

"… in the quake almost 80% of buildings were destroyed." – *Wikipedia*

"At least 7,000 school buildings throughout the province collapsed." – *Wikipedia*

CHILE EARTHQUAKE, 2010

"People were found dead after the earthquake struck, mostly under buildings and inside cars." – *Damage and Casualties, Chilean Earthquake News*



EARTHQUAKES CANNOT BE PREVENTED. PREPAREDNESS IS THE KEY.

Can Technology come to our rescue?

OULUN YLIOPISTO
UNIVERSITY of OULU

SMARTPHONE INSTRUMENTATION FOR COLLAPSE DETECTION OF BUILDINGS

A MOBILE CROWD-SOURCING APPROACH TOWARDS EARTHQUAKE DETECTION AND EARLY WARNING SYSTEM

MOTIVATION

- WHY ARE WE DOING WHAT WE ARE DOING?

MOTIVATION

- Collapse of buildings is the primary cause of death
  - Kobe: Over 100,000 collapsed structures
  - Kobe: Over 6000 total deaths
- Sparse distribution of hi-fidelity monitoring stations
  - Approx. 10 km in Southern California Seismic Network (SCSN)
- Mobile Crowd-Sourcing has potential
  - Mild activities in Los Angeles region has produced over 40,000 entries

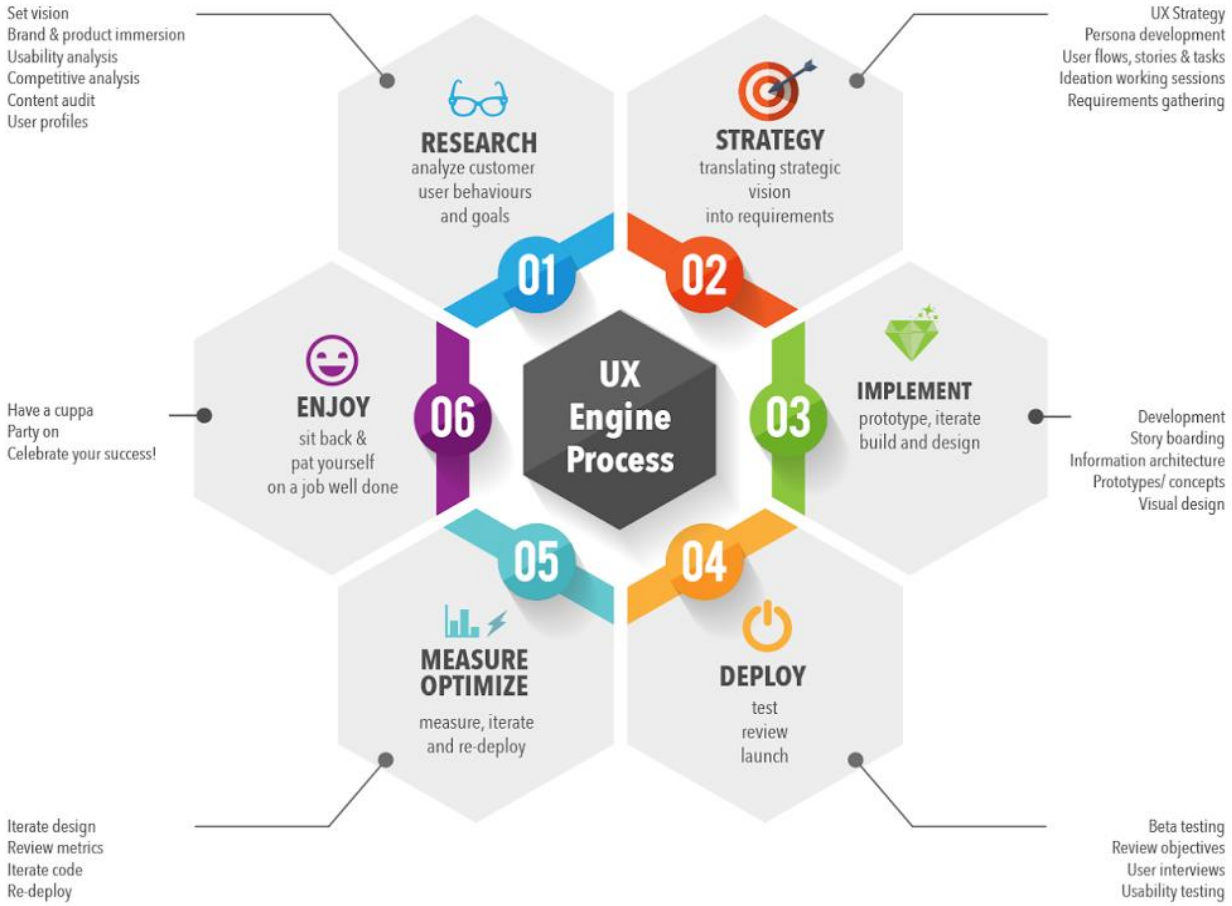
MOTIVATION

- Current seismic sensors DO NOT monitor for building collapses
  - Our system counts the number of collapsed buildings
- Smartphones can provide a good estimate of earthquakes
  - Cheaper
  - Ubiquitous

