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Shared Internet Of Things Infrastructure Platform: Domain Analysis Software Architecture (H09B5a and H07Z9a) – Part 1

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1. Domain analysis

1.1 Domain models

The domain model is shown in figure 1.1.

1.2 Domain constraints

In this section we provide additional domain constraints.

- Gateways can to only run light-weight programs that are not too demanding in resources.
- The SIoTIP Online Service must be almost permanently available and sensor data is never lost or inconsistent.
- Core running inside SIoTIP must be able to interact with external applications and systems.
- Relaying information to the motes by the gateway is done by GET and PUT requests.

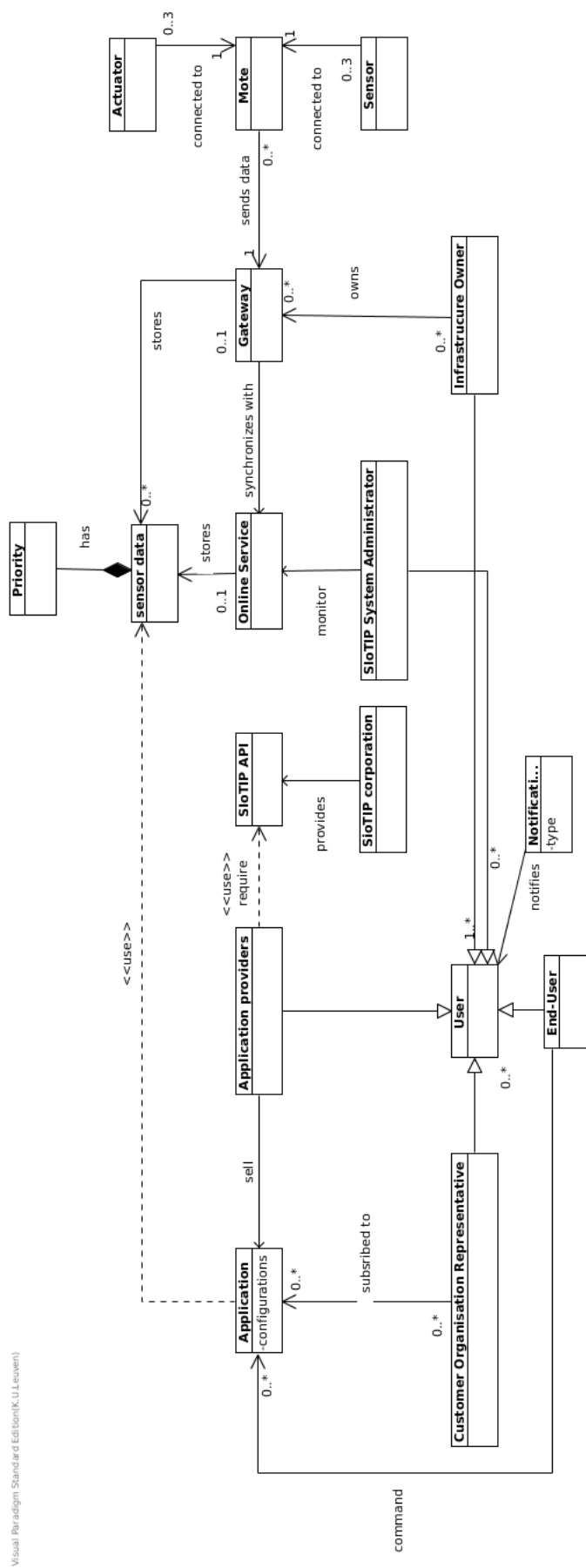


Figure 1.1: The domain model for the system.

1.3 Glossary

In this section, we provide a glossary of the most important terminology used in this analysis.

