Software Architecture

Remote Measurement, Monitoring and Control System: Phase I - Domain analysis and requirement elecitation

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March 22, 2012

Contents

1 Overview

This report handles the domain analysis, the functional and non-functional requirements for phase I of the `Remote Measurement, Monitoring and Control System`. We will handle, in order, the domain model for the Remote Metering domain, additional constraints, a glossary, an overview of the use cases in the form of a use case diagram and the detailed use case scenarios. Finally we will also handle some important quality attribute scenarios.

2 Domain Analysis

2.1 Domain components

To make it more easy to process and discuss the domain model for remote metering, the domain can be decomposed into different components. The diagram itself has been provided in full, but the different components can be discerned by their color.

The blue color marks the main component of the remote metering domain. This entails the elements representing the modules and the people using them. These component is quite tightly coupled to the next component depicted in orange.

The orange color marks the utility companies and all elements that are directly related to the utility companies.

The red color marks the anomaly-component. All domain elements that have to do with anomalies, problems, alarms and such, are part of this component.

The green color represents the final component and marks all elements which are related to other external parties not related to the immediate metering domain. These elements include external experts, telecommunications providers and such.

NOTE: According to a teaching assistant, the domain model should also contain type information for the attributes of entities in the domain model. Therefor we provided type information in the domain model. We are, however, of the opinion that the domain model is not the place to include type information and would not have done so if not directed by a TA. Type information for attributes is, in our opinion, more a solution oriented aspect instead of a problem oriented aspect.

2.2 Domain model diagram

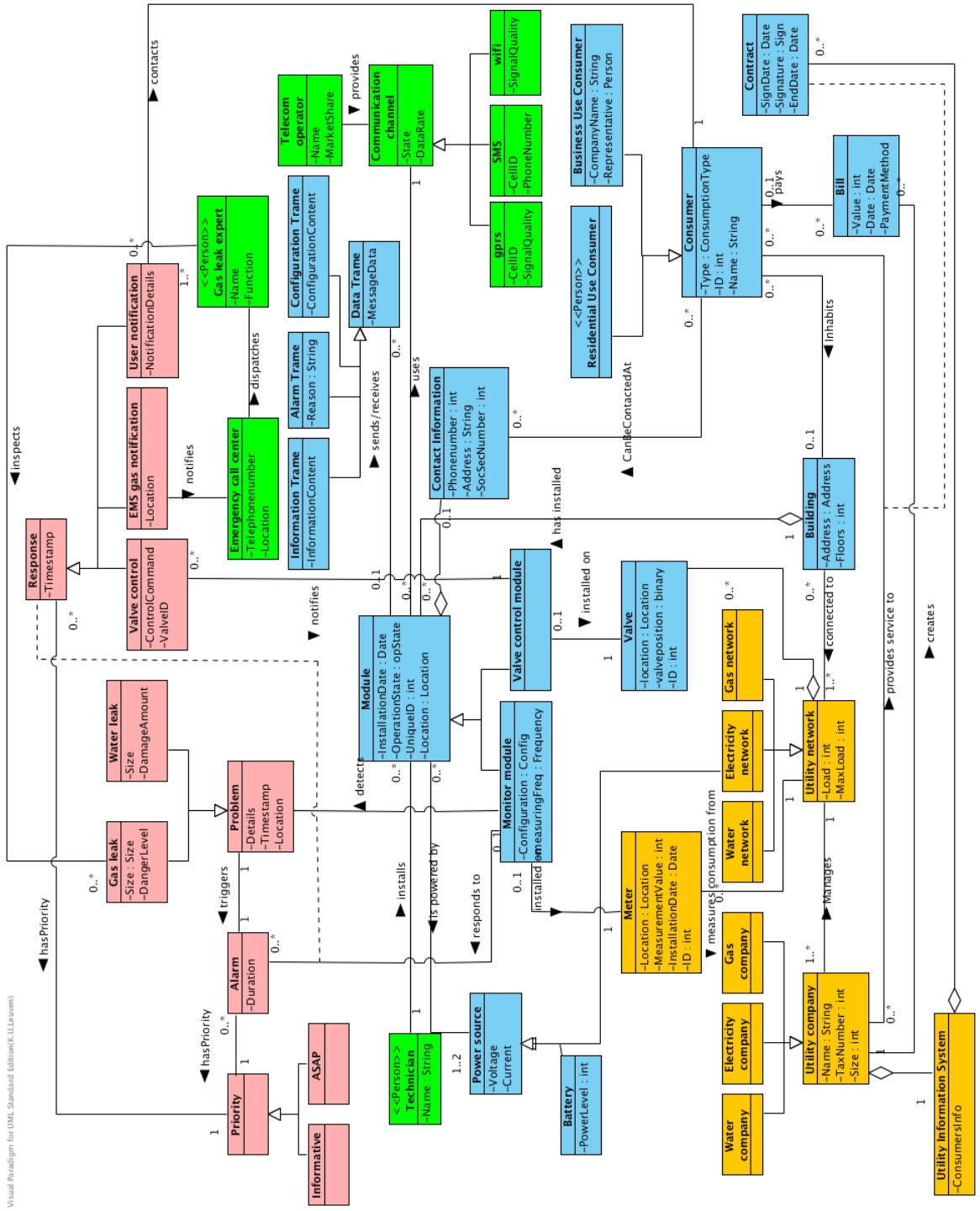

Figure 1: Full domain model with colored components.