DESIGN PROCESS

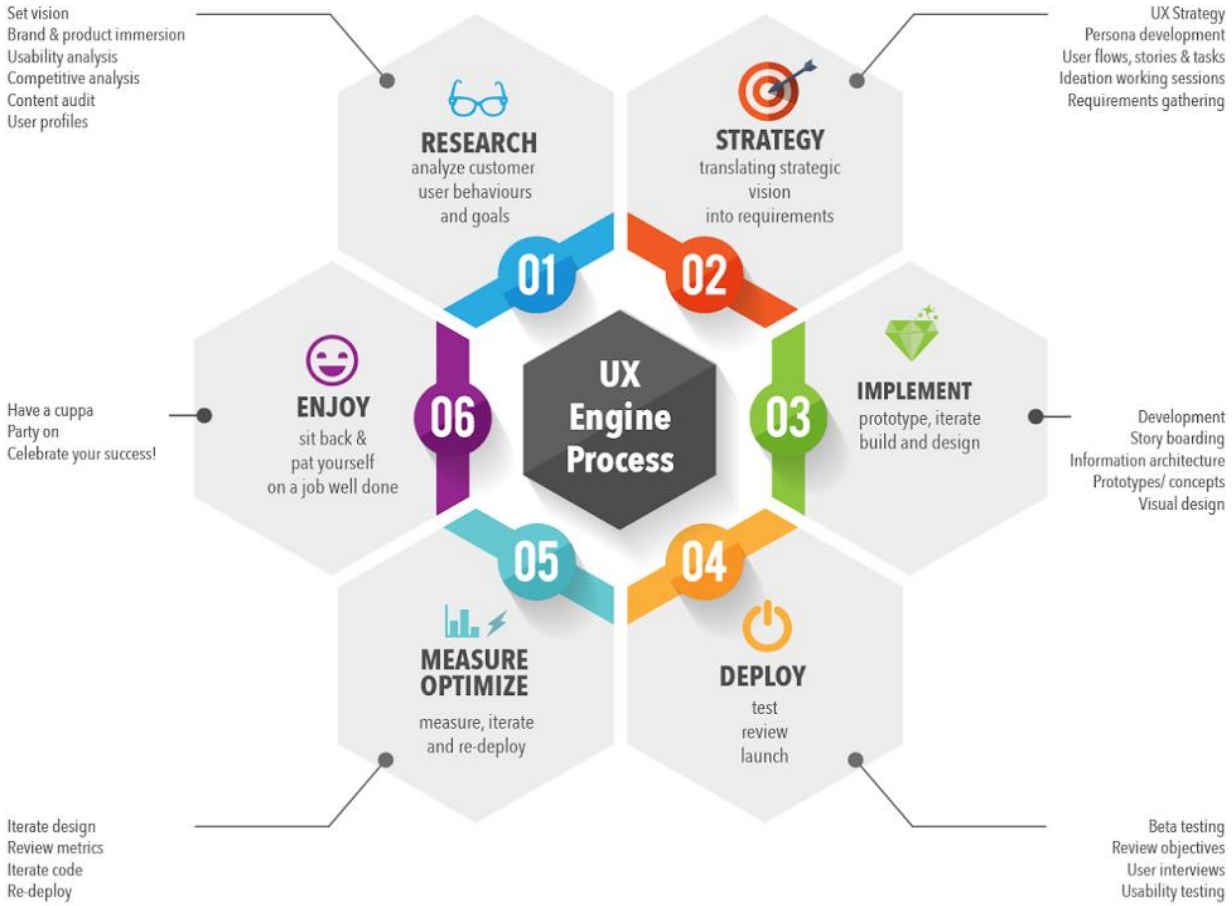
- USER CENTRED DESIGN PROCESS

DESIGN PROCESS



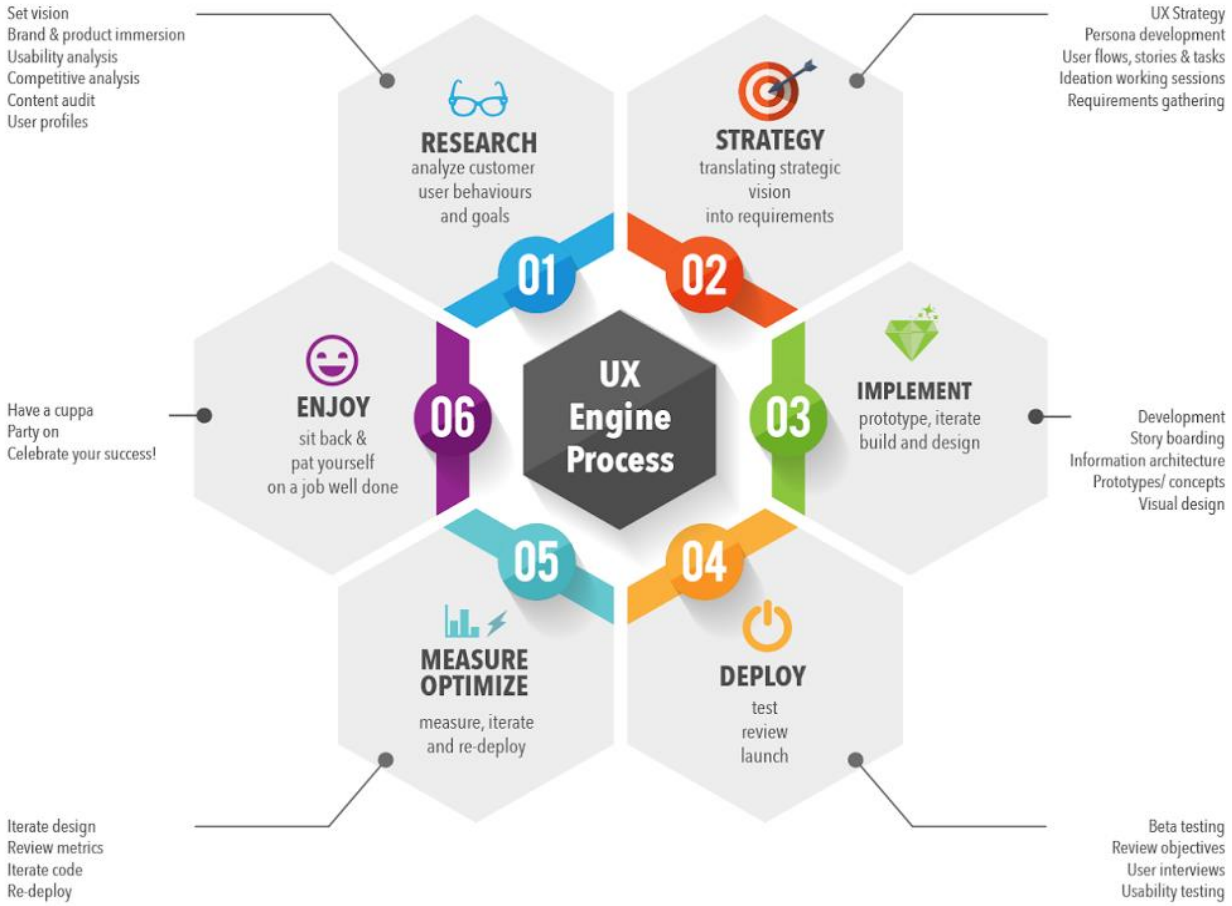
1. RESEARCH
   - Learn about stakeholders
   - Discover Goals and Needs
   - How is it done now?

DESIGN PROCESS



2. STRATEGY
   - Ideation
   - Brainstorming

DESIGN PROCESS



3. IMPLEMENT (50%)
   - Prototyping
   - System design
   - Evaluation

STATE OF THE ART

- KNOWN SOLUTIONS
- KEY FINDINGS

KNOWN SOLUTIONS

- TriNet ShakeMaps – by SCSN
  - Rapid generation of peak ground motion and intensity maps
  - Sparse distribution – Low resolution maps
  - Expensive
- Did You Feel It? – by US Geological Survey
  - Crowdsourcing – Simple post-earthquake questionnaire
  - Has potential – over 40,000 entries
  - But, responders in the areas of heavy shaking DO NOT make the data entry their first priority

KNOWN SOLUTIONS

- Quake Catcher Network (QCN) – Cochran et al.
  - Crowdsourcing – USB MEMS sensors plugged into volunteer's computer or laptop
  - Data sent to central server for processing
- iShake - Reilly et al.
  - Smartphone application measures ground motion and intensity
  - Measurement is ONLY possible during INACTIVE state

KNOWN SOLUTIONS

- Community Seismic Network – Faulkner et al.
  - Rapid detection of earthquakes
  - Smartphones accelerometers
  - Consumer USB devices
  - Heterogeneity of sensors is difficult to manage

KEY FINDINGS

- Relying on Network infrastructure for data transmission
  - Do detection process locally on smartphone
- Heterogeneity of sensors
  - Fall detection is independent of sensor measurement quality
- Data entry is not the priority
  - Ensuring minimum interactions
- Mobile Crowd-Sourcing is promising
  - How to model human activity?

PERSONAS AND SCENARIOS

- STAKEHOLDERS
- PERSONAS
- SCENARIOS

STAKEHOLDERS

- Direct stakeholders
  - People who need to monitor Earthquake events
    - Seismologists/Researchers
  - People who need to be aware of Earthquake events
    - Residents near earthquake prone areas
    - Office/Desk workers
    - Tourists, Bloggers
  - People who need to provide Emergency Services
    - Emergency Response Units (ERUs)
    - Hospitals/Ambulance
    - Fire department

STAKEHOLDERS

- Indirect stakeholders
  - Natural calamity and disaster department of the Government
  - News/Media

PERSONAS

DR. SUSANNA HILBERT

ANTTI MAKINEN

PERSONAS

DR. SUSANNA HILBERT

- Age: 44
- Seismologists
- 15 years of experience
- Would like to exploit the ubiquitous nature of smartphones

ANTTI MAKINEN

- Age: 22
- Second-year exchange student
- Curious about earthquake events
- Blogger and uses smartphones

SCENARIOS

DR. SUSANNA HILBERT

- Deployed Building Collapse Detection System
- Recently hit by a earthquake
- Needs to check buildings collapsed
- Needs to check smartphone data

ANTTI MAKINEN

- Installed Building Collapse Detection System
- Recently hit by an earthquake
- Receives alert notifications
- Receives safety and first-aid tips
- Opportunity to navigate
- Opportunity to participate in citizen news reporting (blogging)

REQUIREMENTS ENGINEERING

- STATEMENT OF NEED
- FUNCTIONAL AND NON-FUNCTIONAL
- USE CASES
- CLASS DIAGRAM
- SEQUENCE DIAGRAM

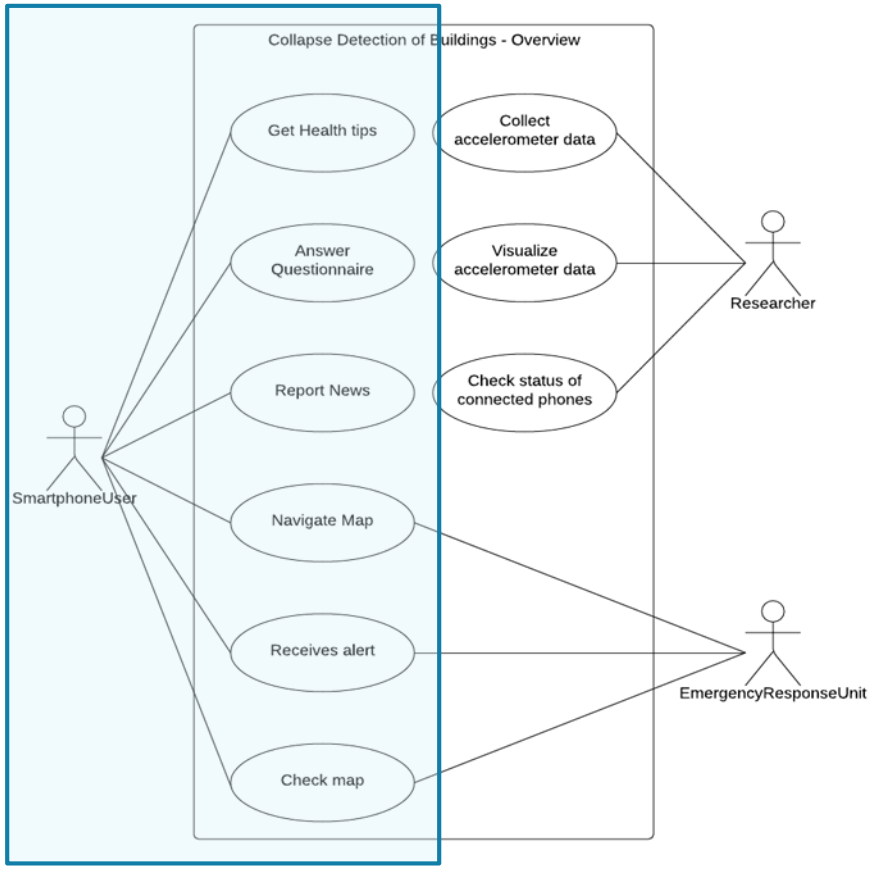
STATEMENT OF NEED

- Seismologists or researchers in general shall be able to monitor and check the data being recorded by the smartphones based on the day/time of occurrences of events.
- Smartphone users who subscribe to the service will be able to receive alerts of any collapsed buildings. They shall also be able to navigate to the area using their smartphones. Upon arrival they shall be able to either provide aid to the victims or create local news items for public consumption.

