University of Groningen

Software Architecture

Group 3

Smart Flood Monitoring

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Revision History

Version	Author	Date	Description
0.1	all	06-09-15	Setting up the working environment and the initial document structure. Draft versions of the first four chapters created, which are (respectively) Context, Architectural business information, Requirements and Analysis.
0.1.2	Menninga, ...	10-09-15	First version of functional requirements
~~0.1.3~~	~~Joris & Gerrit~~	~~13-09-15~~	~~Changed the context and enhanced the business~~ information
0.2	Brandsma Guntur	13-09-15 13-09-15	Updated the requirements part Updated the stakeholder of requirements part
0.2.1	Menninga Brandsma Klinkenberg	17-09-15 17-09-15 17-09-15	Updated the functional requirements Updated architectural vision and use-cases Updated technical requirements, some formattin

Is the "all ok? or do we need to split this up in multiple entries from all authors?

Contents

List of Figures

List of Tables

1 System Context

We are the architecture team of the company RugSAG3. Our team is specialized in making smart systems for environmental monitoring.

All around the world, natural disasters cause a lot of trouble. These disasters can result in catastrophic events that cause deaths and require a huge amount of money to repair the damages caused.

Climate change and extreme weather phenomena cause these floods to get worse every year. This causes the damage of the natural disasters to increase, which means that there is a great need for a system that can reduce this damage. There is a huge need for a system that will help the people during natural disasters like these, which is what this system aims to do.

The goal of our first product is to:

1. safe lives,
2. reduce damage costs,
3. reduce the social consequences.

In order to do this, the system tries to predict upcoming floods as correctly and accurately as possible. The system will provide warnings and guidance to the necessary people during and, if possible, before a flood. By using various kinds of sensors, vehicles and control units, this system monitors certain areas. If something suspicious is happening, the system will check and verify the information in order to not give false flood warnings. When a flood indeed occurs (or will occur), the system provides warnings and guidance to the necessary people during and, if possible, before a flood.

To achieve the aforementioned goals, the system will provide predictions with regard to upcoming floods.

The first release of this system that we, as RugSAG3, build, will only focus on floods as a natural disaster. The system will provide warnings and guidance to the necessary people during and, if possible, before a flood. By using various kinds of sensors, vehicles and control units, this system monitors certain areas. If something suspicious is happens, the system will check and verify the information in order to not give false flood warnings. When a flood indeed occurs (or will occur), the system provides warnings and guidance to the necessary people during and, if possible, before a flood.

When this flood monitoring system works as planned and shows that it can indeed reduce the damage of floods, new products will be made by our company that will focus on reducing the damage of other kinds of natural disasters.

Over time, the system will reduce social, financial and human losses of natural disasters, starting with floods. This will revolutionize the way we think about natural disasters. Though the market around environmental monitoring is very competitive, this system aims at being a core part of future monitoring systems by being as dynamic and flexible as possible. Thereby allowing new features to be added easily, allowing the system to grow over time, including new upcoming user needs.

2 Architectural business information

The following section describes the different aspects of the business environment of the Smart Flood Monitor. First we will explain our vision and why there is place for us at the market. After this the product and its customers will be explained. This chapter is completed with a more detailed look at the business model and some models about the market and the financial prospect.

2.1 Business opportunity

There are many natural disasters happening each year all over the world. Each year these disasters take lives, waste a lot of properties and money and cause social disturbance. It is expected that natural disasters will cause $300 billion in losses annually in the upcoming decade. Climate change causes the natural disasters to get worse every year. Also the number of natural disasters has increased significantly since 1970.
Looking at, for example, the Indian ocean's tsunami in 2004, it looks that the damage could have been significantly reduced if the necessary people were warned. A system that would reduce the damage of natural disaster, could result in billions.
A system that warns and guides the people before or during the floods can result in billions being saved and will save a lot of lives.

2.2 Vision statement

The Smart Flood Monitor will cause a revolutionary innovation on the environmental monitoring market. RugSAG3 will offer a system which can detect floods early and correctly. This system helps us to enforce our vision, to limit the social and financial consequences of floods and avoid the loss of human lives.

RugSAG3 will not be the only player on the environmental monitoring market as there are a lot of other competitors taking part on this area of expertise. This means RugSAG3 will have to take their own strength and weaknesses into account. If we combine these qualities with an analysis of the opportunities and weaknesses on the market, we should be able to become a core part of the future environmental monitoring systems.