2.3 Additional Domain Constraints

In this section some extra domain constraints will be specified in the formal OCL. It was not possible to directly model this information in the domain model, so therefor the following OCL constraints were created.

```
context Consumer:
        self.canBeContactedAt.Address = self.inhabits.Address

context Monitor module inv:
        self.location = self.EMSGasNotification.location

context Monitor module inv:
        self.detects.oclIsKindOf(Gas Leak) implies
        self.Response.asSet()->includes(EMSGasNotification)

context Monitor module inv:
        self.respondsTo.hasPriority.oclIsKindOf(self.Response.hasPriority)

context Monitor module inv:
        not self.detects.asSet()->isEmpty() implies
        not self.respondsTo.asSet()->isEmpty

context Utility company inv:
        self.oclIsKindOf(Water company) implies
        self.manages.oclIsKindOf(Water network)

context Utility company inv:
        self.oclIsKindOf(Elektricity company) implies
        self.manages.oclIsKindOf(elektricity network)

context Utility company inv:
        self.oclIsKindOf(Gas company) implies
        self.manages.oclIsKindOf(Gas network)

context Contract inv:
        self.SignDate < self.EndDate

context Alarm inv:
        self.Duration > 0

context Module inv:
        self.oclIsKindOf(Valve control Module) implies
        (self.isPoweredBy.oclIsKindOf(Battery) and
        self.isPoweredBy.oclIsKindOf(Electricity network))

context Utility network inv:
        self.Load < self.MaxLoad
```

3 Glossary

In this glossary section, some non trivial domain elements will be furtherly explained. The elements will be explained per domain component.

3.1 Main Metering (Blue)

3.1.1 Module

The Module represents the remote measurement modules and the remote valve control modules. These modules are installed on Meters and valves respectively. These modules are also powered by a Power source. This can either be a battery or the electricity network provided by the utility network described in the Utility Company section.

3.1.2 Valve

The valve the valve control module is installed on, is part of the main metering component and not part of the utility company component. This is because the valve control and valve itself are often delivered in one single component by the people in charge of the metering. The context for usage of this element lies not with the Utility Company.

3.1.3 Data Trame

The data trame entity is an entity that is used to communicate with modules. There is an hierarchy of trames in existence that is structured on the type of trame. As such there is an information trame, an alarm trame and a configuration trame.

3.1.4 Contact Information

The contact information entity represents the information that a module is configured to have about who to notify in case of an emergency.

3.1.5 Consumer

The consumer represents the person or company that uses or consumes the services offered by utility companies. This consumer inhabits a building, whether it be a personal home residence or perhaps a company facility.

3.1.6 Contract

When a utility company provides services (in the form of either gas, electricity or water) a contract is signed between the utility company and the consumer. This contract holds all the information about the details, terms, conditions and duration of the agreement between consumer and provider.

3.2 Utility Company (Orange)

3.2.1 Meter

The Meter is an entity representing the physical meter a utility company installs on various locations in the utility network to monitor the consumption of utility resources. These meters are installed with or without remote measurement modules.

3.2.2 Utility Network

The utility network entity represents the different utility networks in the domain. It is a high level representation of the gas, electricity and water networks on a large scale. The networks have collections of valves and meters that are installed in various locations in the network. In the functional requirements analysis section, the term utility network interface point will occur. This term is merely a description of a location where a valve or a meter can be installed in a network.

3.2.3 Utility Information System

The utility Information System is an existing information system that is present in all utility companies. Each utility company has such a system for storing contact information and contracts of customers.

3.3 Anomalies (Red)

3.3.1 Problem

The problem entity represents a problem such as a possible leak. This problem can be detected by the remote monitoring module. When a problem is detected, an alarm will be triggered with an appropriate response. The possible problems the remote monitoring module can detect at this moment are a gas leak and a water leak, depending on what utility network the monitoring module is installed. A problem also has a timestamp, indicating when the problem was detected.

3.3.2 Alarm

Whenever a problem is detected, an alarm will be triggered for this problem. An alarm has an appropriate response which will be the response of the monitor module. A monitor module responds to an alarm. Each alarm also has a priority. A gas leak has a higher priority as a water leak for example.

3.3.3 Response

Each problem has an appropriate response. Responses will also receive the same priority as the alarm of the problem that causes them. Possible responses are valve control, where the monitor module will instruct the valve control to close the valve, user notification, where the monitor module will inform the user from its contactinformation about the alarm, and EMS gas notification, where the monitor module will alert the Emergency Services about a gas leak. This last response can only be used in case that the problem is a gas leak.

3.3.4 Priorities

A response and an alarm have a priority. Connected alarms and responses have the same priority. A priority is an instance to indicate how fast an alarm must be dealt with or how fast the response must be executed. Possible priorities are ASAP and Informative.

3.4 Other External Parties (Green)

3.4.1 Emergency Call Center

An emergency call center is a center someone or something can call in case of emergency. The monitor module uses this call center through a EMS gas notification when a gas leak is detected. The monitor module will contact the emergency call center, notifying the authorities about the gas leak. The emergency call center will respond to this call by dispatching one or more gas leak experts who will inspect the gas leak.

3.4.2 Communication Channel

A communication channel is an external communication channel that the remote module will use to send or receive data trames. To use this communication channel, there has to be made an agreement with a telecom company about the services it can offer. Without this contract the remote modules won't be able to use the external communication channel. A communication channel can be a wifi connection, a gprs connection or a SMS service.

