Design Thinking and Advanced Prototyping

ELEC-C9821 – Concept Presentations

Aalto University
School of Electrical
Engineering

Salu Ylirisku

15.2.2023

Today’s agenda

09:15 - 10 Lecture

1. Defining IoT Prototype Requirements
2. Recap learning goals and requirements for prototypes

10:15 - 12 Workshop

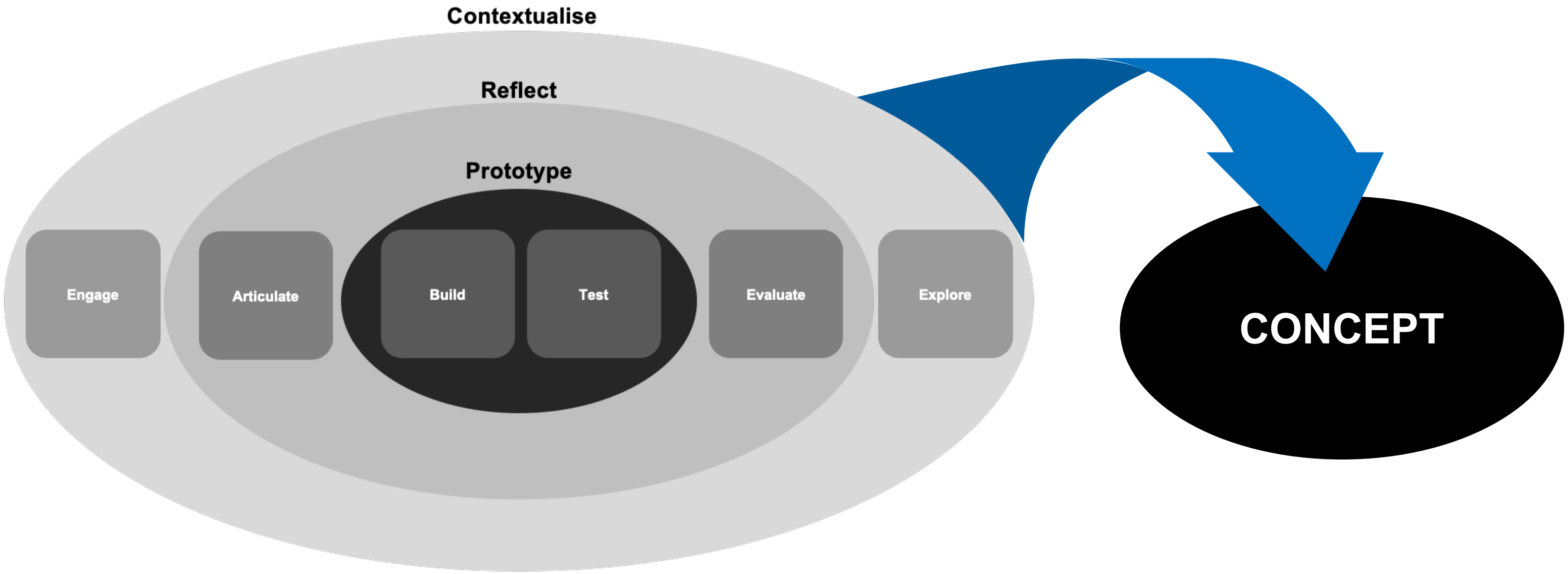
3. Teamwork: Present your chosen concept – explain (CAPE)
4. Discussion