FUNCTIONAL AND NON-FUNCTIONAL

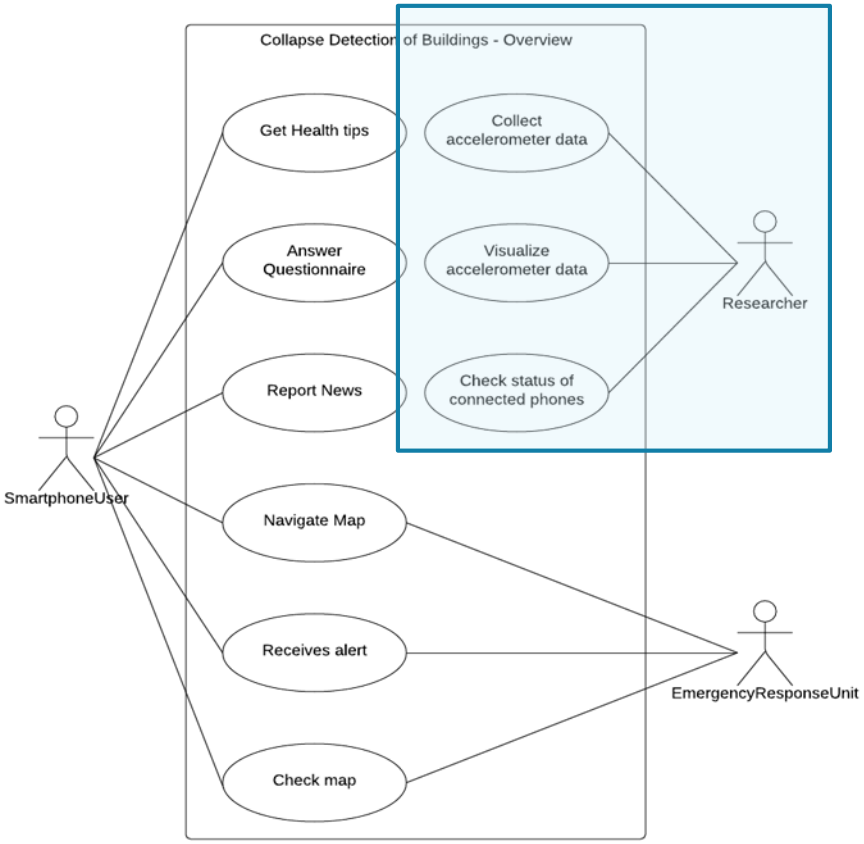
- *<Stakeholder>* shall be able to *<capability>* *<performance or constraints>*.
  - *<Capabilities>* – Functional requirements of the system
  - *<performance or constraints>* – Non-functional or performance requirements of the system.
- The *<smartphone users>* shall be able to *<receive alerts>* *<within 't' minutes of the event>*.

USE CASES (1)



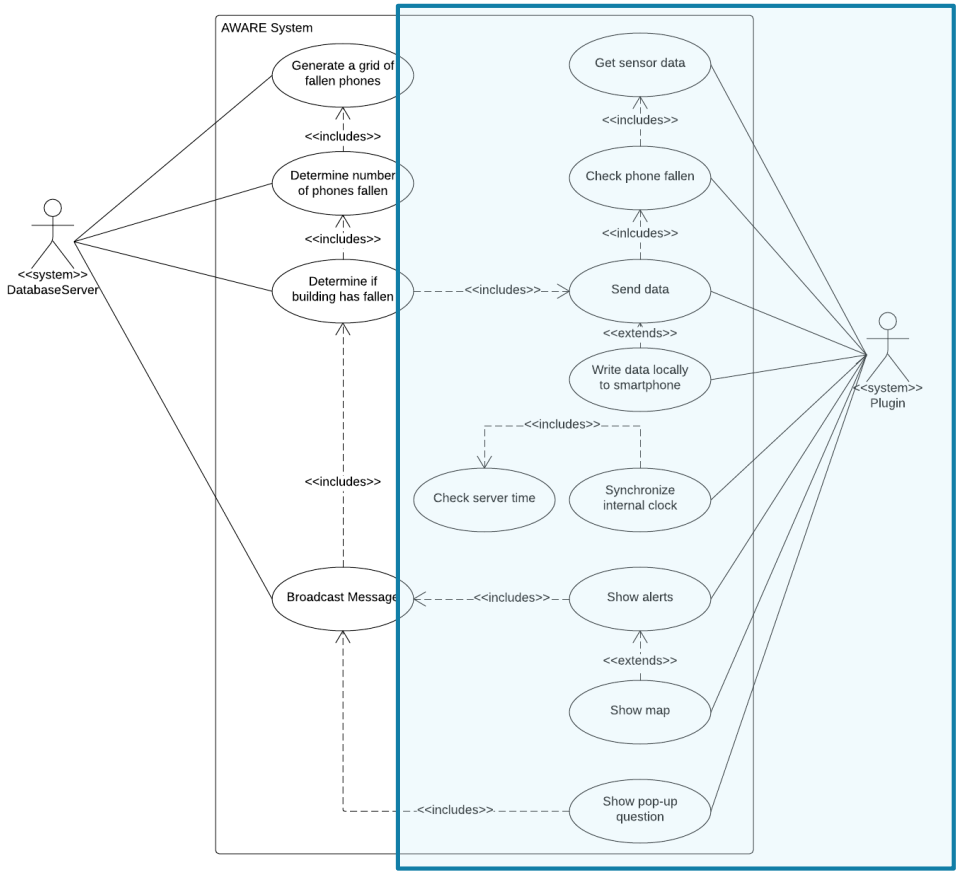
- Smartphone user
  - Get health and safety tips
  - Answer questionnaire
  - Check map
  - Navigate map
  - Receives alert
  - Report news

USE CASES (1)



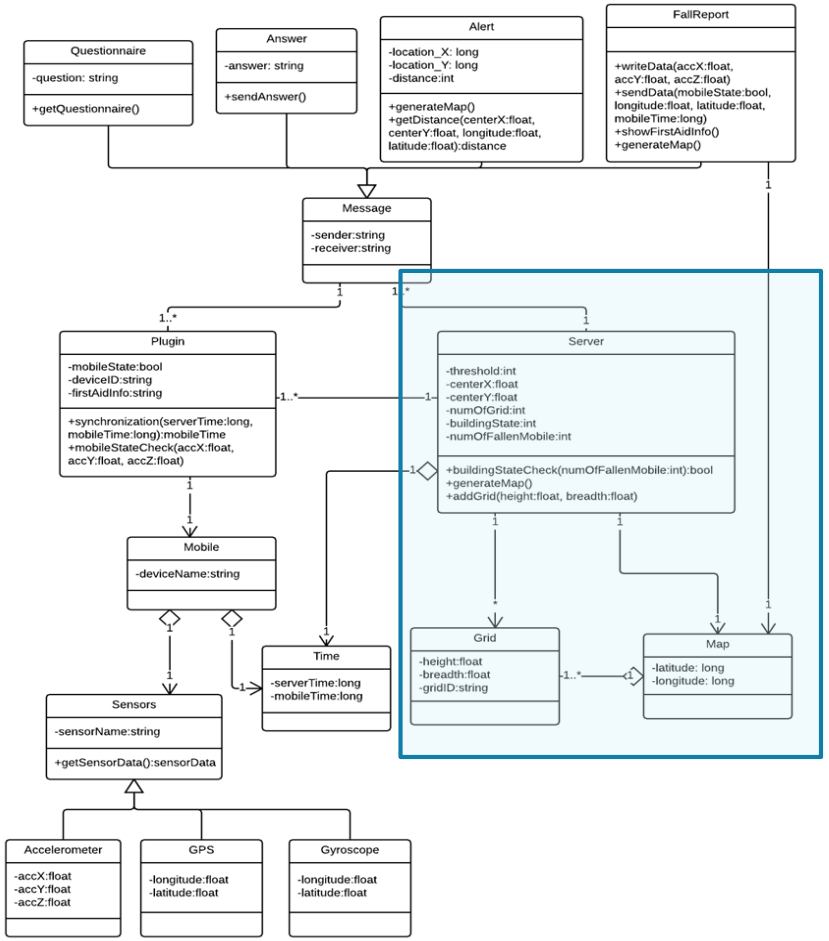
- Researcher
  - Collect smartphone data
  - Check status of smartphones
  - Check collapsed buildings
  - Download data for processing

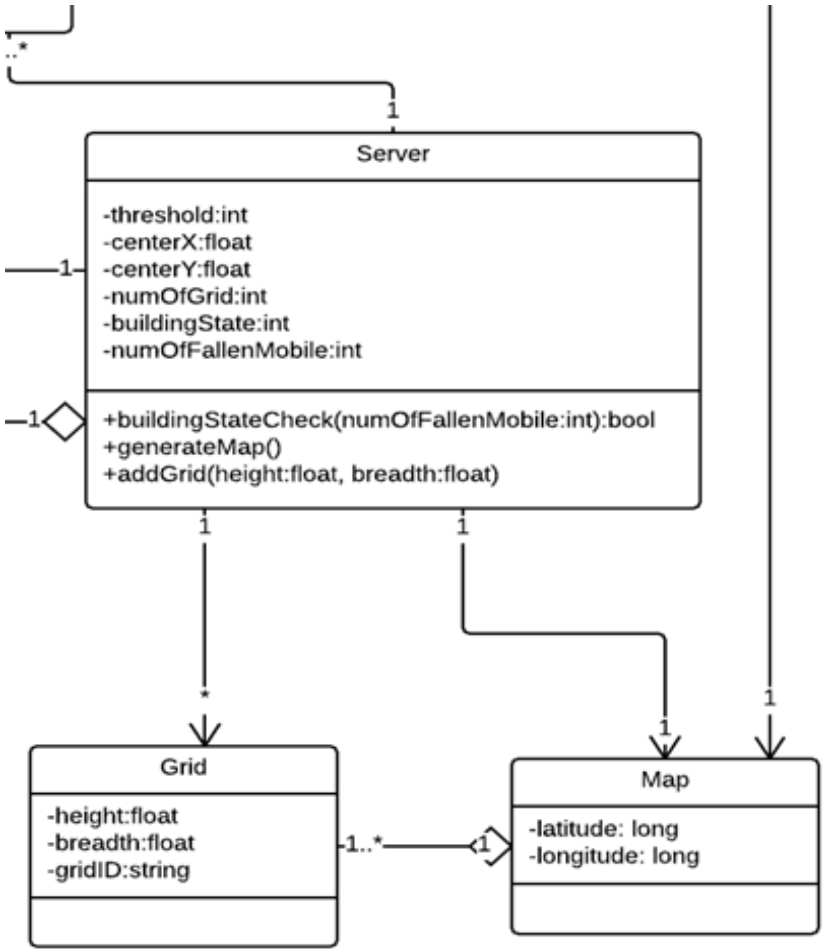
USE CASES (2)