We try to map our position on the market by using SWOT-analysis. This analysis will map our strengths, weaknesses, opportunities, and threats as described as follows:

Strengths
: Diverse team with several skills in IT and management. Experience with working with sensors.

Weaknesses
: No experience with creating such system. Less knowledge about floods and environmental sciences. The product is a complex system.

Opportunities
: Due to climate change, the market will grow and such a system becomes more urgent. Few competitors in the market. Smart sensors are a hot topic, new sensors will be developed.

Threats
: High production costs. Competitors will enter the market because of growing market. Climate change will force to improve the system over time.

Our unique selling point is to provide a system with low selling price and high profit from the service contracts and upgrades.

	Helpful (to achieve the objective)	Harmful (to achieve the objective)
Internal origin (product/company attributes)	S • Adjustable system that is future proof • Having a low selling price. Lower then the competitors • Diverse team with several skills in IT and management • Having a good management team • Frequent discussion with technical and business experts in the field. • Experience with working with sensors	W • Decisions need to be made by the entire project team. There is a higher chance of a difference of opinion is members, holding back the project and leads to time wastes • No experience with creating such system • No knowledge of floods • The product is a complex system • Some main features rely on country-specific systems
External origin (environment/market attributes)	O • Due to climate change, the market will grow and such a system becomes more urgent • Few competitors in the market • With a bigger program team, the pros and cons of the decisions are more clear • Allowing the system to be flexible so it can also be used for other kinds of monitoring activities • Smart sensors are a hot topic, new sensors will be developed. Making the system support and use the newest sensors allows it to obtain more, and a wider variety of valuable information	T • High production costs • Competitors will enter the market because of growing market • New competitors will enter the market • Climate change will forces the system to be improved over time. • Changes of the external systems that our system uses to properly communicate. • The sizes of certain area's to monitor can be too big to get a good and reliable view of them

Figure 2.1: SWOT-analysis diagram.

2.3 Business rationale

RugSAG3 will develop a new flood warning system in order to minimize the damage caused by a flood. In the Netherlands protection against floods is an important issue, because the position of the Netherlands itself is actually below sea level. Global warming will increase the urgency of this issue. The people within the Netherlands must be well protected against floods. The flood warning system will detect floods, warn people and governmental institutions located in the disaster area and provide guidance where to go to.

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RugSAG3 is new within the flood warning system market. By using sensors and automated systems, a reliable and adequate product that uses of the newest technologies will be launched. RugSAG3 will use hardware which is already on the market and is tested. Buying third party hardware will also speedup the development of the system and lower the costs.

The product price will be low in order to get a market share and prove the product in a real-time environment. By providing maintenance and updates in the future RugSAG3 will earn money to improve the product further and sell it to other potential customers. This in combination with the increasing need of a reliable warning system for imminent floods will result in a viable business.

The unique selling points of our system are:

- To provide a system with low selling price and high profit from the service contracts and upgrades.
- Warn the people in and around the area as soon as possible if the system is very certain that a flood is or will happen.
- Inform people about the details of the flood so the right preparations are made.
- Inform people how to save themselves, others or goods.

This way, people will know when an area gets flooded, or when it is about to happen. People who requested it, will get informed on how to prepare for the flood and what to do during the flood.
These features are things that are be unique for our system and that make it successful. The main goal of this project, however, is to safe lives, reduce costs and reduce social consequences. These main goals will be met when:

1. 80% of the people in a dangerous area regarding a flood, receive a warning message. This message must contain enough information for receivers to know whether they are save or not and if not, how they can get to a save location.
2. 80% of the people who receive a warning successfully get to a safe environment in time.
3. 80% of the people receiving information before or during a flood, find these messages helpful and reported that it guided them successfully in order to save extra lives and/or goods.

When the first version of Smart Monitoring is released and is used to start monitoring actual floods, its success will be measured according these statistics. Getting a warning message to the people who need to be warned is the most important thing to do. Using this warning message, people can move to a saver location.

2.3.1 Scope of Initial and subsequent releases

The initial release will only focus on floods as a natural disaster. It will send warnings to the necessary people, but will not yet interact much with the user. The system, however, doesn't stop there, and will get increasingly more capabilities. The extra capabilities of system include:

- Support for more kinds natural disasters
- More individual guidance
- Interaction with the system, users can give input
- Adding more sensor support
- Using multiple communication networks to send information

The first thing RugSAG3 will focus on after the first release, is to let users interact with the system more. This will allow the system to have better knowledge of the area. However, mistakes can easily be made by a user and so this data needs to be verified in order to get valuable information. That is why adding this feature goes beyond the scope of this project.