3.4.3 Technician

A technician can be a regular plumber who knows how to remove and install remote modules. This plumber or techician has to be certified to install or deinstall certain modules.

4 Functional Requirements

4.1 Use Case Diagram

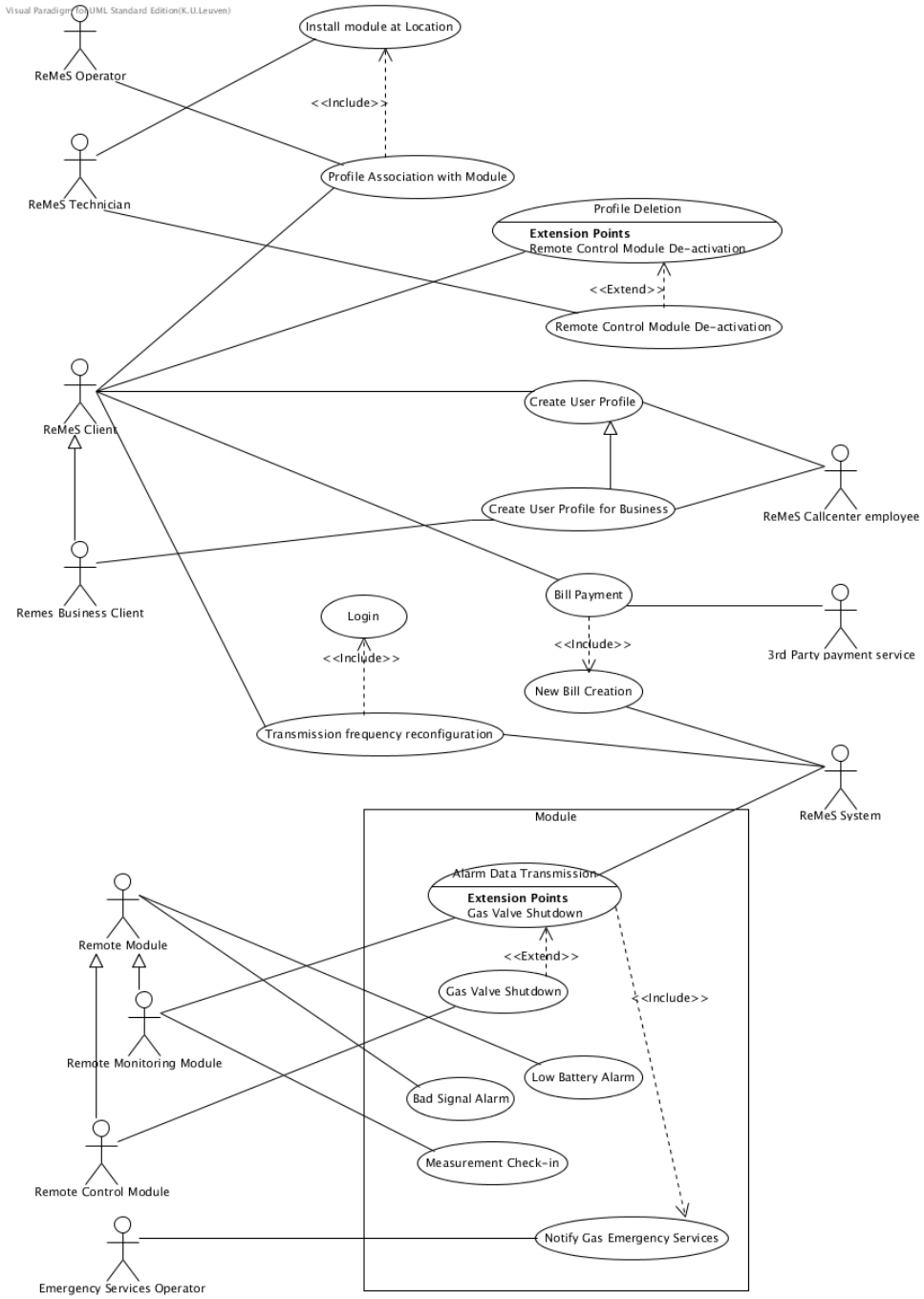

Figure 2: Use Case Diagram for ReMeS System.

4.2 Use Case Scenarios

In this section, the use case scenarios fromt he use case diagram will be explained. The official standard vor inclusion, extension and generalization have been used. Use case generalization will be done by copying the base use case and marking the changes in bold.

4.2.1 Create user profile

Use Case Name Create user Profile

Primary Actor A potential client: Whenever someone wants to join ReMeS, the future client first needs to request an account.
ReMeS call center employee: Whenever a potential client calls to request a new profile, the ReMeS operator needs to send an empty contract to the potential client.

Interested Parties Utility Company: The utility company of which the potential new client of ReMeS is a client of.

Preconditions The person in question can not already be a client of ReMeS.

Normal Flow

1. A person calls the ReMeS call center and requests the contract for becoming a residential client to be sent to his home address.
2. A contract is sent to the provided home address.
3. The person fills in the contract and sends it back to ReMeS.
4. The person is added to the ReMeS system as a residential user.
5. A confirmation letter is sent to the new user's home address by regular mail.
6. The new client receives a letter containing an authentication token consisting of a user name and password.

Alternative Flow

4a. The person filled in the wrong information and the contract is not valid.

4a1. The person is sent a letter explaining that there was a problem processing his request. The person is also sent a new contract to be filled in.