- **Application:** An application in the system is a program that uses sensors for a specific goal (e.g. fire detection). Customer organisations can subscribe to applications.
- **Application providers:** Application providers develop, upload, and maintain applications for the SIoTIP system.
- **Customer organisations:** Organisations that want to subscribe to applications. These organisations can subscribe to or unsubscribe from applications and get an overview of the invoices for their subscriptions.
- **Dashboard:** A dashboard is a collection of information which is available to a user. There are different dashboard for different type of users.
- **End-user:** End-users are the users that interact with deployed applications. They can issue commands to the application via a plethora of devices. For all end-users, the use of applications should simplify or automate their daily tasks.
- **Gateway:** A device which is connected to the Online Service and that has access to sensors and actuators. It can run some application logic and transmit data between the Online Service and the sensors/actuators.
- **Infrastructure owner:** This is someone who owns building(s), gateways, motes, sensors, and actuators. Owners are responsible for buying, installing, and maintaining hardware and the topology of their infrastructure. Owners can allocate installed hardware to specific customer organisations.
- **Mote:** A device that can host sensors and actuators. It connects these to the network and is used for communication between sensors/actuators and a gateway.
- **Notification:** A message that contains information about some event that occurred in the system. Notifications have some priority. This influences how some notifications will be handled compared to others.
- **Online Service:** The online back-end which provides those services that are expected to generate the main revenue. Those services include the selling of hardware required for IoT infrastructures, and a platform where application providers and potential buyers can meet for a low price.
- **Replica:** definition
- **Sensor data:** Data about some sensor reading(s). Sensor data has some priority. This influences how some data will be handled compared to other data.
- **System:** "The system" is used to refer to the collection of entities that will be used by the SIoTIP corporation to render services. This includes the Online Service, gateways, motes, applications, etc.
- **System administrator:** System administrators monitor and manage the entire platform. They can view information about performance, running applications and sensors, shut applications down. These users are notified if alarming events threaten the platform.
- **User:** Someone who can log in and use parts of the system. Possibilities are system administrators, infrastructure owners, customer organisations, application providers, end-users.

2. Functional requirements

2.1 Use case model

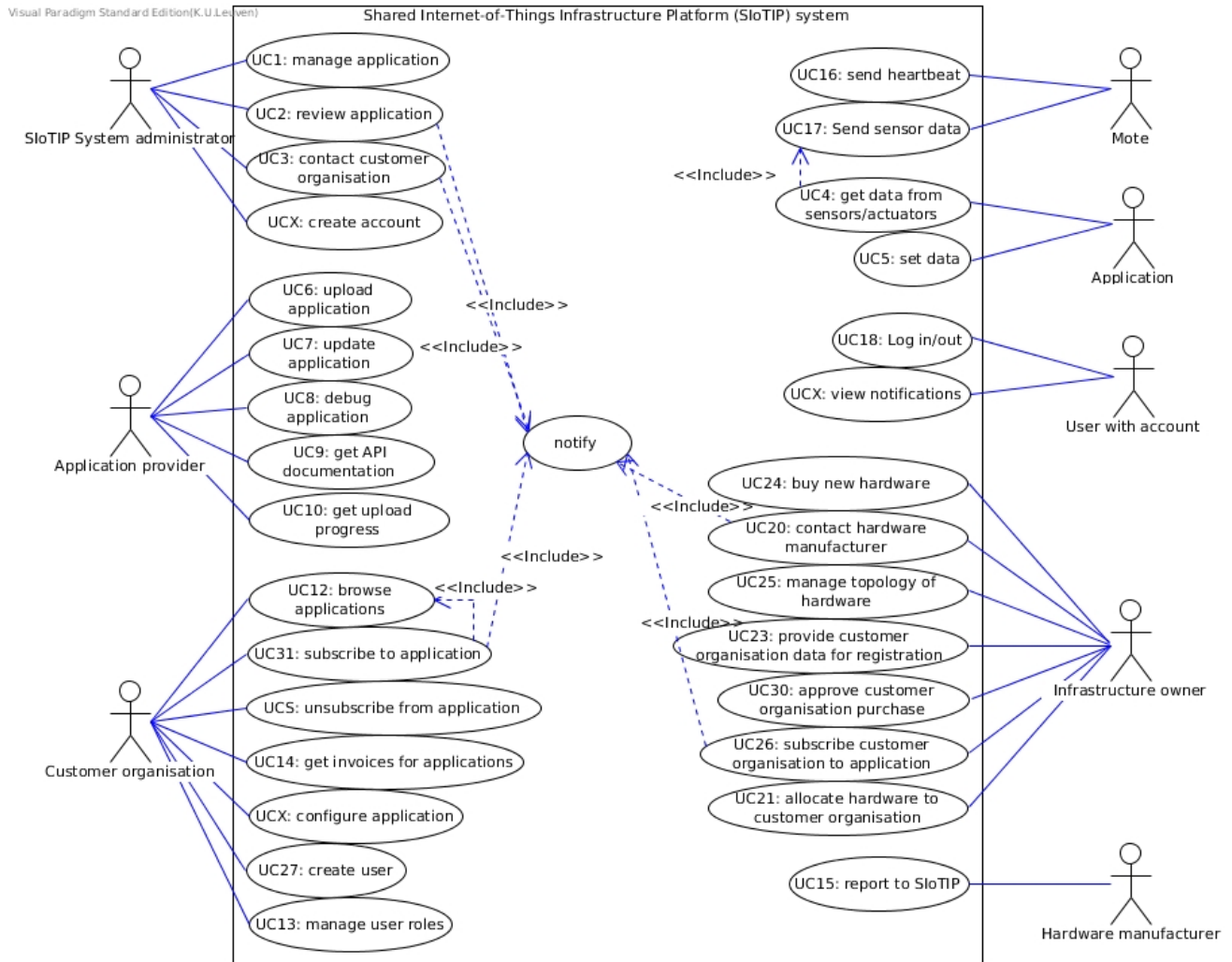


Figure 2.1: Use case diagram for the system.