Adding sensor support is a continuous process. The sensors that are available are steadily increasing and their technology becomes more advanced. RugSAG3 will monitor the sensor technologies and improvements to check if these can improve the system.
Depending on where the system resides, it will need to interact with various kinds of networks en media. Initially the flood warning system will focus on communicating with resources in the Netherlands. However, if a future release implements additional support for monitoring tornadoes or volcanoes, the system will most likely not be in the Netherlands.

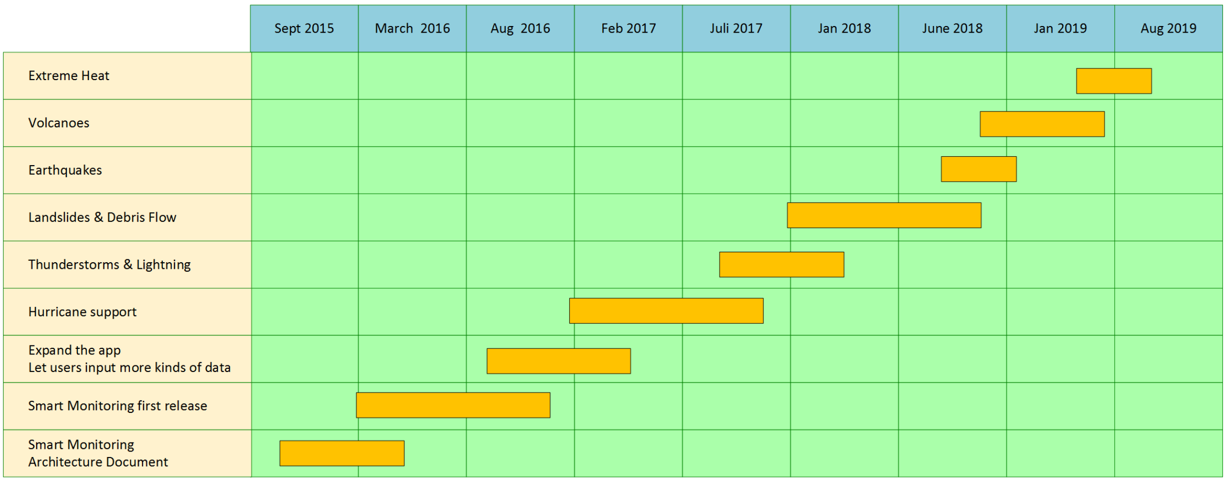

Figure 2.2: Future releases.

2.4 Product and service description

RugSAG3 offers a flood warning system. When a imminent flood is monitored by the sensors of the system a warning should be sent to governmental organizations and people within the danger area. Also guidance should be provided when a flood is happening to assist rescuers and guide inhabitants to safe areas.

Basically the system will consist of four subsystems: monitor the state of dykes and water levels, monitor if a imminent flood is occurring, warn governmental organizations and inhabitants in the danger area, and provide guidance to search and rescue organizations and inhabitants.

The first subsystem, monitor the state of dykes and water levels, will consist of various sensors that are placed near and in dykes and water ways. The state of the dikes must be monitored continuously, i.e. pressure of the dyke. Also, sensors must be installed to monitored continuously the water level. The data of all the sensors will be sent to a server, in a safe location, to store all the data.

The second subsystem, monitor if a imminent flood is occurring, will analyze all the data from the sensors and data from weather forecasting service. Based on this data an algorithm will monitor continuously if there are dangerous situations.

The third subsystem, warn governmental organizations and inhabitants in the danger area, will send warning messages when the algorithm identified a dangerous situations. The safety region —in Dutch Veiligheidsregio— will receive a warning message that an area is in danger. Information like place, sort danger and amount of danger will be send. The safety region will be responsible to take action based on this information. Inhabitants can receive warnings via sirens, mobile phone, radio, television, and by UAV.

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The last subsystem, provide guidance to search and rescue organizations and inhabitants, will help people that are in the danger area how to flee and rescue in a save way. Rescue organizations will receive information where are probably the most casualties and how to get safe to those locations.

The service will consist of maintenance for the product and upgrades.

2.5 Target audience

The Dutch Ministry of Infrastructure and the Environment is the target customer. They have the responsibility in the government to identify unsafe situations caused by floods. When this ministry wants a new warning system they need to start a procurement. This gives the opportunity for various companies to bid on the procurement. At first the Dutch Ministry is our target audience, later on the product can be sold to other countries.