4a2. Goto step 3.

Postcondition The person in question is now a client of ReMeS and can login with his personal user name and password.

4.2.2 Create user profile for business user.

Use Case Name Create user Profile for **business** user.

Primary actor Potential client: An employee of a company wanting to become a client of ReMeS.
ReMeS call center employee: Whenever a potential client calls to request a new profile, the ReMeS operator needs to send an empty contract to the potential client.

Interested Parties Utility Company: The utility company of which a client wishes to become a client of ReMeS.

Preconditions The company in question can not already be a client of ReMeS.

Normal Flow

1. An **employee of a company** calls the ReMeS call center and requests the contract for becoming a **business** client to be sent to his address.
2. A contract is sent to the provided address.
3. The **employee** fills in the contract and sends it back to ReMeS.
4. The **company** is added to the ReMeS system as a **business** user.
5. A confirmation letter is sent to the **company**'s address by regular mail.
6. The **company** receives a letter containing an authentication token consisting of a user name and password.

Alternative Flow

4a. **The employee** filled in the wrong information and the contract is not valid.

4a1. **The employee** is sent a letter explaining that there was a problem processing his request. **The employee** is also sent a new contract to be filled in.

4a2. Goto step 3.

Postcondition The **company** is now a client of ReMeS and can login with his personal user name and password.

4.2.3 Profile Association

Use Case Name Profile Association with remote monitoring module

Primary Actor ReMeS Operator: An operator at ReMeS who links the device to the user profile.
Client representative: A residential user or a representative for a business user.

Interested Parties Utility company: The Utility company's UIS wants to be informed of the outcome of this use case.
Regular Mail Service: The regular postal service which will transport and deliver the modules.

Preconditions The representative who will be provided a remote monitoring module has to be a residential, or a business client of ReMeS.

Normal Flow

1. The use case starts when a ReMeS operator gets the order to link a profile to a module.
2. The ReMeS operator verifies that the monitoring module has an identification number that has not been used yet in the system.
3. The ReMeS operator creates a new entry in the system for the remote monitoring module.
4. The ReMeS operator links the newly created entry to the user profile provided.
5. The ReMeS operator sends the module by regular mail to the address provided by the user profile
6. The client representative receives the module.
7. Include use case *Install module at location.*
8. The ReMeS operator receives confirmation from the system that installation has been successful.
9. The ReMeS operator signals the UIS of the utility company in question that the customer in question now uses ReMeS.

Alternative Flow

5a. In the user profile it is indicated that the user would rather pick up the module at a ReMeS collection point.

5a1. The ReMeS operator sends the module by regular mail to the ReMeS collection point indicated in the user Profile.

5a2. The client representative goes and picks up the module from the collection point.

Postcondition The module is installed at the site and is linked to the user profile the module was intended for.

4.2.4 Install Module

Use Case Name Install Module at location

Primary actor ReMeS Technician: A certified technician that install the module.

Interested Parties Client: The client owning the module which will be installed.
ReMeS operator: The ReMeS operator who needs confirmation on the succesful installation of the module.

Preconditions The module cannot already be installed. The appointment for the technician is verified and the client has been reminded of the appointment.

Normal Flow

1. The ReMeS technician arrives at the location where the module is supposed to be installed.
2. The technician installs the module physically on the utility net interface.
3. The technician physically seals the module to prevent tampering.
4. The technician enters the current meter value in the system.
5. The module uses the pre-cooked configuration to communicate with the ReMeS system and sends its initial trame to the system.
6. The ReMeS system acknowledges the correct installation of the module and notifies interested parties of this event.
7. The technician finalizes the paperwork and asks for a signature.

Alternative Flow None

Postcondition The module is installed and works correctly at the desired location. The interested parties are also notified of the installation of the module.

4.3 Measurement Check-in

4.3.1 Use Case Name

Measurement check-in data transmission

4.3.2 Primary actor

The remote measurement module: Measures the data and initiates the check-in.
ReMeS system: receives the data.

4.3.3 Interested Parties

Utility company: Is interested in the data gathered.

4.3.4 Preconditions

The module is powered (either by battery or electricity net).

4.3.5 Normal Flow

1. The use case starts when the module is powered on or when this use case has been completed.
2. The module reads the preset configuration for the desired interval.
3. The module sets a timer matching the interval.
4. The set timer expires
5. The module sends a trame containing the measurement data to the ReMeS system.
6. The ReMeS system receives and stores the measurement data from the module.

4.3.6 Alternative Flow

None

4.3.7 Postcondition

The measurement is sent to and stored at the ReMeS System in specified intervals.

4.4 Log in

4.4.1 Use Case Name

Log in to ReMeS.

4.4.2 Primary Actor

ReMeS Client: The client who wants to login.
ReMeS System: The system who handles the procedure.

4.4.3 Interested Parties

ReMeS: Is interested in the people who login to their service.

4.4.4 Normal System Flow

1. The system asks for username and password.
2. The customer provides username and password.
3. The provided username exists.
4. The supplied password for the username is correct.
5. The system loads the preferences of the customer.

4.4.5 Alternate System flow

3a. The username doesn't exist.

3a1. The customer decides to try again. GOTO step 1.

4a. The password is incorrect.

4a1. The customer decides to try again. GOTO step 1.

4.4.6 Outcome (post condition)

The Customer is logged into the store.