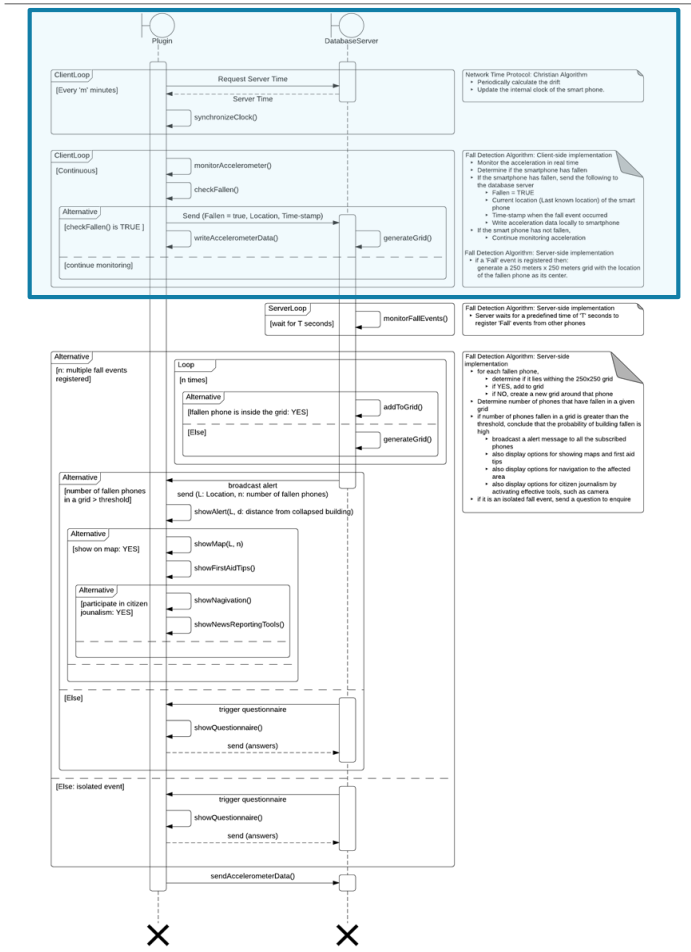
- Plugin ‹‹ system ››
  - Synchronize time
  - Get sensor data
  - Check phone fallen
  - Write data locally
  - Send data to server
  - Show alert
  - Show map