Learning goals

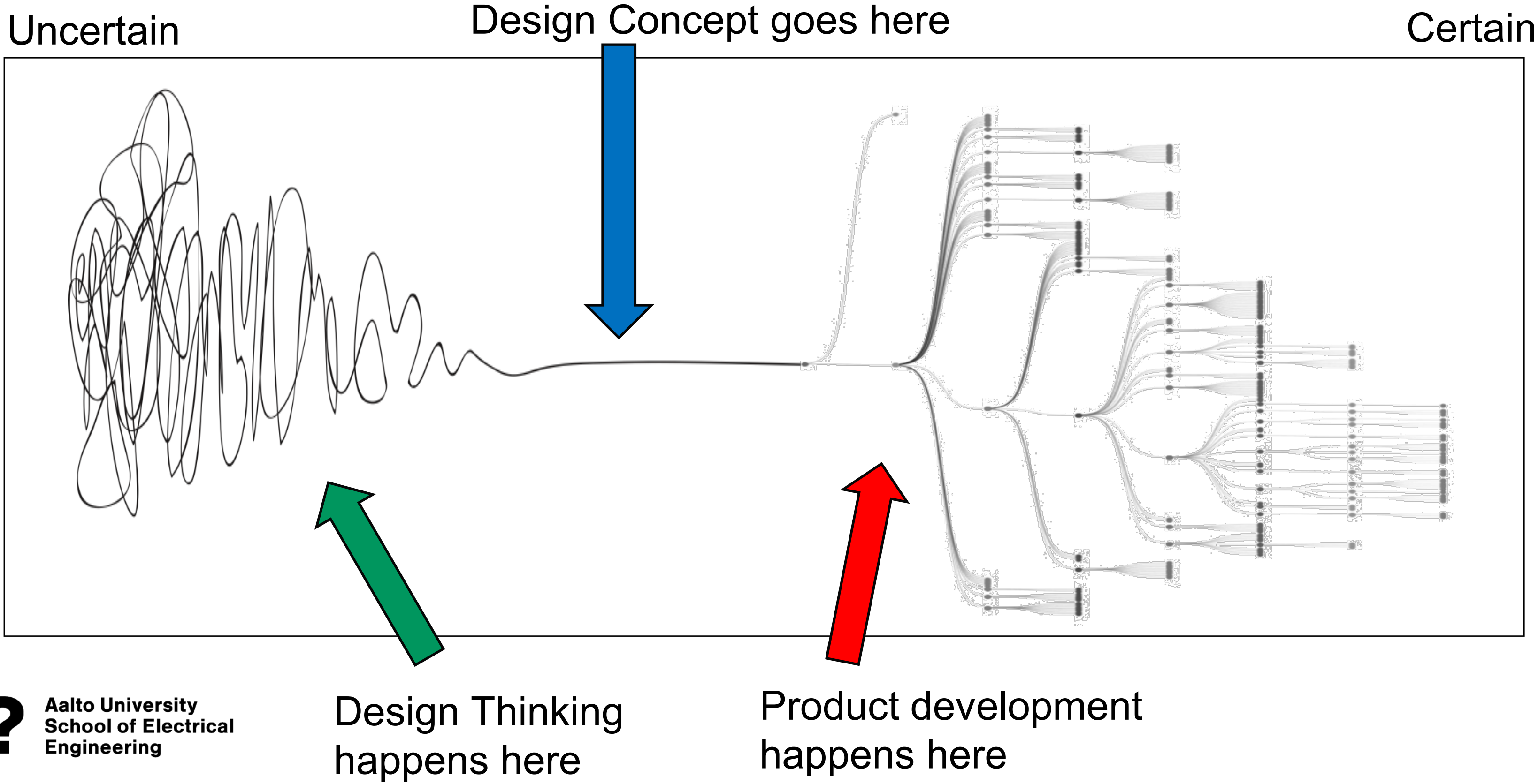
- Learn to see the place of different kinds of prototypes in the process
- Learn to specify requirements for complex IoT prototypes

Prototypes in the process

Design Thinking Model 3-2-1



Design Concept and the Process



Uncertain

Design Concept goes here

Certain

Design Thinking happens here

Product development happens here

Aalto University
School of Electrical
Engineering

Prototypes in DTAP

Iterations

V1 – First prototype(s)

- Requirements by Fri 24th of Feb, Tested by 10th of Mar

V2 – Second prototype(s)

- Requirements by 17th of Mar, Tested by 21st of Apr

V3 – Third prototype (only the 8 ECTS teams)