4.5 Transmission frequency reconfiguration

4.5.1 Use Case Name

Transmission frequency reconfiguration

4.5.2 Primary actor

ReMeS client: The client of the ReMeS system ordering the reconfiguration.
ReMeS system: Handles the order.

4.5.3 Interested Parties

Utility company: Can offer lower prices for consumers who update more frequently.

4.5.4 Preconditions

The client has a remote monitoring module installed.

4.5.5 Normal Flow

1. The use case starts with the ReMeS client deciding to change the update frequency.
2. include use case *Log into ReMeS*.
3. The ReMeS system show the user a list of installed modules.
4. The client selects the module he wants to reconfigure.
5. The client indicates that he is willing to send data more frequently.
6. The ReMeS system processes this indication and sends a configuration command (trame) to the module in question.
7. The previously chosen module receives a reconfiguration command correctly.
8. The module processes the command and sets its update frequency accordingly.
9. The module sends an acknowledgement back to the ReMeS system.

4.5.6 Alternative Flow

4a. The selected module is not a valid module for reconfiguration.

  4a1. The user is notified. GOTO step 3.

7a. The module does not receive the command correctly.

  7a1. The module does not do anything and does not send back an acknowledgement.

  7a2. After a fixed amount of time a system timer at the ReMeS system expires and the event is logged.

7a3. The command is sent again. GOTO step 7.

4.5.7 Postcondition

The update frequency of the module has been succesfully changed at the clients intent. The module will update more frequently from now on.

4.6 Alarm data transmission

4.6.1 Use Case Name

Alarm data transmission for the gas monitoring module.

4.6.2 Primary actor

Remote monitoring module (gas): Notices an anomaly and does the notifying.
ReMeS system: The system needs to notify interested parties and emergency services.

4.6.3 Interested Parties

ReMeS Client: will be notified of the anomaly.
Emergency services (gas): Will be notified of gas anomalies.

4.6.4 Preconditions

The module in question needs to be a gas remote control module.

4.6.5 Normal Flow

1. The use case starts when the module detects an anomaly
2. The module ignores all timers and pending tasks and immediately sends an alarm trame to the ReMeS system.
3. The ReMeS system receives the alarm trame from the module.
4. The ReMeS system looks up the contact information that is related to the module.
5. The ReMeS system sends an alarm notification to the recipient, as configured in the remote module.
6. include use case *Notify Gas Emergency Services*
7. Extension point: Use Case *Gas Valve shutdown* if the client has a gas remote control module installed.

4.6.6 Alternative Flow

4a. The module is configured not to send notifications to the client.

4a1. Goto step 6.

4.6.7 Postcondition

The emergency services are notified and the alarm notification of the user is carried out if configured.

4.7 Gas Valve Shutdown

4.7.1 Use Case Name

Gas Valve Shutdown

4.7.2 Primary actor

ReMeS system: The system that commands the valve shutdown.
Remote control module: The module that shuts down the valve.

4.7.3 Interested Parties

The ReMeS client: The client might be hindered by the operations described.

4.7.4 Preconditions

There must be a remote control module installed. The control command sent must be a shutdown command.

4.7.5 Normal Flow

1. The use case starts when the remote control module receives a control command indicating the initiation of a valve-shutdown.
2. The module parses the content of the control command.
3. The module effects the mechanical shutdown of the valve.
4. The valve was successfully shutdown. The module send an acknowledgement that shutdown was successfully executed.

4.7.6 Alternative Flow

4a. Something went wrong in shutting down the valve.

4a1. The module sends a negative acknowledgement to the ReMeS system indicating that something went wrong in shutting down the valve and further action should be taken.

4.7.7 Postcondition

An attempt is made to shut down the valve and the ReMeS system is notified of the result of the attempt.

4.8 Bill Payment

4.8.1 Use Case Name

Bill Payment

4.8.2 Primary actor

Client: The client that has to pay the bill.
3th party payment service: The 3th party payment service that has to manage the bill.

4.8.3 Interested Parties

ReMeS: ReMeS must create bills for clients at certain fixed points.
Utility company: The utility company wants to know how it will receive its payments.

4.8.4 Preconditions

The utility company has chosen to let ReMeS handle its payments.

4.8.5 Normal Flow

1. Include use case *New Bill Creation*.
2. The client receives the bill created by ReMeS.
3. The client pays the bill to the 3th party payment service
4. The 3th party payment service pays the utility company accordingly.
5. The 3th party payment service notifies ReMeS that this bill is paid.
6. ReMeS updates this information appropriately.

4.8.6 Alternative Flow

3a. The client waits too long to pay the bill

3a1. The 3th party payment service sends a reminder notification to the client.

3a2. The client receives the notification

3a3. Goto step 3.

4.8.7 Postcondition

ReMeS has indicated that this bill is paid.

4.9 New Bill Creation

4.9.1 Use Case Name

New Bill Creation

4.9.2 Primary actor

ReMeS: ReMeS will have to create new bills at certain fixed points.

4.9.3 Interested Parties

Client: The client of the utility company will want to know how its bills are created.
Utility company: The utility company will want to keep track of the bills that it still need to receive.
Third party payment service: The third party payment service will want to know what bills it needs to keep track of.

4.9.4 Preconditions

The utility company has chosen to let ReMeS handle its bill creations.

4.9.5 Normal Flow

1. ReMeS has received enough measurement data
2. ReMeS creates a bill for the client
3. ReMeS notifies the utility company and the third party payment service about the creation of the bill.
4. The bill is sent to the client.