2.6 Road maps

The Dutch Ministry of Infrastructure and the Environment will end the procurement of a flood warning system on 31-12-2015. The bid must consists of the design of the system and a financial analysis must be made. The engineering part of the system will be finished on 31-12-2016. An operating system is then up and running.

Directly after finishing the initial product, new features will be developed and can be sold.

After this first step there will tried to market the system to other countries in the world.

2.7 Financial model

The financial model will be a low product price. This in order to price the product low in the market. A service description for maintenance will be offered. Also updates will be sold to the customer

2.7.1 Software Architecture costs

The software architecture team consists of seven members. The project will last 10 weeks. All team members will spend 15 hours a week on the project. This totals 1050 working hours. Each working hour costs €150,-. Total spend on the software architecture is €157.500

2.7.2 Development costs

2.7.3 Hardware costs

2.7.4 Total costs

2.8 Competitors

Siemens designed a flood-warning system via SMS in Belgium.

3 Requirements

This chapter will describe the vision and use it to derive stakeholders to be able to properly write use cases and stories. These will be used to extract functional, commercial, technical and evolution requirements. Afterwards, a risk assessment will take place, to ensure that the project is not at great risk.

3.1 Architectural vision

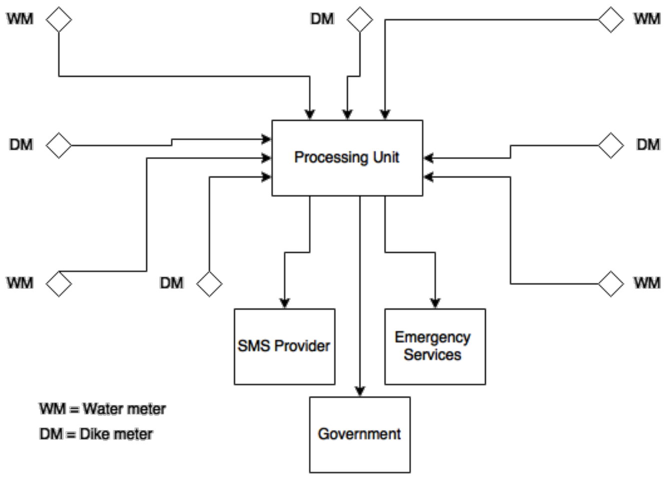

Figure 3.1: Schematic overview of the flood monitoring system

The smart flood monitoring system consists of multiple parts. First of all there is the monitoring part. This part monitors the current state of the environment. To achieve this, we need a lot of data. This data is obtained by sensors and weather data. We use sensors to get the current water level of waterways. We also measure the density and structure of dikes. The data that is obtained through all sensors will be automatically processed. The processed information represents a risk level for the area in which the system is deployed.

In case of an imminent flood a warning will be issued to the government and the citizens who live in the threatened area. We do this by issuing a warning to the government. In their turn the government uses their infrastructure to warn the citizens. In the Netherlands this infrastructure consists of a siren system and an SMS-system. Besides this people can also apply for our service. People who are subscribed to this service will receive a text message with more information about the (imminent) flood.

In case of a real flood the citizens who subscribed to our service will receive a text message with a route to a safe area. These text messages are personalized to the citizens. This means that when a flood happens, different people will have different routes to get to safety.

3.2 Stakeholders and their concerns

There are eight stakeholders who are involved in our system. The stakeholders are ranged from first parties to third parties stakeholders. Detailed description is written below.

Product owner is concerned about reliability, profitability, affordability. Product owner funds the whole project. Product owner highly concerns about the profitability. Thus, to gain big market share and extract large profit from this product, product owner has to make this product reliable. Furthermore, to compete with other competitors in this area, affordability will also be another concern.

Developers are concerned about reliability, maintainability, and testability. We, the architect team of RugSAG3 company, are also part of this. This stakeholder is responsible for the development of the systems until its ready for production. Including architecting, designing, analyzing, testing and implementing this Smart Flood Monitoring System.

Competitors are concerned about reliability, adaptability, profitability, and affordability. Competitors give negative effect on the system because competitors will be aiming on the same customer target. On the other hand, competitors are also triggering us to make a really good system in order to be able to compete with them and to save more lives. Thus, competitors must also be kept in consideration.

Government is concerned about reliability, adaptability, and affortability. Government will be the main customer of this product, specifically, The Dutch Ministry of Infrastructure and the Environment. Government will be part of mitigation when the flood is imminent. This system will help the government by notifying them when this system detects flood and what is the recommendations to do next along with some data regarding this system's findings.