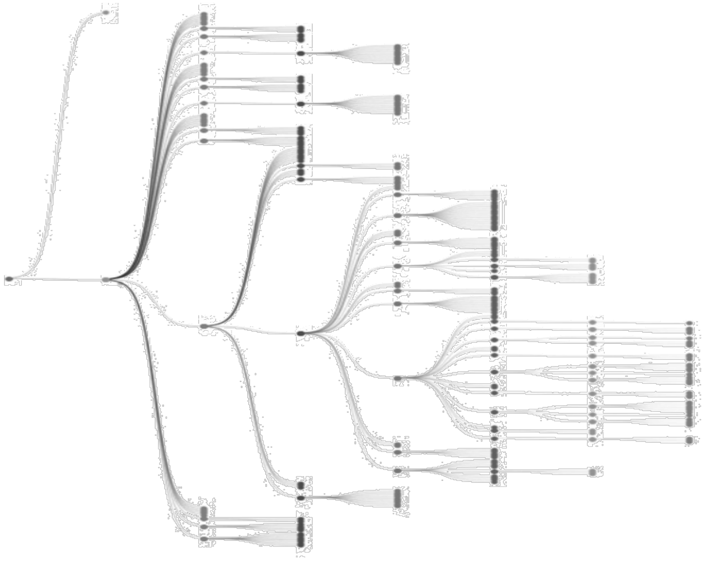
- Requirements by Fri 28th of Apr, Tested by 26th of May

Note: Prototypes are not products

- DTAP course educates you about advanced prototyping, and we are using prototyping tools, which may be (and typically are) different from actual production tools.
- The boundaries are sometimes blurry between prototyping and production tools, though.

The more complex the prototype, the more planning it takes

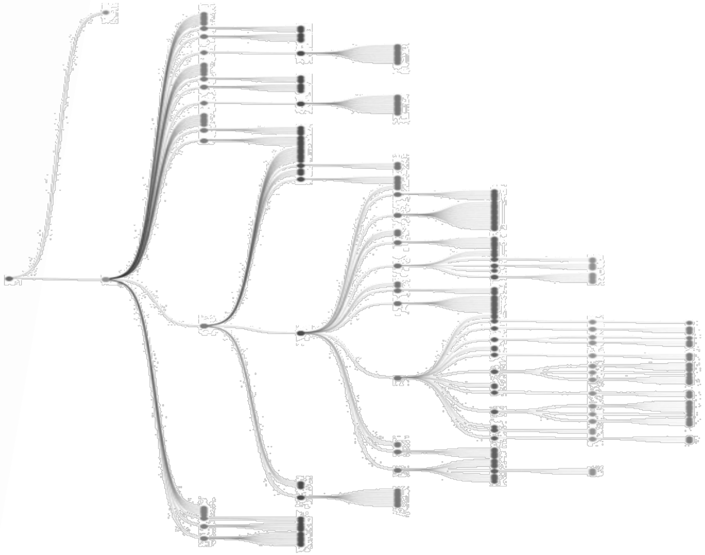
- **So, the planning of a prototype iteration may appear similar to product planning process**



Parts of an IoT product & areas that call for prototyping

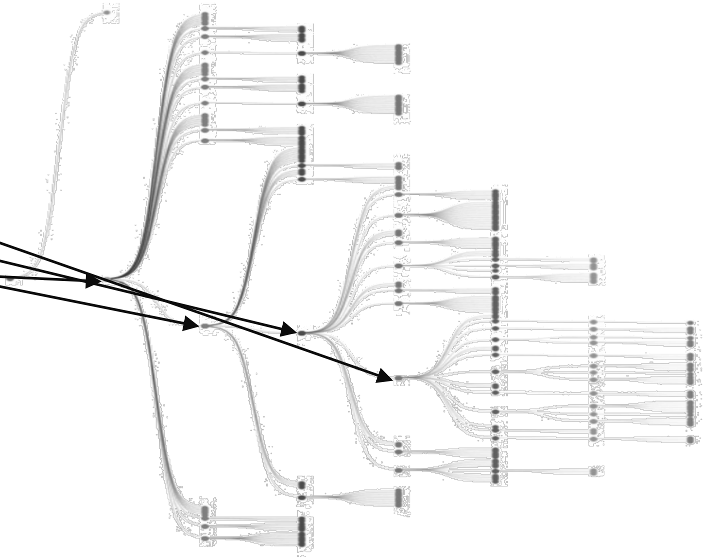
- **Cloud**
- **App**
- **Physical**
- **Embedded**