2.2 Use case overview

UCXXX: send data to gateway A mote sends data to a gateway.

UCXXX: upload application An application developers uploads an application to the Online Service.

UCXXX: get data from sensor An application requests to get data from a specific sensor.

UCXXX: search for applications A customer organisation representative searches for available applications they could potentially subscribe to.

UCXXX: review application A SIoTIP system administrator reviews and approves or declines it.

UC01:

UC02:

UC03:

UC04:

UC05:

UC06:

UC07:

UC08:

UC09:

UC10:

UC11:

UC12:

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UC31:

2.3 Detailed use cases

2.3.1 *UC17*: Send sensor data

- **Name:** Send sensor data
- **Primary actor:** Mote
- **Secondary actors:** Sensor, Gateway
- **Interested parties:**
 - *Customer organisation:* pays for an application that uses this sensor.
 - *Infrastructure owner:* needs the sensor data for an application they set up.
 - *End-users:* use the sensor data in an application.
- **Preconditions:**
 - The mote has received data from a sensor connected to it.
 - The mote is connected to a gateway.
- **Postconditions:**
 - The gateway has received and processed the sensor data.
 - The Online Service has received the data and can process it.
- **Main scenario:**
 1. The mote sends the sensor data to the connected gateway.
 2. The gateway receives the data and if applicable, runs some application logic.

3. The gateway collects data until a synchronisation point is reached. At that point, the gateway sends the data to the Online Service.

- **Alternative scenarios:**

- 3b. The gateway determined that the data was important (e.g. cause for alarm, notification, etc.) and sent the data to the Online Service immediately instead of waiting for the synchronisation point.

- **Remarks:**

- It is essential that the synchronisation protocol works correctly in the presence of non-reliable network communication so that there is no loss of data.

2.3.2 UC6: Upload application

- **Name:** Upload application

- **Primary actor:** Application Developer

- **Secondary actor(s):** SIoTIP system

- **Interested parties:**

- *Customers organisations:* want to subscribe the applications.

- **Preconditions:**

- The application developer has access to his dashboard.

- **Postconditions:**

- The application is uploaded into the Online Service.
- The application is available to customer organisations for subscription.

- **Main scenario:**

1. The application developer logs in and opens his dashboard.
2. The system provides the ability to upload new application.
3. The application developer uploads application.
4. The system check application and initiates a number of automated tests.
5. The application developer follows the progress and results of these tests via application provider dashboard.
6. The application successfully passes all tests.
7. The system makes the application available for the customers organisations.
8. The system send a notification to the application developer.

- **Alternative scenarios:**

- 4b. The system can not load application and send error to the application developer.
- 7b. The system interrupt loading of the application, because of potential memory leak.
- 8b. The SIoTIP administrator performs a secondary review and decides whether to accept or reject the application.

- **Remarks:**

- First remark

2.3.3 UC4: Get data from sensors/actuators

- **Name:** Get data from sensor
- **Primary actor:** Application
- **Secondary actor(s):** Online Service, Gateway, Mote
- **Interested parties:**
 - *End-user:* wants to get information from sensors
- **Preconditions:**
 - The application is uploaded in Online Service.
 - A connection between Online Service and Getway is established.
- **Postconditions:**
 - The application received data from sensor.
- **Main scenario:**
 1. The application send request to Online Service.
 2. The Online service communicate with the Gateway.
 3. The Gateway relay information to the mote by sending request.
 4. The mote send data to Online Service (include:send sensor data (UCXX))
 5. The Online Service send data to the application.
- **Alternative scenarios:**
 - 5b. 5b. The application does not receive any data within 2s. It will retry the request 2 more times.
- **Remarks:**
 - First remark

2.3.4 UC31: Subscribe to application

- **Name:** Subscribe to application
- **Primary actor:** Customer organisation
- **Secondary actor(s):** secondary actor(s)
- **Interested parties:**
 - *Name of interested party:* reason why party is interested
- **Preconditions:**
 - The primary actor is authenticated.
 - The customer organisation wants to install new application.
- **Postconditions:**
 - First postcondition.
 - Second postcondition.
- **Main scenario:**

1. The manager of customer organisation open his dashboard.
2. The system display him new applications.
3. The manager choose one of the application and subbscribe for it.
- 4.