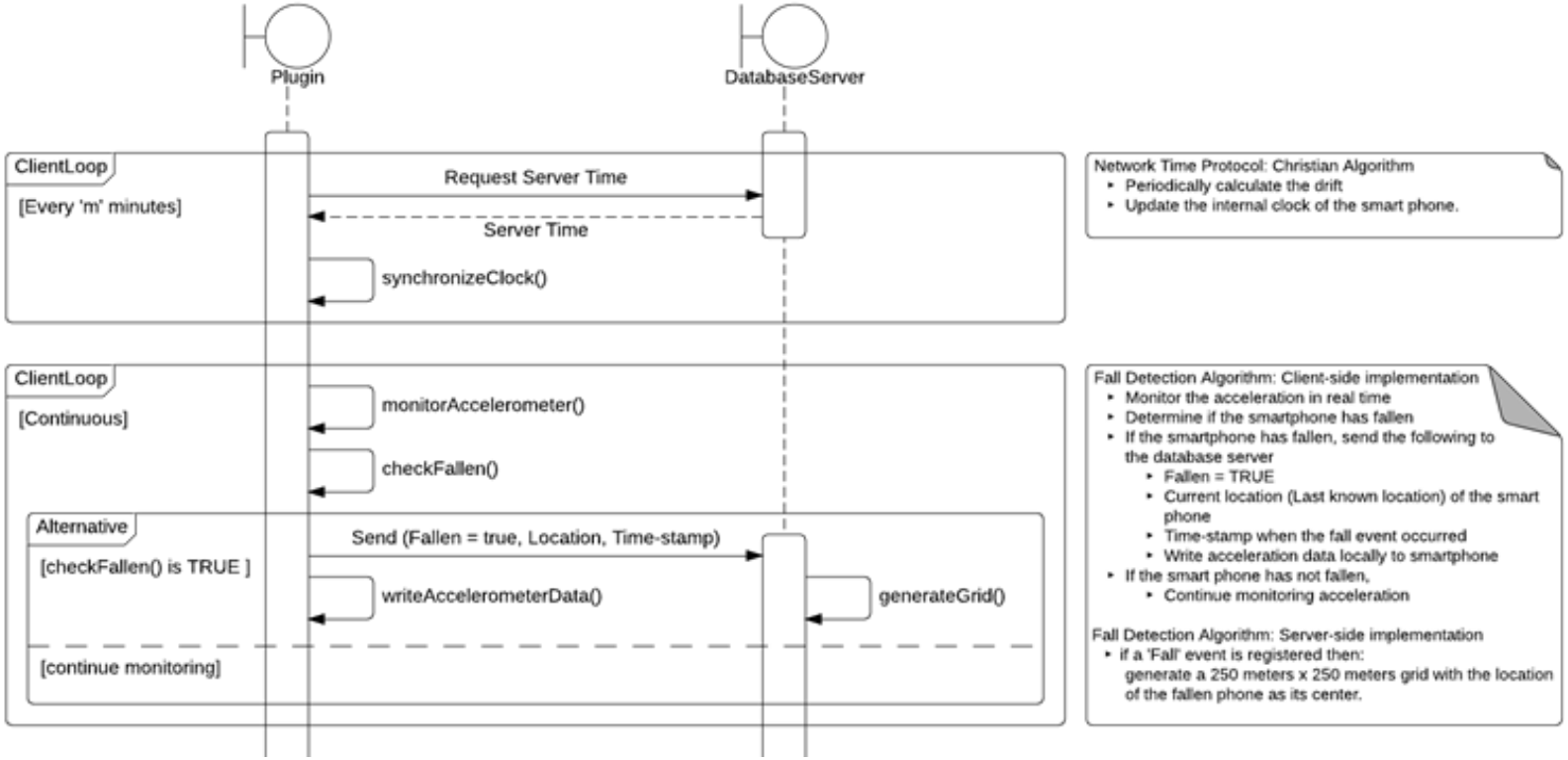
CLASS DIAGRAM





SEQUENCE DIAGRAM

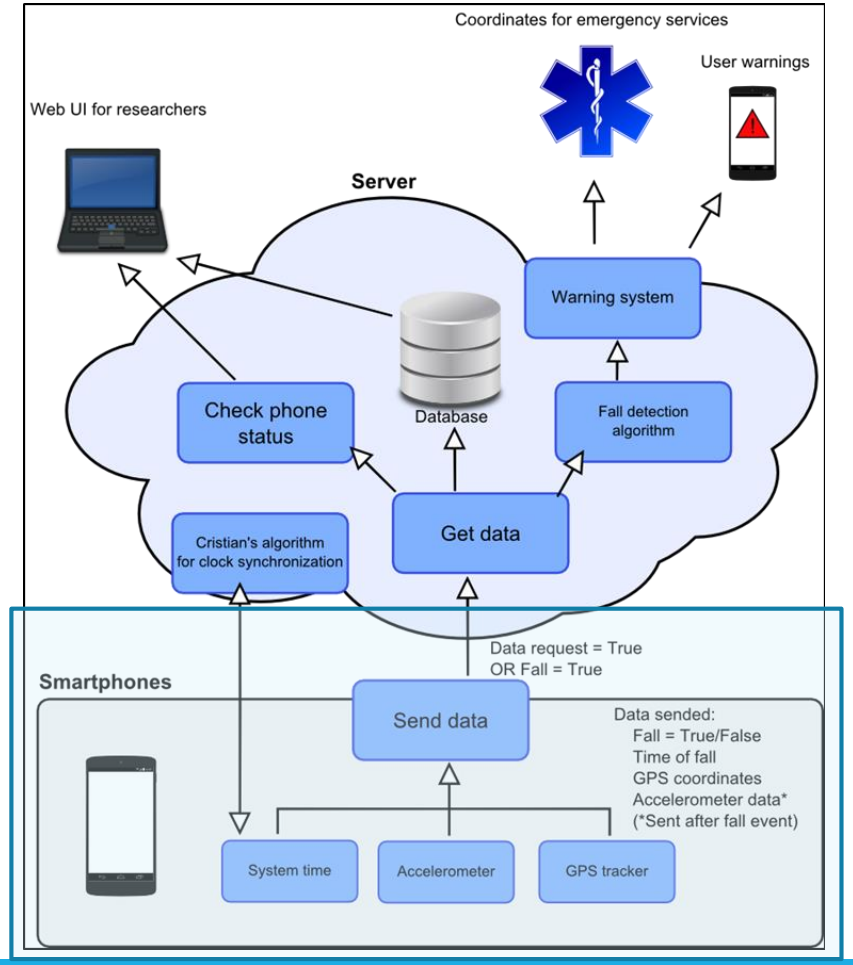


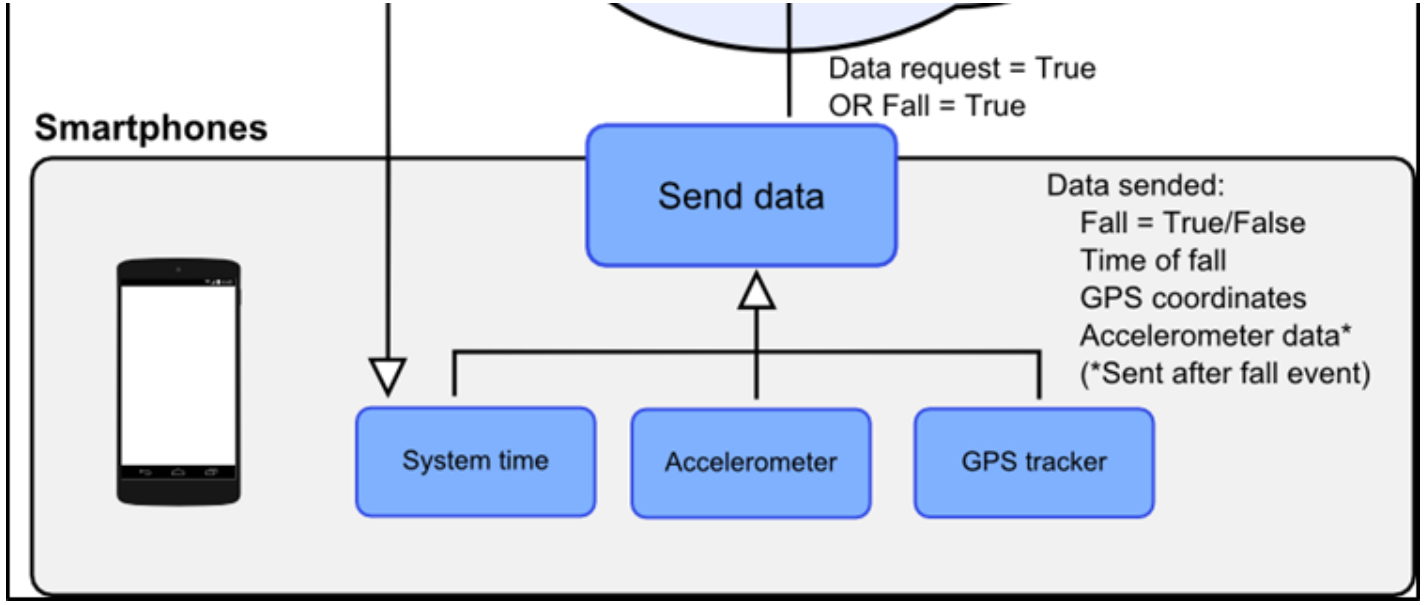


SYSTEM DESIGN

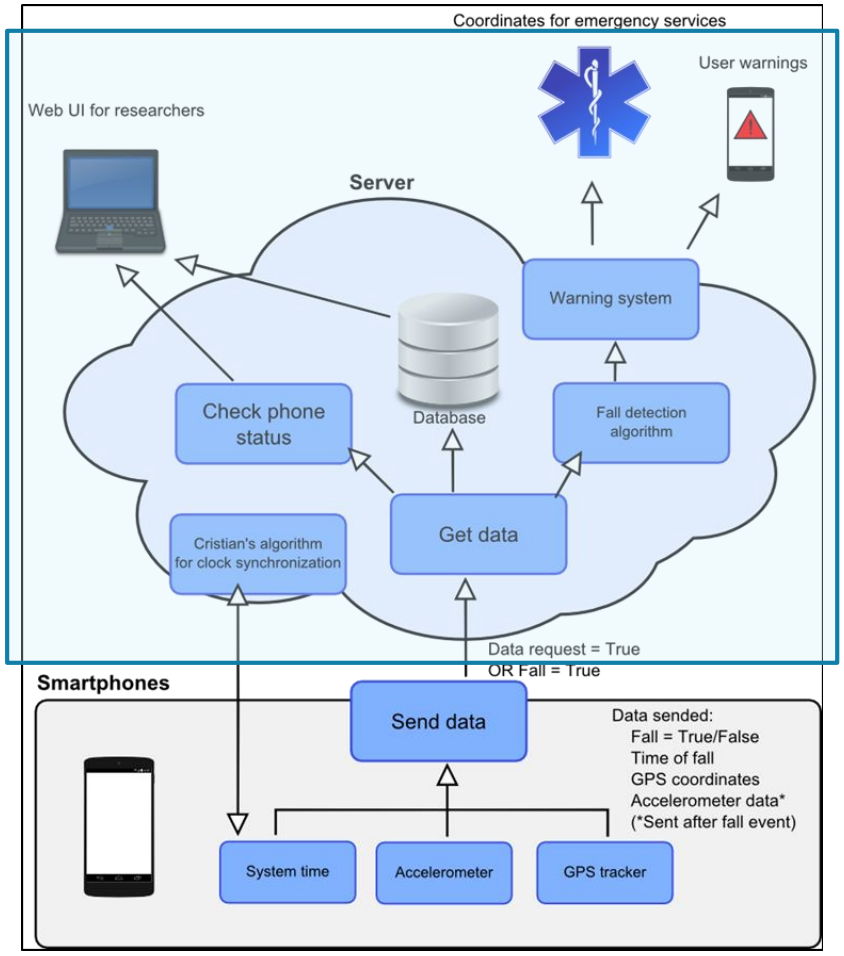
- OVERVIEW
- SMARTPHONES
- AWARE FRAMEWORK

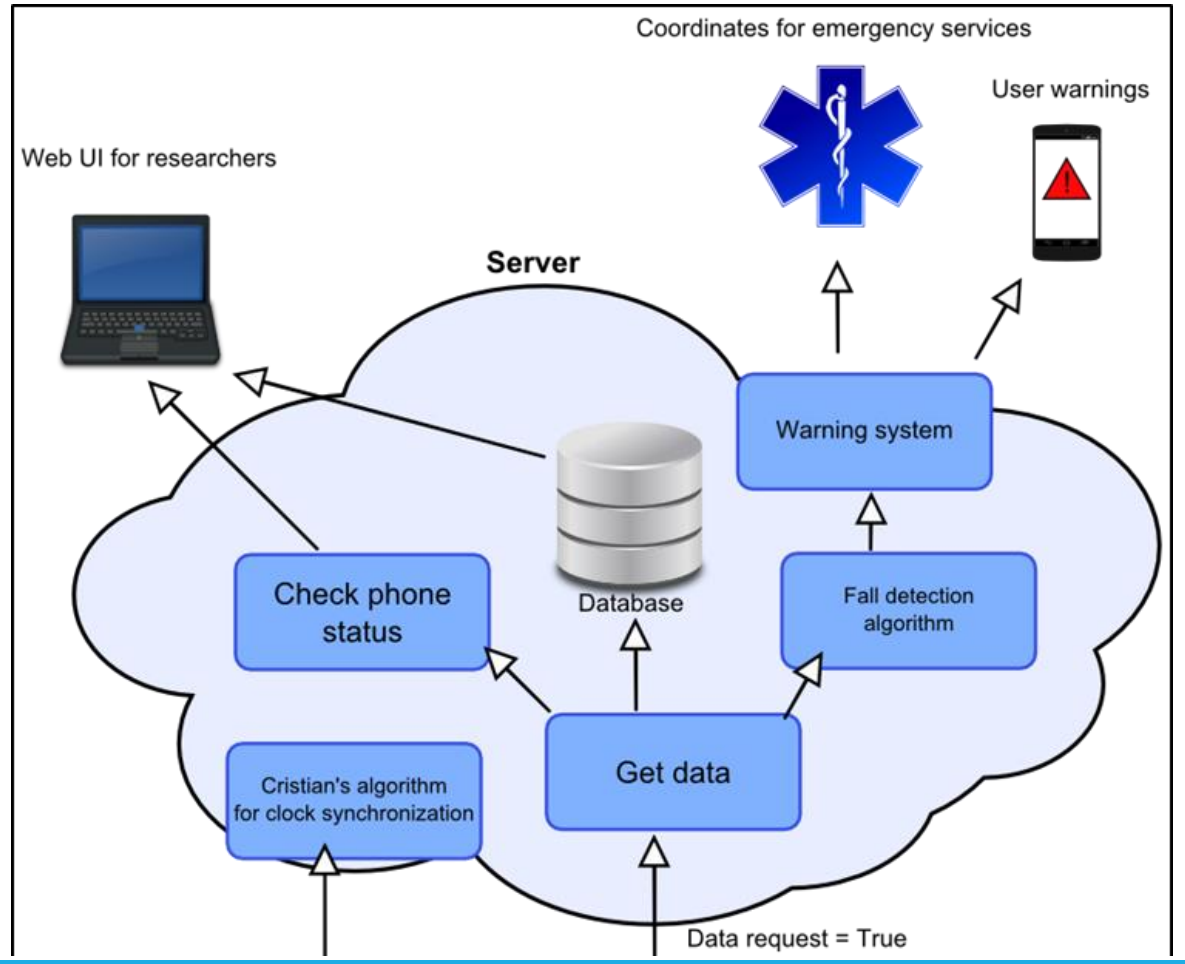
OVERVIEW


Coordinates for emergency services
User warnings
Web UI for researchers
Server
Warning system
Check phone status
Database
Fall detection algorithm
Cristian's algorithm for clock synchronization
Get data
Data request = True
OR Fall = True
Smartphones
Send data
Data sended:
Fall = True/False
Time of fall
GPS coordinates
Accelerometer data*
(*Sent after fall event)
System time
Accelerometer
GPS tracker

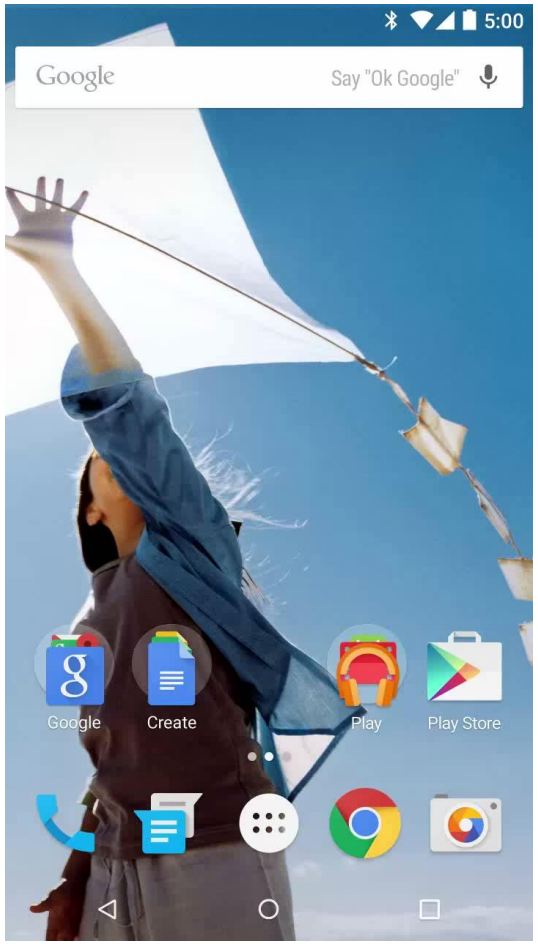

Data request = True
OR Fall = True
Smartphones
Send data
Data sended:
Fall = True/False
Time of fall
GPS coordinates
Accelerometer data*
(*Sent after fall event)
System time
Accelerometer
GPS tracker