CAPE



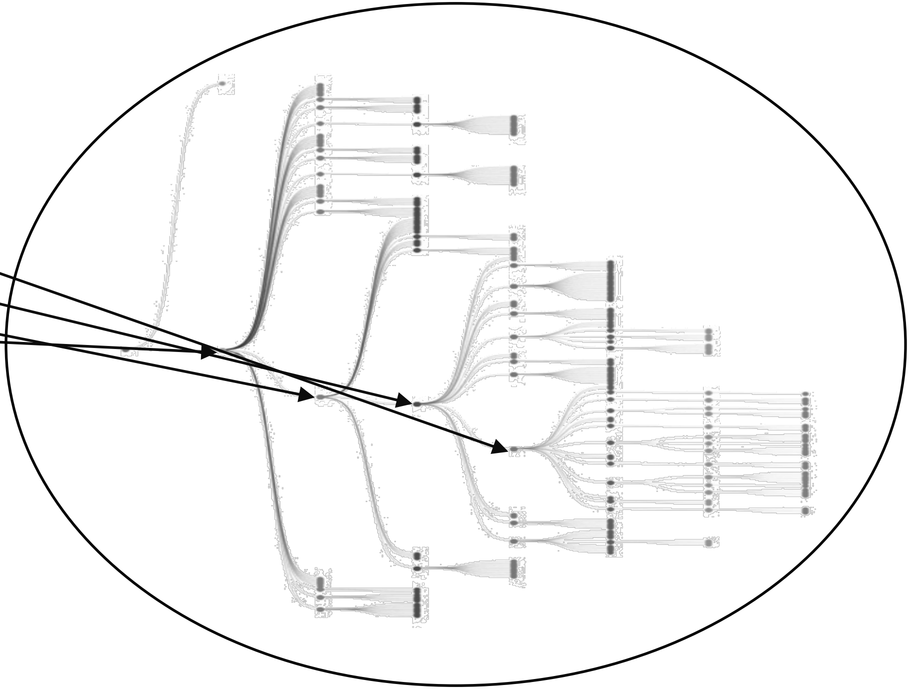
Parts of an IoT product & areas that call for prototyping

- Cloud
- App
- Physical
- Embedded



Parts of an IoT product & areas that call for prototyping

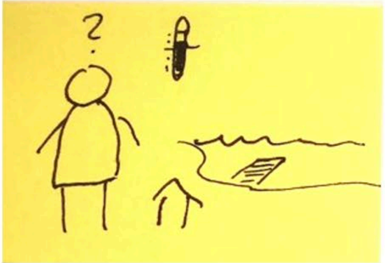
- <u>C</u>loud
- <u>A</u>pp
- <u>P</u>hysical
- <u>E</u>mbedded

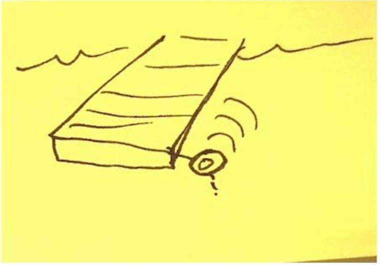


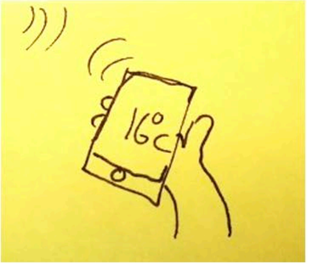
Integration

Parts can (and maybe should) be prototyped separately

Start with your concept







The concept serves as an agreement of the overall goal

- So, make sure that everybody in your team has the same idea of what your design concept is
- You will need to update this as you learn more

Concept

Name

Purpose / Value

Design drivers / Unique qualities

Scenarios / Images

Technical outline / arguments for choices

Price point arguments

Cloud Service

What are the functionalities that you need in the Cloud?

- **Store, process, deliver, connect, …**

App

What are the functionalities that you need in the App?

- **Display, control, remind, connect, …**

Physical thing

What are the physical features that you need for the thing?

- **Forms, buttons, displays, holes, soft/hard, attachments, …**

Embedded electronics

What are the requirements that you set for the electronics?