- **Alternative scenarios:**

3b. Alternative at step 3

- **Remarks:**

- First remark

2.3.5 UC02: Review application

- **Name:** Review application

- **Primary actor:** SIoTIP System Administrator

- **Secondary actor(s):**

- **Interested parties:**

- *Application developers:* want to add their application to the system

- **Preconditions:**

- The system administrator is authenticated.
- The application needs to be reviewed by a system administrator.

- **Postconditions:**

- The system adminstrator accepts or declines the application.
- The application developers have been notified of this event.

- **Main scenario:**

1. The system administrator navigates to the applications component on their dashboard and selects the application that needs to be reviewed.
2. The system administrator reviews the application's functionality and log history, and the message history with the developers.
3. The system administrator indicates he wants to accept the application.
4. The system logs this event and makes the application available to customer ogranisations.
5. The system notifies the application developers.

- **Alternative scenarios:**

- 3b. The system administrator indicates he wants decline to the application and is prompted by the system to fill in the reason for this. The application will thus not become available to customer organisations.
- 3c. The system administrator indicates he wants communicate with the developers before making a decision. Afterwards, return to step 2.

- **Remarks:**

- When an application first gets uploaded to the system, it needs to be reviewed and accepted by a system administrator. This will prevent the available apps to be flooded with apps of very poor quality or apps that are copies of other apps.
- If at some point in the future, automated testing for an app fails, the app will need to be reviewed again before it can be made available again.

3. Non-functional requirements

In this section, we model the non-functional requirements for the system in the form of *quality attribute scenarios*. We provide for each type (availability, performance and modifiability) one requirement.

3.1 Availability

3.1.1 *Av1*: Unusable database

A database in the system cannot be used anymore. This could happen because of corrupted disks, power outages, too many requests coming into the database server, network failures, natural physical disasters, etc. A different database will be used while this one is unusable.

- **Source:** Database server
- **Stimulus:**
 - The database crashed.
 - The database does not respond to requests.
 - The database does not respond to requests within reasonable time.
 - The database returns invalid data or responses.
- **Artifact:** Persistent storage
- **Environment:** Normal operation
- **Response:**
 - Use a working replica until the database can be used again.
 - Log the fault.
 - If the problem with the database cannot be fixed automatically (e.g. by an automatic restart and resynchronisation), send a technician if it is possible for them to fix the problem (e.g. replace corrupted disks). Otherwise (e.g. power outages, natural physical disasters), send a notification of high priority to SIO TIP system administrators.
- **Response measure:**
 - If a database becomes unusable, this should be detected within 3s of the system trying to use the database.
 - When the system detects that a database is unusable, a working replica should be used within 5s.
 - If a database is unusable because of a system crash or user error, the database should restart and start its boot procedure within 5s.
 - If a database is unusable because of corrupted disks, a technician should replace the disk within 30 min.

3.1.2 *Av2*: Broken sensor

A sensor breaks. The infrastructure owner is notified and if possible, another sensor is used for the responsibility that the broken one was fulfilling.

- **Source:** Sensor
- **Stimulus:**

- No data can be received anymore from the sensor.
- The sensor stopped sending regular updates.
- The sensor sends invalid/corrupted data.
- The sensor disappeared from the heartbeats of the mote it is connected to.
- **Artifact:** Communication channel between sensor and gateway
- **Environment:** Normal operation
- **Response:**
 - The gateway uses another sensor to be used for the same responsibility as the broken one.
 - Log the fault and notify the infrastructure owner.
- **Response measure:**
 - When a sensor breaks, this is detected within 2s.
 - If there is another sensor that can fulfill the same responsibility as the broken one, it should be chosen within 2s.

3.2 Performance

3.2.1 *P1*: Application requests under peak load

An application sends requests to the Online Service while the system is under peak load. These requests could be for getting data from a specific sensor, for configuring application settings, etc. These request should be processed in a timely manner.

- **Source:** Application
- **Stimulus:**
 - An application sends a request to the Online Service.
- **Artifact:** The whole system
- **Environment:** Under peak load
- **Response:**
 - When a request comes into the system, core work necessary to generate a reply is done first. Other work of less importance (e.g. sending emails, generating low-priority notifications, etc.) is scheduled to be done later.
 - Load balancing is used to divide the requests over available servers.
 - Servers that are closest to source of the request are chosen over servers that are farther away to minimize network delay.
- **Response measure:**
 - Applications get a response within 3s.