OVERVIEW



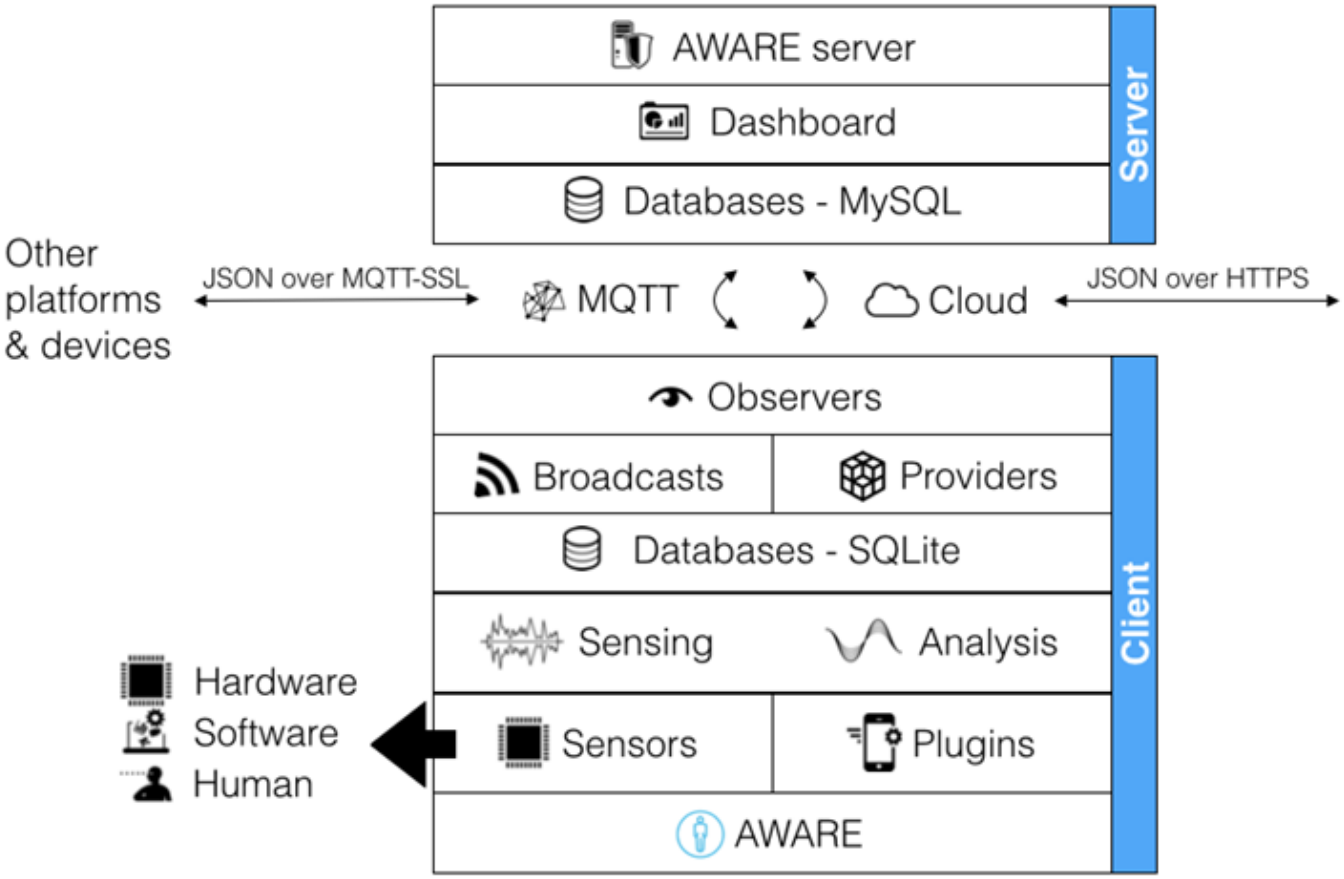


SMARTPHONES



- Platform - Android
- Sensors
  - 3-axis accelerometers and gyroscope
  - Sampling between 50 Hz and 100 Hz
  - Magnitude 5 achieve acceleration of 0.5 m/s^2,
  - Magnitude 6 roughly 1.5 m/s^2
- Android Play Store for apps

AWARE FRAMEWORK



- Platform – Android
- Logging, sharing, and reusing
- Easy Data storage and access
- Supports plugin development
- Intuitive dashboard for conducting research studies

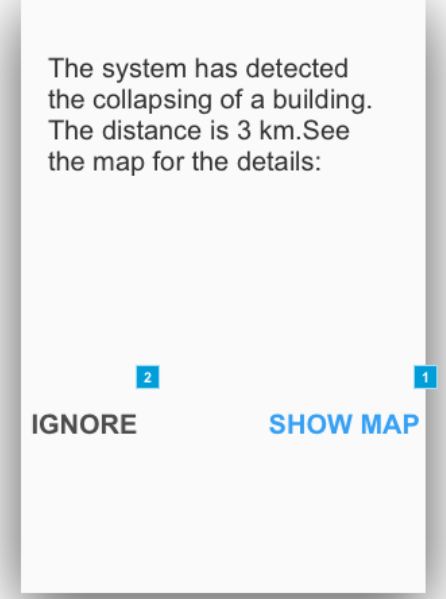
INTERFACE DESIGN

- DESIGN PATTERNS
- MOBILE USER INTERFACE
- WEB USER INTERFACE

DESIGN PATTERNS

ANDROID DESIGN PATTERN LIBRARY

YAHOO DESIGN PATTERN LIBRARY


The system has detected the collapsing of a building. The distance is 3 km.See the map for the details:
IGNORE
SHOW MAP

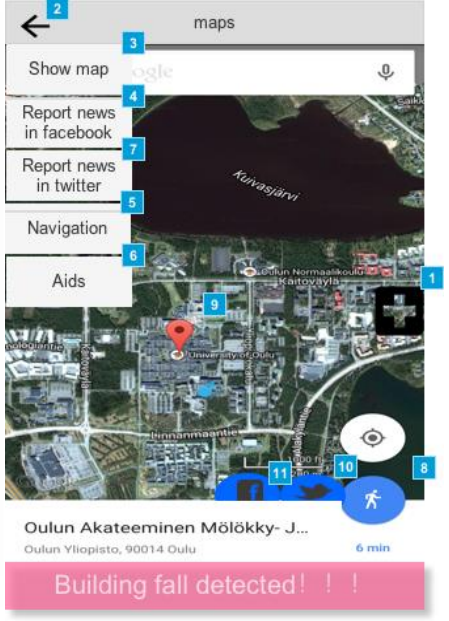
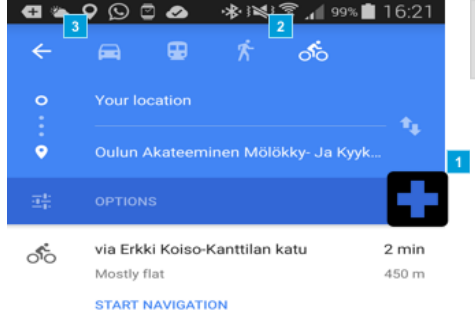
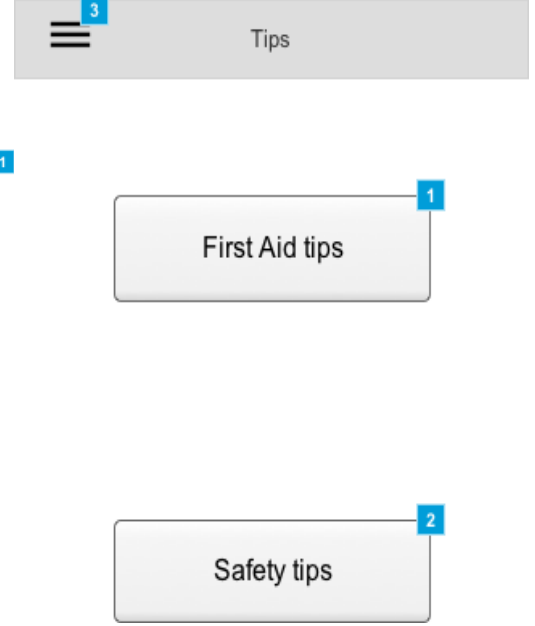
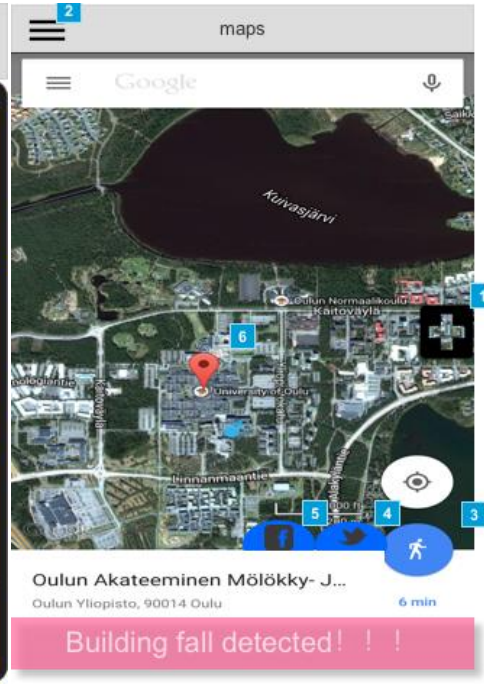

maps
Show map
Report news in facebook
Report news in twitter
Navigation
Aids
Oulun Akateeminen Mölökky- J...
Oulun Yliopisto, 90014 Oulu
6 min
Building fall detected! ! !