Citizens are concerned about reliability and adaptability. The Dutch residents are indirect user of this systems. However, they are also able to directly subscribe to this service and thus they want this system to be adaptable to their current technological viewpoint. Furthermore, they want this system to run correctly and notify them with the reliable information.

Insurance companies are concerned about reliability of this system. The damages caused by flood sometimes are also covered by the insurance companies. Thus, the insurance companies will also be part of the stakeholders and they will make sure that their business is running well.

Local companies are concerned about reliability and adaptability. Local companies will also be affected by the flood, they also have a lot of resources that are in danger. Local companies want to know whether or not this system is reliable so that they can arrange a proper action sets when the flood comes to save their assets. Moreover, local companies are also willing this system to be as adaptable as possible to their current technological viewpoint.

Emergency services are concerned about reliability, adaptability, and testability. Emergency services are important when any accident happens, including flood. They will be really concerned about the thing that makes this system reliable, adaptable to their current system, and could be tested in order to make sure things are running correctly.

Table 3.1 illustrates the stakeholder concern matrix. In our approach every stakeholders are equally the same. Thus, each stakeholder receives 100 points in total that has to be distributed among all the concerns.

Table 3.1: Matrix of stakeholders concern.

Stakeholder	**Concerns**					
	Reliability	Adaptability	Profitability	Affordability	Maintainability	Testability
Product owner	30		40	30		
Developers	40				30	30
Competitors	25	25	25	25		
Government	55			45		
Citizens	70	30				
Insurance companies	100					
Local companies	75	25				
Emergency services	45	30				25
Total	440	110	65	100	30	55

As can be seen from Table 3.1, the most important concern of our system is the reliability, following adaptability as the second most important concern. This is also identical with our significant key driver.

3.3 Stories and use-cases

3.3.1 A citizen receives a warning about an upcoming flood

Scope: Warning part of the system

Level: Main process

Primary actor: Citizen

Stakeholders and interests:

1. Citizens - citizens want to be warned in case of a flood

Precondition: There is an upcoming flood and the citizens are not warned
Postcondition: There is an upcoming flood and the citizens are warned

Main succes scenario:
1 - The sensors send the data to the processing unit.
2 - The processing unit determines there is an imminent flood.
3 - The processing unit generates a map with vulnerable areas.
4 - A text message with a warning is send to all subscribers in the vulnerable area.

Extensions:
2a - The flood doesn't get to dangerous, it retreats. No warning mechanism is triggered.
4a - The citizen is not in the vulnerable area. No text message is send.

Discussion on main succes scenario step 4: How do we send a warning to the government. Also extension nr 5.

3.3.2 Government and emergency services receive a warning about an upcoming flood

Scope: Warning part of the system

Level: Main process

Primary actor: Government, Emergency services

Stakeholders and interests:
1. Government - the government wants to warn the citizens in case of a flood
2. Emergengy services - the emergency services want to help the citizens in times of need.

Precondition: There is an upcoming flood and the government and emergency services are not warned
Postcondition: There is an upcoming flood and the government and emergency services is warned

Main succes scenario:
1 - The sensors send their data to the processing unit.
2 - The processing unit determines there is an upcoming flood.
3 - The processing unit generates a map with vulnerable areas.
4 - A warning attachted with the map is send to the government and the emergency services.
5 - The system receives a confirmation that the government and the emergency services received the warning.

Extensions:
2a - The flood doesn't get to dangerous, it retreats. No warning mechanism is triggered.
5a - No confirmation is received within 15 seconds. Send warning message in another way.

3.3.3 A citizen requests guidance to get to a safe place in a flooded area

Scope: Guidance part of the system

Level: Main process

Primary actor: Citizen

Stakeholders and interests:

1. Citizens - citizens want to be guided to a safe place in case of a flood.

Precondition: There is a flood and the citizen is subscribed to the SMS service.
Postcondition: Citizen received his personal route to safety.

Main succes scenario:
1 - The processing unit determined there is a flood.
2 - The processing unit determines the optimal route for every known phone number.
3 - The processing unit turns this route into a MMS message with the right directions.
4 - The personal route is send through MMS message to all known phone numbers.

Extensions:
4a - MMS message can't be send. Wait a minute and try to resend.

3.3.4 The system receives data from the weather forecast service

Scope: Monitoring part of the system

Level: Main process

Primary actor: Developers

Stakeholders and interests:
1. Developers - Developers would like to have a simple to use API.