4.9.6 Postcondition

A bill is created for the client to pay for the utilities he/she consumed.

4.10 Remote Control Module De-activation

4.10.1 Use Case Name

Remote Control Module De-activation

4.10.2 Primary actor

ReMeS Technician: A technician who removes the remote control module
Client: A client who needs his/her remote control module removed.

4.10.3 Interested Parties

None

4.10.4 Preconditions

The client must have a remote control module installed. The appointment for the technician is verified and the client has been reminded of the appointment.

4.10.5 Normal Flow

1. A ReMeS technician arrives at the location where the module is installed.
2. The technician removes the remote control module from the utility net interface.
3. The technician notifies ReMeS that the remote control module has been removed.
4. ReMeS updates his information that the remote control module is no longer active.
5. The technician finalizes the paperwork and asks for a signature.

4.10.6 Alternative Flow

1a. There is nobody at the location where the module is installed who can grant access to the technician.

  1a1. The technician notifies ReMeS that a new appointment must be made.

  1a2. The technician starts a new assignment.

1a3. ReMeS requests the client to make a new appointment.

1a4. The client makes a new appointment.

1a5. The client is charged a fee for missing the appointment.

1a6. Goto step 1.

4.10.7 Postcondition

The remote control module is removed from the location.

4.11 Low Battery Alarm

4.11.1 Use Case Name

Low Battery Alarm

4.11.2 Primary actor

Remote monitoring module: The module that has a battery.

4.11.3 Interested Parties

ReMeS technician: A ReMeS technician sometimes needs to help a client to replace the battery of a remote module.
Client: The client will want to know how and when to replace the battery of a remote module.

4.11.4 Preconditions

The client has a remote monitoring module installed

4.11.5 Normal Flow

1. The remote monitoring module's battery is low
2. The remote monitoring module sends a low battery alarm to ReMeS
3. ReMeS receives the alarm and creates an alarm to the appropriate recipient
4. The recipient receives the alarm and replaces the battery
5. The next time the remote monitoring module sends data, the battery status is automatically updated.

4.11.6 Alternative Flow

4a. The recipient is unable to replace the battery

4a1. The recipient notifies ReMeS.

4a2. A ReMeS technician will be sent on site.

4a3. The ReMeS technician replaces the battery.

4a4. Goto step 5.

4.11.7 Postcondition

4.12 Bad Signal Alarm

4.12.1 Use Case Name

Bad Signal Alarm

4.12.2 Primary actor

Remote monitoring module: The module that works with a remote connection.

4.12.3 Interested Parties

ReMeS technician: Sometimes a ReMeS technician must go on site to solve the problem with a remote module.
ReMeS operator: If a remote monitoring module hasn't been repaired within a certain period of time, a ReMeS operator must call and help the client to repair the problem.
Client: A client will be notified and will try to fix the problem with the bad signal of the remote module.

4.12.4 Preconditions

The client has a remote monitoring module installed

4.12.5 Normal Flow

1. ReMeS detects that a remote monitoring module hasn't sent any data for a certain period of time.
2. ReMeS creates an alarm.
3. ReMeS notifies the client and the ReMeS call center about this alarm.
4. The client solves the problem with the module.

4.12.6 Alternative Flow

4a. The client is unable to solve the problem.

4a1. A ReMeS operator contacts the client.

4a2. The ReMeS operator tries to look for the problem and its resolution.

4b. The client and the ReMeS operator are unable to solve the problem.

4b1. A ReMeS technician is dispatched to the user.

4b2. The ReMeS technician solves the problem with the remote monitoring module.

4.12.7 Postcondition

4.13 Profile Deletion

4.13.1 Use Case Name

Profile Deletion

4.13.2 Primary actor

Client: A client who no longer wishes to be a client

4.13.3 Interested Parties

ReMeS: ReMeS will want to know how and when to delete profiles.

4.13.4 Preconditions

The client is a residential or a business user of ReMeS.

4.13.5 Normal Flow

1. A client notifies ReMeS that it wishes no longer to be a client of ReMeS.
2. Extension Point: use case *Remote Control Module Deactivation*.
3. ReMes indicates that the profile of the client is now inactive.
4. The client is notified about his/her profile deletion.

4.13.6 Alternative Flow

None

4.13.7 Postcondition

The client is no longer a residential or a business user of ReMeS.

5 Quality Attribute Scenarios

5.1 Availability

5.1.1 Av1: Communication channel between the remote module and the ReMeS system

Because of a failure in the intermediate telecom infrastructure, or because of a bad signal from the remote module to the intermediate telecom infrastructure, key functionalities of the ReMeS system are compromised: reading data from a remote monitoring module cannot be sent to ReMeS and ReMeS cannot control the remote valves in case of a leak.

- **Source:** external
- **Stimulus:** The external communication channel between the remote module and the ReMeS system is failing. This results in the inability of sending data from ReMeS to a remote valve or from a remote monitoring module to ReMeS. It is also possible that there is a bad signal between the remote module and the external communication channel of the intermediate telecom infrastructure.
- **Artifact:** Remote modules, external communication channel of the intermediate telecom infrastructure.
- **Environment:** normal execution
- **Response:**
  - Prevention:
    * The ReMeS company has negotiated a Service-Level Agreement (SLA) with the intermediate telecom operator that maintains the external communication channel. This SLA states that the external communication channel has 98% availability.
    * Before installing the remote module, the connection to the external communication channel should be checked if it's sufficient. Otherwise another solution needs to be found to improve this connection such as trying another type of connection (gprs, wifi, SMS).
  - Detection:
    * ReMeS detects that a remote module hasn't sent any data for a certain time.
    * ReMeS detects that all remote modules using a certain type of communication (gprs, wifi, 3G) haven't sent any data for a certain time. ReMeS can conclude that the external communication channel is failing and not the signal between the remote module and the external communication channel.
    * ReMeS keeps track of how long there has been a lack of communication.