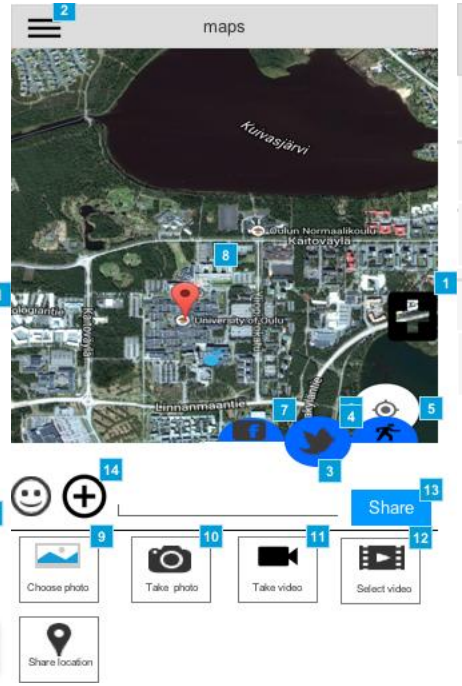

Image
Done
Show map
Report news in facebook
Report news in twitter
Navigation
Aids

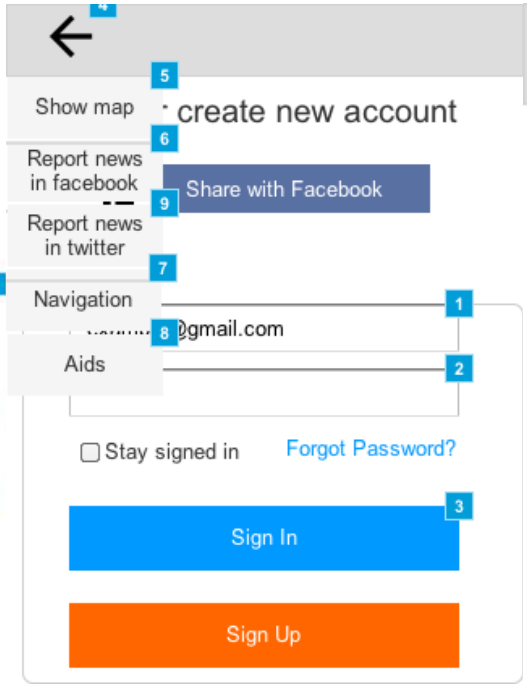

Your location
Oulun Akateeminen Mölökky- Ja Kyyk...
OPTIONS
via Erkki Koiso-Kanttilan katu
2 min
Mostly flat
450 m
START NAVIGATION

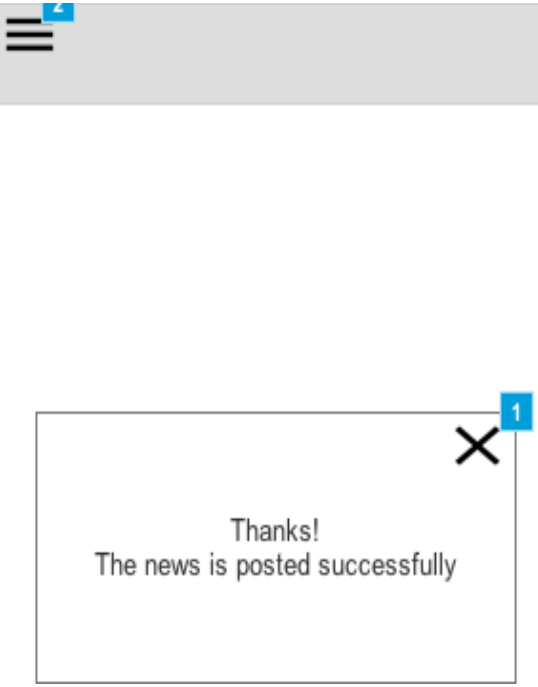

Tips
First Aid tips
Safety tips

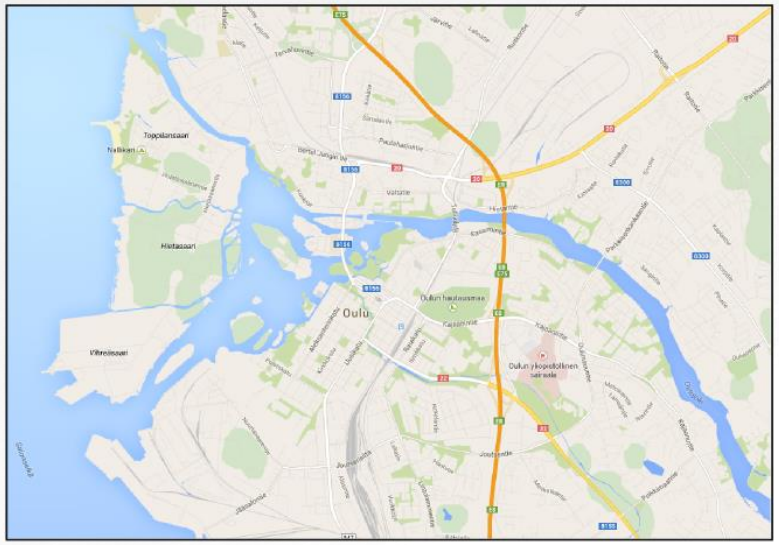

Safety tips
What to do during an earthquake
DROP!
COVER!
HOLD ON!
CALM DOWN
Try to stay as calm as possible
INSIDE
Stay away from furniture, windows and lamps
OUTSIDE
Stay away from buildings, walls and power poles
STOP
If you are driving stop in a safe place, turn on the hazard lights and stay inside the vehicle
If you use a wheelchair, put the brakes on in a safe place and protect your head with your arms
If you are in a crowded place protect your head with your arms or take cover under seats and tables


maps
Oulun Akateeminen Mölökky- J...
Oulun Yliopisto, 90014 Oulu
6 min
Building fall detected! ! !


maps
Share
Choose photo
Take photo
Take video
Select video
Share location

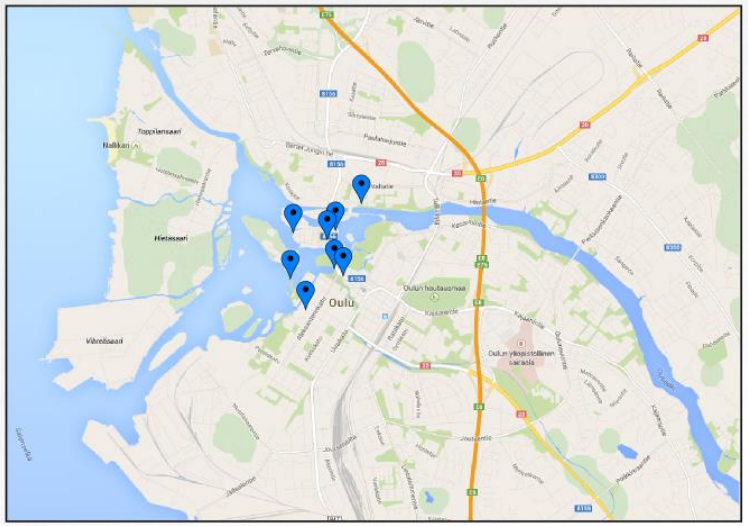

Show map
Report news in facebook
Report news in twitter
Navigation
Aids
create new account
Share with Facebook
@gmail.com
Stay signed in
Forgot Password?
Sign In
Sign Up


Thanks!
The news is posted successfully



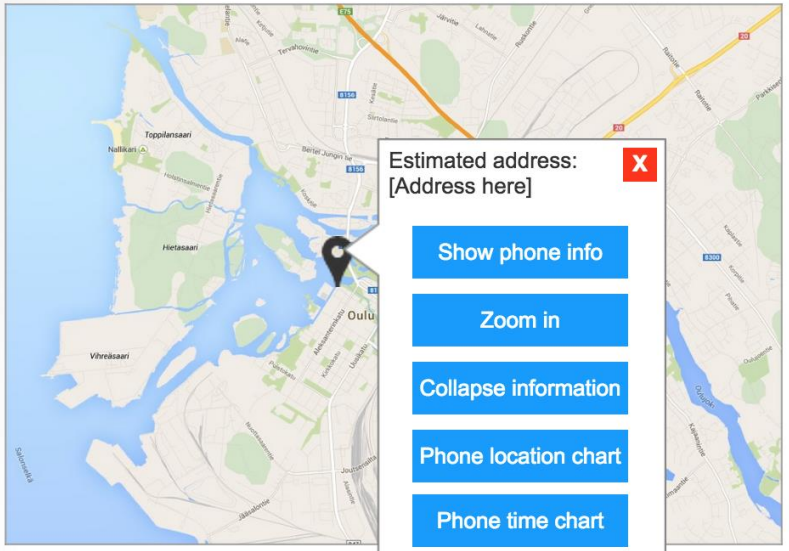
Select time pediod:

Day Month Year — Day Month Year



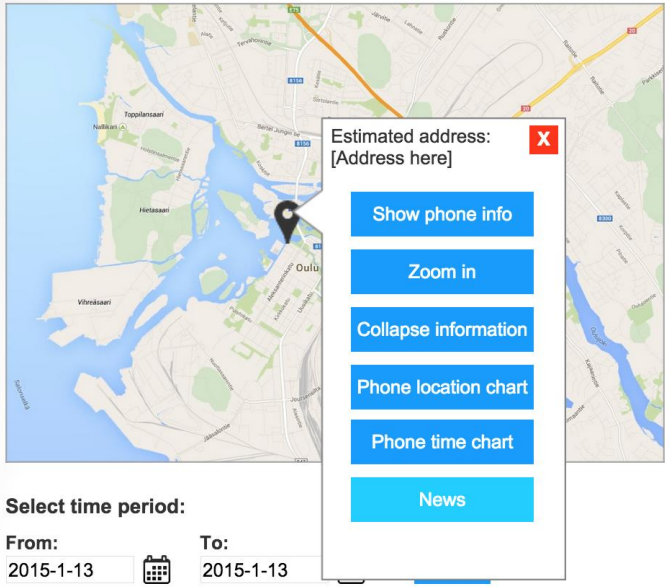
Select time pediod:

2 1 2015 — 25 1 2015



Select time period:

From: 2015-1-13 **To:** 2015-1-13

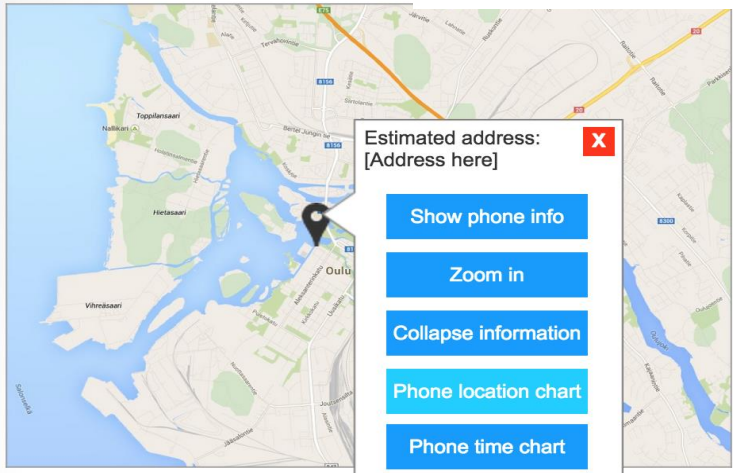


Select time period:

From: 2015-1-13 **To:** 2015-1-13

News from collapse:

- Building collapse at Oulu
- Large building destroyed 10 people in hospital
- Should earthquakes be banned?
- Earthquake in Oulu Finland



Select time period:

From: 2015-1-13 **To:** 2015-1-13

Phone location chart:

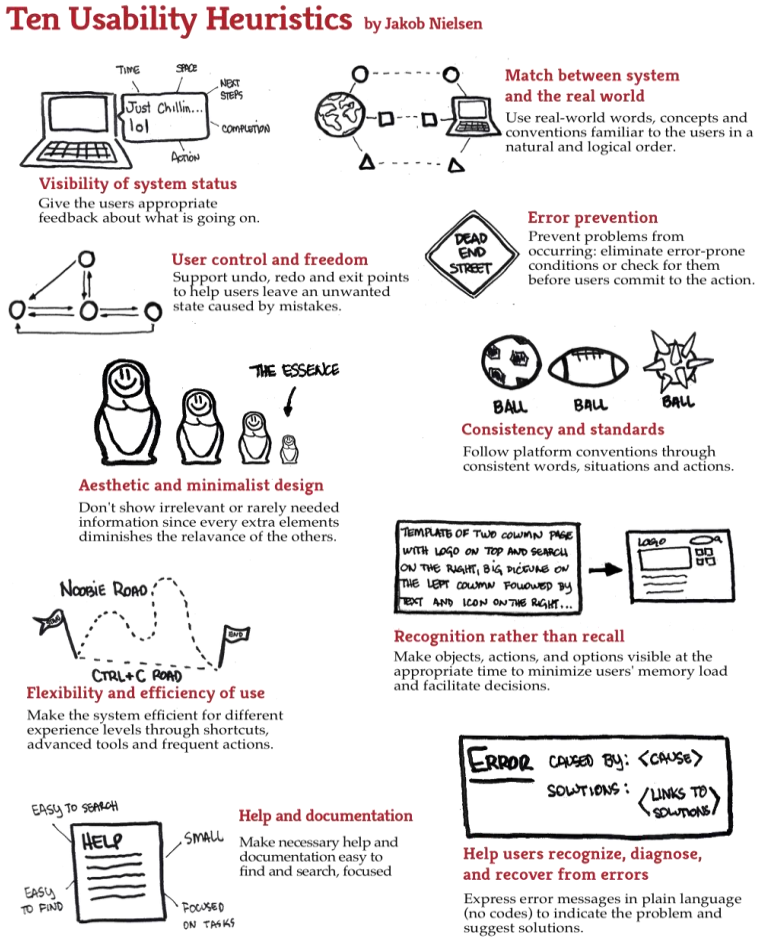
Phone number	Longitude	Latitude
1	32472, 29837	32472, 29837
2	32472, 29837	32472, 29837
3	32472, 29837	32472, 29837
4	32472, 29837	32472, 29837
5	32472, 29837	32472, 29837

Download table

EVALUATION

- HEURISTIC EVALUATION
- METHODOLOGY

HEURISTIC EVALUATION



- 10 Heuristics
  - Visibility of system status
  - Match between system and the real world
  - User control and freedom
  - Consistency and standards
  - Error prevention
  - Recognition rather than recall
  - Flexibility and efficiency of use
  - Aesthetic and minimalist design
  - Help users recognize, diagnose, recover from error
  - Help and documentation

METHODOLOGY (WEB UI)

- Design
  - A scenario and 3 tasks for the evaluator to perform
- Task 1
  - Find the total number of collapsed building.
- Task 2
  - Find the total number of phones that detected the collapse of the State Tower building.
- Task 3
  - Find news articles posted by the locals during the earthquake.

METHODOLOGY (MOBILE UI)

- Design
  - A scenario and 3 goals for the evaluators to achieve
- Goal 1
  - Users should be able to determine their distance from the building collapsed site.
- Goal 2
  - Users should be able to navigate to the building collapsed site.
- Goal 3
  - User should be able to access first-aid and safety information.

CHALLENGES

- SERVER-SIDE IMPLEMENTATION
- THRESHOLD VALUES
- TESTING

SERVER-SIDE IMPLEMENTATION

- Technical challenges
- Rely on server for classification – TRUE fall or ISOLATED fall
- Bandwidth limitation

THRESHOLD VALUES

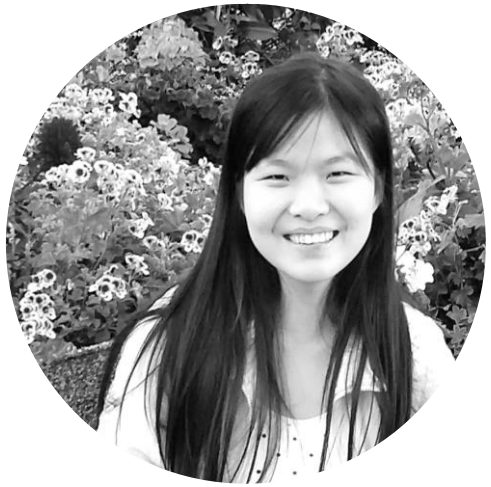
- Signal Chunking
  - Magnitude signal partitioned into several short signals of equal length
  - 0.1 seconds ?
- Total number of fall events
  - Should more than 1 concurrent fall events be categorized as TRUE fall ?

TESTING

- Simulating a Fall is easy – drop test
- How to simulate a 1000 phones scenario?
- Measurement
  - Time delays
  - Accuracy – number of False positives

CONTRIBUTIONS

- MEET THE TEAM
- INDIVIDUAL CONTRIBUTIONS



ZEYUN ZHU

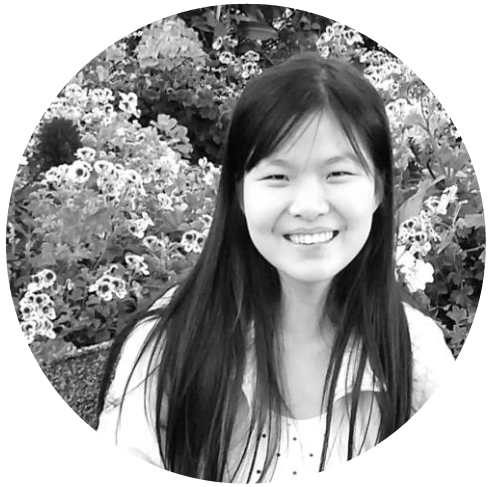
HAEJONG DONG

PERTTU PITKÄNEN

PRATYUSH PANDAB

MEET THE TEAM

DEPT. OF COMPUTER SCIENCE AND ENGINEERING, UNIVERSITY OF OULU



ZEYUN ZHU

Topic	Hours
Project Management	2
Literature Research	20
System Design	10
Mobile UI wireframes - paper	3
Mobile UI Axure prototypes	20
Report writing	10
Total	**65**

65 HOURS, 25.9% CONTRIBUTION

HAEJONG DONG

Topic	Hours
Literature Research	30
Case Study	10
Class Diagram	25
Expert Evaluation	3
Total	**68**

68 HOURS, 27.1% CONTRIBUTION

PERTTU PITKÄNEN

Topic	Hours
Literature Research	15
Case Study	8
System Design	10
Collapse detection algorithm	8
Web UI wireframes - paper	3
Web UI Axure prototypes	6
Presentation Slides	3
Total	**53**

53 HOURS, 21.1% CONTRIBUTION

PRATYUSH PANDAB

Topic	Hours
Literature Research	10
Requirements Analysis	7
Use Cases	5
Sequence Diagram	7
Collapse detection algorithm	10
System Design Architecture	10
Expert Evaluation	3
Report writing	13
Total	**65**

65 HOURS, 25.9% CONTRIBUTION

SPECIAL THANKS

TO PROF. VASSILIS KOSTAKOS, PROF. TIMO OJALA, AND AKU VISURI.

QUESTIONS ?

FEEDBACK AND DISCUSSION SESSION