Precondition: The system needs external data from a weather forecast service.
Postcondition: The system received the forecast data.

Main succes scenario:
1 - The processing unit determines it needs forecast weather data.
2 - A call is made to the weather forecast service.
3 - The weather forecast service returns the requested data.

Extensions:
3a - The data can't be returned. Repeat this process with another weather forecast service. If non is available, proceed monitoring without weather forecast data.

3.4 Functional requirements

Nr.	Prio	Description
FR-1	**Must**	The system is able to receive input from sensors with regards to the water level. This information will be used to determine if there is an imminent flood.
FR-2	**Must**	The system is able to process input from sensors with regards to the water level.

FR-3	**Must**	The system is able to receive input from sensors with regards to the pressure/consistency of the dykes.
FR-4	**Must**	The system is able to process input from sensors with regards to the pressure/consistency of the dykes. This information will be used to determine if there is an imminent flood.
FR-5	**Must**	The system retrieves weather forecasting data from weather forecasting services. The retrieved weather forecasting data consists of predictions about the precipitation and wind data and is used by the system to help in determining when a flood becomes imminent.
FR-6	**Must**	The system is able to detect when a flood is imminent by using the retrieved sensor data and weather forecasting data.
FR-7	**Must**	The system has access to geographic information, including road data and terrain height data.
FR-8	**Must**	The system can determine the area affected by a flood, by using the location data of the sensors and geographic information.
FR-9	**Must**	The system computes (from geographic information) the area which will be affected by a flood.
FR-10	**Must**	The system collects information pertaining to the severity of the flood: the expected water level, how fast the water level in the flood area will rise, and the number of civilians living in the affected area (population density).
FR-11	**Must**	The system provides emergency services with information about the flood. This includes the area affected by the flood and information needed to deduct the severity of the flood.
FR-12	**Must**	When a flood is imminent, the system sends a warning to the emergency services and to the authorities. The warning contains information about the area affected by the flood.
FR-13	**Must**	The system is able to compute a safe route, free of obstruction and floods, to a safe area, not affected by the flood, where citizens can be evacuated to in case of an (imminent) flood.
FR-14	**Must**	The system is able to receive and process input from sensors with regards to the pressure/consistency of the dykes. This information will be used to determine if there is an imminent flood.
FR-15	**Must**	Citizens who are subscribed for flood warnings are warned about imminent floods through by text message.
FR-16	**Must**	The system can determine the location of citizens who are subscribed for flood warnings.
FR-17	**Must**	Citizens who are subscribed for flood warnings get route information to a safe area by MMS.
FR-18	**Must**	The location of citizens who are warned through the app can be determined in order to supply them with a safe route to a safe area.
FR-19	**Must**	The system is able to predict the development of the water level. This information can be used to predict how fast a flood will develop.
FR-20	**Must**	The system uses different sources to confirm imminent flood warnings, in order to limit false positives.
FR-21	**Must**	The system can detect a faulty sensor, either when the sensor raises an error or when the data from the sensor is inconsistent with other sensor data.
FR-22	**Must**	There is a control panel, where an overview of warnings and errors of the system can be viewed.
FR-23	**Must**	The system can detect and report faulty sensors, so these sensors can be repaired or replaced.
FR-24	**Must**	In case of a flood, the system provides emergency services with safe routes to incident locations.

FR-25	**Must**	The system can determine the location of an emergency vehicle, so it is able to compute a safe route to incident locations.
FR-26	Optional	The system is able to detect extreme weather phenomena, like storms etc.

3.5 Quality attributes / non-functional requirements

Attribute priority:

Attribute	Score	Availability	Integrity	Interoperability	Performance	Reliability	Robustness	Security	Usability	Verifiability
Availability	8		<	<	<	<	<	<	<	<
Integrity	7			<	<	<	<	<	<	<
Interoperability	3				<	^	^	^	<	<
Performance	2					^	^	^	<	<
Reliability	5						^	<	<	<
Robustness	6							<	<	<
Security	4								<	<
Usability	3									<
Verifiability	1									

Nr.	**Prio**	**Description**
AVL-1	**Must**	The system shall be at least 99% available.
INT-1	**Must**	The system shall protect against unauthorized addition, deletion or modification of sensor data
INT-2	**Must**	The system shall verify unusual sensor data that shouldn't happen in normal situations, with at least one other sensor
INT-3	**Must**	The system shall send warning and guidance messages only in case of a flood

3.6 Technical non-functional requirements

This section describes the technical aspects that are important to the system as requirements. These requirements determine various APIs and programs that the system will rely on.