  - Resolution:
    * In case that one remote module hasn't sent any data for a certain time, the client owning the remote module is notified. Also a ReMeS operator is notified. If the problem isn't solved in time, the ReMeS operator will contact the client. If the problem still isn't resolved after the help of the ReMeS operator, a ReMeS technician will be sent to solve the problem with the remote module.
    * In case that the external communication channel is failing, the ReMeS System Administrator is notified. The System Administrator will contact the telecom operator to resolve this problem.

- **Response measure:**
  - Detection time
    * The detection time of a single module equals to the transmission rate of the remote monitoring module plus 1 minute margin. As soon as a remote module should send a new data trame and ReMeS doesn't receive any, ReMeS can conclude that there is a problem with that connection.
    * If many remote modules aren't sending data, we will detect this later as only one module. Suppose T is the transmission data of a module, we will detect this problem within $2 * T$ time.
  - Notification time
    * When only one remote module isn't sending any data, the owner of the module will be notified. Since this notification can happen through SMS or through email, there are different notification times. Through SMS the maximum time should be 5 minutes. If the owner is notified through email, the email will be delivered within 5 minutes, but we cannot predict when the owner shall read that notification email.
    * If more remote modules aren't sending data, we can conclude that there is a problem with the external communication channel. A system administrator will be notified about this within 5 minutes. He/she will then contact the telecom company in order to resolve the issue.
  - Resolution time
    * In the case that the external communication channel has a problem, we cannot ensure a fast recover of this channel. The SLA we have with the telecom company tells us that if there is a problem, it should be resolved within maximum 30 minutes.
    * When there is a problem with the signal between the remote module and the external communication channel, the time to resolve this issue depends on the client, the ReMeS operator and the ReMeS technician. If the client cannot resolve the problem within 2 days, a ReMeS operator will call the client to help

him/her. If the ReMeS operator and the client are unable to resolve the problem, a ReMeS technician will be dispatched. This technician will go on scene to resolve the issue. Since the ReMeS technician will arrive within 5 days. Therefor the maximum repair time is 7 days.

5.1.2 Av2: Availability of the webportal

Because of a failure of our servers or because of a failure of the hosting service ReMeS uses, it is possible that the webportal where users can access their own information is not available all the time. There can also be a failure in the communication channel between the hosting service and the user. This communication channel is typically managed by an internet provider.

- **Source:** internal or external. If ReMeS rents a hosting service, the source is external. If ReMeS manages it's own servers, the source will be internal. In case of a combination, the source will be internal and external.
- **Stimulus:**
  - There is a failure in our servers or in the hosting service and nobody can access the webportal.
  - There is a failure in the communication channel provided by our (or the webhosting's) internet provider.
  - There is a failure in the communication channel provided by the user's internet provider. We will not consider this case since ReMeS has no SLA with this provider.
- **Artifact:** our servers or the servers of a webhosting service, external communication channel provided by an internet provider.
- **Environment:** normal execution
- **Response:**
  - Prevention:
    * In case that ReMeS rents a webhosting service, the ReMeS company has negotiated a Service-Level Agreement (SLA) with the webhosting service. This SLA states that the webservers are available in 99% of the time. They also ensure an average response time of 100 milliseconds.
    * In case that ReMeS manages its own servers, ReMeS hires technicians who maintain and improve the servers so they won't crash frequently. Also ReMeS will have multiple servers so that in case 1 of the servers crashes, another one will take over its jobs.
    * The ReMeS company has a SLA with the internet provider ensuring maximal availability of the external communication channel. The SLA ensures that the internet connection is available in 99% of the time. They also ensure an average response time of 80 milliseconds.

- Detection:
  - In many cases the downtimes of the server are announced. These downtimes are needed for maintenance or other upgrades.
  - If a system goes down, it will typically send a notification to subscribed watchdog systems. These watchdog systems will notify the server administrator about the problem.
  - It is very unlikely that all components of the system crash at the same time (without sending a notification to subscribed watchdog systems). When one component crashes, another component that uses this one will notice that there is no longer a connection possible to this component. It will then notify the server administrator about the problem.
  - In the case that all components crash at the same time (without sending a notification to subscribed watchdog systems), the webportal of our ReMeS operators will also fail. The ReMeS operators will notify the server administrator in this case.
- Resolution: In any case, the server administrator gets notified of the problem. The server administrator (and eventually other technicians) will try to reboot the servers and locate the error. In case that the servers won't reboot, they will have to locate and repare the error before rebooting the servers.