3.2.2 *P2*: Mote data to application delay

When a mote sends data to an application, that data reaches its destination in a bounded time. This bound is determined by the priority of the data. The possible priorities are low, medium, and high. These priorities can be set by an infrastructure owner.

- **Source:** Mote
- **Stimulus:**
 - A mote sends data to an application.
- **Artifact:** The whole system
- **Environment:** Normal operation
- **Response:**
 - The data is always sent to the next node before other extra work is done. For example, other work could be logging or sending notifications.
- **Response measure:**
 - If the data priority is low, the data reaches the application within 60s.
 - If the data priority is medium, the data reaches the application within 10s.
 - If the data priority is high, the data reaches the application within 1s.

3.3 Modifiability

3.3.1 *M1*: Add a new type of sensor

The SIoTIP corporation wishes to provide a new type of sensor to customers.

- **Source:** SIoTIP developer
- **Stimulus:**
 - Developers add a new type of sensor to the system
- **Artifact:** System codebase and database.
- **Environment:** Normal operation, during a development iteration
- **Response:**
 - The software on motes and gateways must be updated so that the new sensor can be read, calibrated and configured.
 - Components in the system responsible for storage of sensor readings must be updated to save the readings of the new sensor correctly.
 - UI components must be updated so that the readings of the new sensor can be displayed correctly.
 - This modification does not affect the way data is communicated within components of the system.
 - Infrastructure owners can choose when the update will happen. The motes and gateways must be updated before the new type of sensor can be ordered.
 - The updates to the UI components and storage components can be deployed at run time. There is no need to destroy any login sessions for this, since the sensor will not be in use at that time yet.
- **Response measure:**
 - This modification is finished within 5 man months of development time.
 - The deployment of the modifications to the UI components and storage components is finished within 10 minutes.

3.3.2 *M2*: Changes to UI components or new UI components

Developers want to add or edit components that make up the UI. For example, they want to improve components that are reused in dashboards.

- **Source:** SIoTIP developers
- **Stimulus:**
 - Developers add a UI component.
 - Developers edit a UI component.
- **Artifact:** User interface and platform.
- **Environment:** Normal operation, during a development iteration
- **Response:**
 - Users are not able to use the system during the deployment of the changes. All users that are logged in at the time the deployment starts will be logged out first.
 - All users are notified in advance of incoming downtime.
 - The update does not affect currently ongoing activity in the system.
 - The update only affects the subsystem responsible for the UI.
- **Response measure:**
 - The deployment of the new UI components is finished within 30 minutes. Users can log in again immediately after the deployment is finished.

3.4 Usability

3.4.1 *U1*: System administrator reviews application

Before an application can be published or when its automated tests fail, it needs to be reviewed by a SIoTIP system administrator.

- **Source:** SIoTIP system administrator
- **Stimulus:**
 - The system administrator wants to review the application and/or test logs quickly.
 - The system administrator wants to contact the application provider.
- **Artifact:** System administrator dashboard
- **Environment:** At normal operation
- **Response:**
 - The system administrator dashboard is built up using clear components which contain informations about different elements of the system. One such component displays applications that are waiting for a review.
 - The application review page contains a component that describes the application's functionality. There are clear buttons to accept or decline the application. There is a button to open the application.
 - Optionally, the application review contains a component which displays images of the application from an infrastructure owner's point of view.
 - There is a component which displays the log history of the application.

- There is a component for communication with the application provider.

- **Response measure:**

- All actions for reviewing the application, accepting or declining the application, reading the application's log history, and contacting the application provider are possible within 5 clicks.

3.4.2 *U2*: User wants to learn to use the system

A user wants work with the system efficiently. He wants to learn search for important information quickly. An easy to use help system is put in place for this.

- **Source:** User

- **Stimulus:**

- The user wants to use the system efficiently.
- The user wants to feel comfortable with his dashboard.

- **Artifact:** Help subsystem, UI components

- **Environment:** At normal operation

- **Response:**

- The user uses the help system to learn about the functionality every page. When this help system is used, it displays key information about the page the user is currently on.
- The help system contains a search form so the user can learn about anything they want that is relevant to their dashboard.
- The user's dashboard consists of clear UI components that provide information about different elements of the system.
- All forms have clear error notifications. The user is navigated the right way when he does something wrong.

- **Response measure:**

- Anything the user would want to know about relevant to the system can be learned within 5 clicks.