3.6.1 Reliability

Nr.	**Prio**	**Description**
REL-1	**Must**	Sensorsites are equiped with atleast two sensors
REL-2	**Must**	Data from the sensors is sent via a TCP connection

3.6.2 Resilience

The system needs to be resilliant to recover from errors and mistakes without impacting the systems functionality.

Nr.	**Prio**	**Description**
RES-1	**Must**	The system recognizes failures within half an hour
RES-2	**Must**	The system recovers from failures without the Quality of Service or the functionality of the system being affected.

RES-3	**Must**	The system continues to function with the same Quality of Service in a situation where up to 10% of the sensors suffer from failures.

3.6.3 Performance

Nr.	Prio	Description
PERF-1	**Must**	Data is transmitted from and to the system with a minimum speed of 10 megabits per second

3.6.4 Interoperability

Nr.	Prio	Description
INTR-1	**Must**	The system pulls weather forecasts from five weather forecasting services.
INTR-2	**Must**	The system pulls water forecasts from one water forecasting service.
INTR-3	**Must**	When the system detects a high risk of flood, it warns the government automatically using the government provided API.
INTR-4	**Must**	When the system detects a flood, it automatically tells emergency services where a flood is happening using the API provided by the emergency services.
INTR-5	**Must**	The system sends out a SMS to all users who are subscribed to flood warnings.
INTR-6	**Must**	The systems is able to easily connect to different sensors.

intr-6 Not measurable

3.6.5 Security

Nr.	Prio	Description
SEC-1	**Must**	Access to the system is restricted to user accounts that are stored in a database.
SEC-2	**Must**	User account information are hashed using bcrypt after being salted with 128 randomly generated characters.
SEC-3	**Must**	The system is protected by a firewall that at least scans at the application layer, while also scanning for and preventing DDoS attacks.
SEC-4	**Must**	All communication to, from and between different subsystems of the system are encrypted.
SEC-5	**Must**	The system communicates with it's sensors via a REST API that only allows for HTTPS connection.
SEC-6	**Must**	All system data must be backed up every 24 hours.
SEC-7	**Must**	Backup copies are stored in a secure location which is not in the same area as the system.

3.6.6 Scalability

Nr.	Prio	Description
SCALE-1	**Must**	The database and services run in parallel on a private cloud that is hosted within the Netherlands

SCALE-2	**Must**	Cassandra is used as database for the storage of the sensor data.
SCALE-3	**Must**	The system is configurable to run in different areas and with different sensors.

3.7 Risk assessment

The system is confronted by severals risks which are determined and mitigated in this section.

Nr.	**Description**
RISK-1	The warning system does not detect floods in time
RISK-2	The system sends warnings of a non-excising flood (false positive), making people more negligent to future messages.
RISK-3	The system can't send messages to the necessary people because the communication platform is also destroyed by the flood.
RISK-4	The system sends incorrect information, causing extra damage.
RISK-5	Hacker get access to the system
RISK-6	The sensors company become bankrupt
RISK-7	Competitors lowering their prices

4 Analysis

Assumptions:

- People requesting guidance have access to a phone that is either connected to a mobile network or to the internet
- The system is able to monitor various kinds of sensors
- The system has access to the internet
- The sensors are (in some way) connected to the system
- The system is able to use various kinds of sensors in order to predict floods.
- When the system has enough proof of a flood, the users will be informed in a timely manner (within 30 seconds maximal).
- People within a range of (30km?) will be warned about a detected flood
- The system uses multiple weather forecasting services to make its own predictions about possible upcoming floods.

Decisions:

- Security? (What if someone tries to manipulate a sensor?)
- One or multiple warning systems (failover)
- Networking? Redundancy of cables (trunked?)
- When to alarm? What to do if only 1 sensor warns about a flood?
- Security decisions?
- Operating system decision
- Storage decision
- Push or pull updates? (Pushing I'm hoping)
- Programming language(s) for the system? Web-interface, sensor monitoring, weather forecasting system, push notification system
- In what ways will the system detect a flood? Sensors, UAV's, forecasting?
- How to detect a flood based on the forecasting? Warn beforehand? Pay extra attention to the new upcoming flood by sending extra robots/uav's?

A higher score means a more favourable result. Meaning a high score for costs means a low cost for the system.