- **Response measure:** TODO
  - Detection time
    - When all components crash at the same time without sending a notification to subscribed watchdog systems, a ReMeS operator will notice this rather fast, unless there is no ReMeS operator working at that time (ie at night). Therefor the maximum time for a detection of the problem will be 12 hours. We remind that the chance that this case happens is very very slim.
    - In any other case, the watchdog system or another component will detect the loss of connection very fast. The maximum time for detection of the problem will be 30 seconds.
  - Notification time Notifying the server administrator about the problem when the problem gets detected will take maximum 5 minutes. The server administrator must be available every time of every day, even at night. If the server administrator is unavailable for some period of time, he/she must provide a new contact person with atleast the same knowledge about the system.
  - Resolution time
    - If the server administrator (and eventually other technicians) can reboot the servers, the resolution time will be maximum 60 minutes (providing time for the administrator to get to the location of the servers). Locating and reparing the error will take

more time, but as long as the servers keep running, this isn't a problem.

* In the case that rebooting the server is impossible, the downtime could take up to 24 hours. Remember that not necessarily all servers are down. It is very more likely that some servers are still up and running who can take over the job of the crashed server(s). In that case the users won't even notice the crashed server.

5.1.3 Av3: Consumption prediction model updates

The consumption prediction model that ReMeS creates for the utility companies is send periodically to these companies. Updates on the model can also be requested by the companies. ReMeS will send these updates within reasonable time.

- **Source:** internal and external
- **Stimulus:**
  - ReMeS will send these models periodically to the companies. It is time to send a new update.
  - A newer, better version of the model is available. ReMeS will send this model as fast as it can
  - A utility company requests a certain model. ReMeS will send this model as fast as possible
- **Artifact:** ReMeS Utility Production Planning
- **Environment:** normal execution
- **Response:** In each case ReMeS will send the latest available model. If ReMeS Utility Production Planning has almost finished calculating a newer version of the model, we will wait until this newer version is calculated and send this newer version to the utility companies.
- **Response measure:**
  - In the case that it is time to send a periodical update of the model, ReMeS will wait for the newest model only if the calculation will be finished within 30 minutes. The average time between two periodical updates should be around 24 hours.
  - If a newer, better version of the model is available, ReMeS will try to send this model as fast as possible. The delivery time depends solely upon the delay of the communication channel ReMeS uses to communicate with the utility company.
  - If a utility company requests a certain model (yearly, monthly, weekly, ...) ReMeS Utility Production Planning first has to compose this model. This should take 30 minutes at max. If the utility company requests the newest available daily model, ReMeS will send the latest

model it has calculated unless the calculation of a newer model will be finished within 30 minutes.

5.2 Performance

5.2.1 PF1: Remote monitoring module sends new data

The remote monitoring modules will send data about the amount of consumed utilities, the battery state, signal level, leak detection, etc. ReMeS needs to respond correctly to this information.

- **Source:** internal
- **Stimulus:** A remote monitoring module sends a new trame of data containing valuable information.
- **Artifact:** System services
- **Environment:** Normal mode
- **Response:**
  - The trame contains data about the amount of consumed utilities. ReMeS will update its database so that the database has more correct values.
  - The trame contains a byte indicating that the battery is running low. ReMeS will notify a ReMeS operator and will also notify the client about the battery status.
  - The trame contains a byte indicating that the signal of the remote module connection is low. ReMeS will notify the client and a ReMeS operator about this alarm.
  - The trame's data indicates that there is a leak detected by the monitoring module. ReMeS will control the remote valve if available. ReMeS will notify the client about the leak and in the case of a gas leak, ReMeS will also notify the emergency services for gas.
- **Response measure:**
  - If the trame indicates that there is a leak, this alarm will receive the highest priority. ReMeS will notify the user within 5 minutes. If the leak is a gasleak, ReMeS will notify the emergency services within maximum 2 minutes. The remote valve (if installed) will also be controlled within maximum 2 minutes.
  - The other trames are receiving a lower priority. They will be handled within maximum 30 minutes.

5.2.2 PF2: A user requests data through the web portal

The web portal allows users to view their own consumption data. It also allows users to view personalized tips on how to lower their utility consumption. We

assume that the web portal is available (see availability of the web portal)

- **Source:** external
- **Stimulus:**
  - The user logs in into the web portal
  - The user requests his/her measurement data over the last weeks, months or years
  - The user edits his/her contact information
  - The user edits the configuration of the remote monitoring module
  - The user requests consumption advice
- **Artifact:** System services
- **Environment:** Normal mode
- **Response:**
  - If the user logs in into the web portal, ReMeS will check if the username and password are consistent. If they are, ReMeS will provide a token for this user and the user will have access to his/her services.
  - If the user edits his/her contact information, ReMeS will update its database accordingly.
  - In the case that the user edits the configuration of the remote monitoring module, ReMeS will update this information in its database. ReMeS will also send a configuration trame to the remote monitoring module.
  - When the user requests measurement data or consumption advice, ReMeS will obtain the data from its database, process this data and show it to the user.
- **Response measure:**
  - Logging in into the web portal is a fairly easy task for ReMeS. From the moment the request is sent until the user sees the logged in information shouldn't take more than 30 seconds. In peak times, where the servers are overloaded, this could take longer.
  - Updating contact information also is an easy task. This operation shouldn't, as logging in, take more than 30 seconds.
  - Requesting and processing consumer data for one user is a slightly harder task. Therefor this could take almost 60 seconds until the user receives the processed data.
  - If the user wishes to edit the configuration of the remote monitoring module, ReMeS will send a configuration trame to the module. From the moment the user indicated the changes until the moment where the remote monitoring module changes its configuration could take up to 5 minutes. This because of the possible delay on the external communication channel.