Name	**Linux**
Decision	**DEC- 1**
Status	**New**
Problem/Issue	The warning system software for the natural disasters need a platform to work on.
Decision	The warning system will use Linux as a platform. Based on Unix, Linux is a free platform that has proven itself and is used by many servers. It's open source meaning that everyone can check out how it works.
Alternatives	*Windows* Operating system is a closed platform developed by one of the biggest tech companies who provide a big development environment with it. *OpenBSD* A Unix-based system that is famous for it's proactive security and runs most of the Linux applications. However, some software packages aren't certified to run on OpenBSD, but are for Linux.
Arguments	

	Reliability	Resilience	Performance	Interopertability	Security	Scalability	Cost	**Score**
Weight	1	1	1	1	1	1	1	
Linux	4	4	4	4	4	4	4	28
Windows	3	2	3	2	3	3	1	17
OpenBSD	5	5	4	4	5	4	4	31

We either need to adjust some weights or we need to switch to OpenBSD. Also, I might be biased.

Name	**Connectivity of the sensors**
Decision	**DEC- 2**
Status	**New**
Problem/Issue	The sensors need to deliver their data to the system and are located outdoors with atleast 100m distance between each other.
Decision	The sensors will send their data to the system using mobile broadband. Using cellphone towers to communicate with the system.
Alternatives	*Landline* Connecting the sensors to the telephone network and use that network to communicate with the server.
Arguments	

	Reliability	Resilience	Performance	Interopertability	Security	Scalability	Cost	**Score**
Weight	1	1	1	1	1	1	1	
Mobile broadband	4	4	4	4	2	5	4	27
Landline	2	2	3	4	3	3	5	22
Satalite	3	1	2	4	4	4	3	21
Direct lines	2	1	5	2	5	1	1	17

Table 4.1: Decision – Cassandra Database.

Name	**Cassandra Database**
Decision	**DEC- 3**
Problem/Issue	A reliable database, which is the best in scalability and availability is needed to store our data for further processing and analysis.
Decision	Smart Flood Monitoring system will use Cassandra, which will run on top of the Linux platform, to store great amount of data from huge sensor arrays needed to carry out analytics and logging.
Alternatives	*Redis* Redis is a database that is best for storing data that changes rapidly with foreseeable database size which mostly fits in memory. This database is good to store real-time stock prices. *MongoDB* MongoDB is suitable for a database that needs dynamic queries. Indexes are mainly needed to runs this database system rather than Map/Reduce functions. *HBase* HBase is also written in Java. HBase is the database for Hadoop. This database is the best way to run Map/Reduce tasks on huge datasets.
Arguments	A short discussion of the cons and pro's is described by the table below

	Reliability	Resilience	Performance	Interoperability	Security	Scalability	Cost	**Score**
weight	1	1	1	1	1	1	4	
Cassandra	4	3	5	3	3	5	4	27
Redis	2	3	3	3	3	2	4	20
MongoDB	2	3	3	3	3	3	4	21
HBase	3	3	4	3	3	4	4	24

5 System Architecture

6 Hardware Architecture

7 Software Architecture

8 Architecture evaluation

9 System evolution

A Time Tracking

A.1 Week 1

Person	Task	Hours
Eedema	Reviewing the document, reading the assignment, initializing requirements, & installing environment for project	8
Putra	Intial preparation for the course	5
Fakambi	Reading the document and assignment	
Schaefers	Setting up the working environment, create the context page and analysis page drafts. Setting up and improving the the document structure.	8
Klinkenberg		
Brandsma	Creating working environment, reading assignment, first draft business part	8
Menninga	Reading assignment, setting up working environment, first non-functional requirements	5

A.2 Week 2

Person	Task	Hours
Eedema	Coaching session, project planning session and work on business information chapters	9
Putra	Coaching session, project planning session, project meeting, first version of stakeholder part of requirements	7.5
Fakambi	Coaching session project meeting , work on Non functionnal requirements	
Schaefers	First coaching session, improved and enhanced the context and business information chapters. Also created a quality attributes prioritization table.	8
Klinkenberg	Coaching session, meetings, providing feedback on requirements	5.5
Brandsma	First version of use-cases, coaching session, meeting, use-cases, architectural vision	6.5
Menninga	First version of the functional requirements, coaching session, meeting	10.25

A.3 Week 3

Person	Task	Hours
Eedema		
Putra		
Fakambi		
Schaefers		
Klinkenberg		
Brandsma	Coaching session, meeting, architectural vision, use-cases	5,5
Menninga		

A.4 Todo

Create figure with processflow and place it somewhere logical