- **Network connectivity, processing, sensing, actuating, …**

The remote water temp sensor example revisited

Example – Remote Temp Sensing

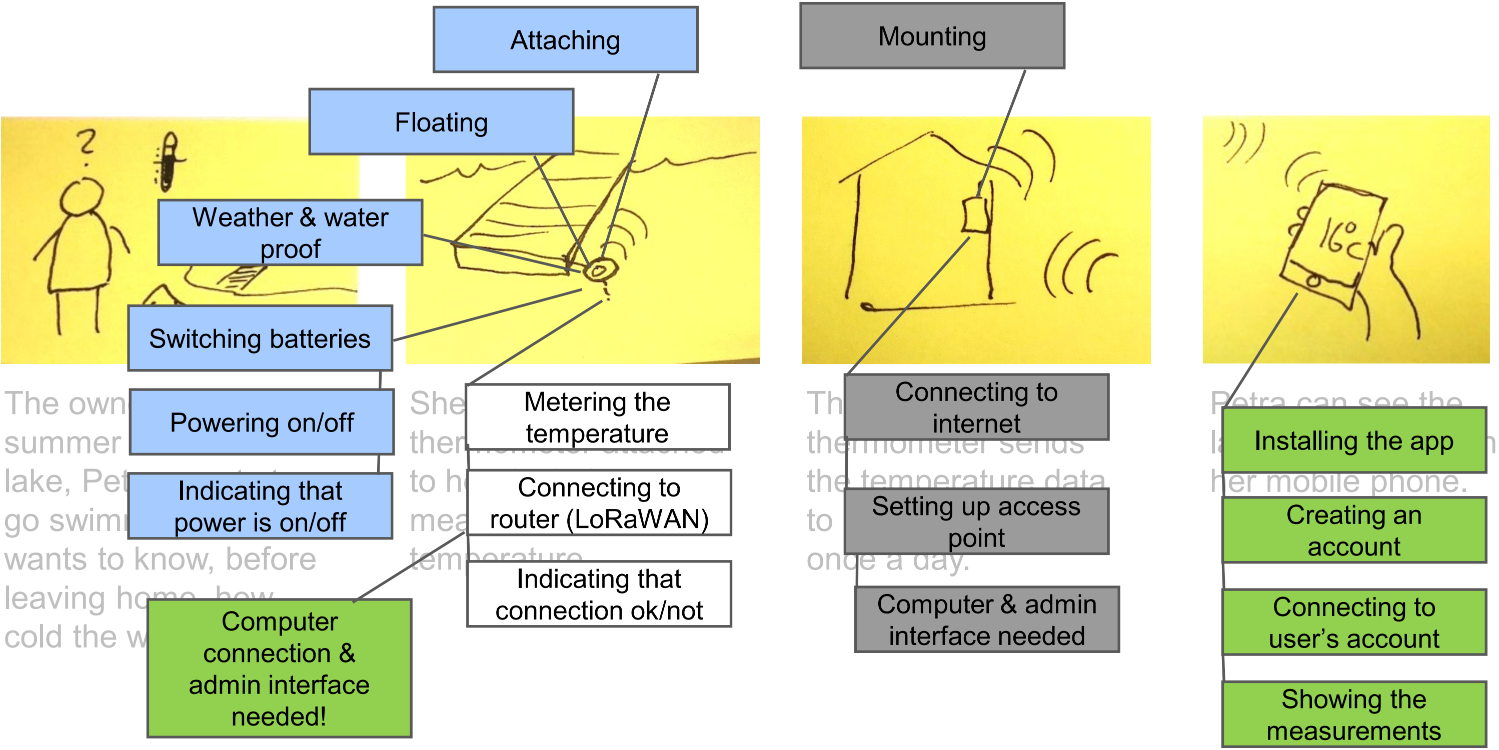
The owner of a summer cabin at a lake, Petra, wants to know how cold the water is at her summer cabin.

She has a wireless thermometer attached to her dock that measures water temperature.

The wireless thermometer sends the temperature data to internet service once a day.

Petra can see the lake temperature on her mobile phone.

What functionalities/features?



Attaching

Floating

Weather & water proof

Switching batteries

Powering on/off

Indicating that power is on/off

Computer connection & admin interface needed!

Metering the temperature

Connecting to router (LoRaWAN)

Indicating that connection ok/not

Mounting

Connecting to internet

Setting up access point

Computer & admin interface needed

Installing the app

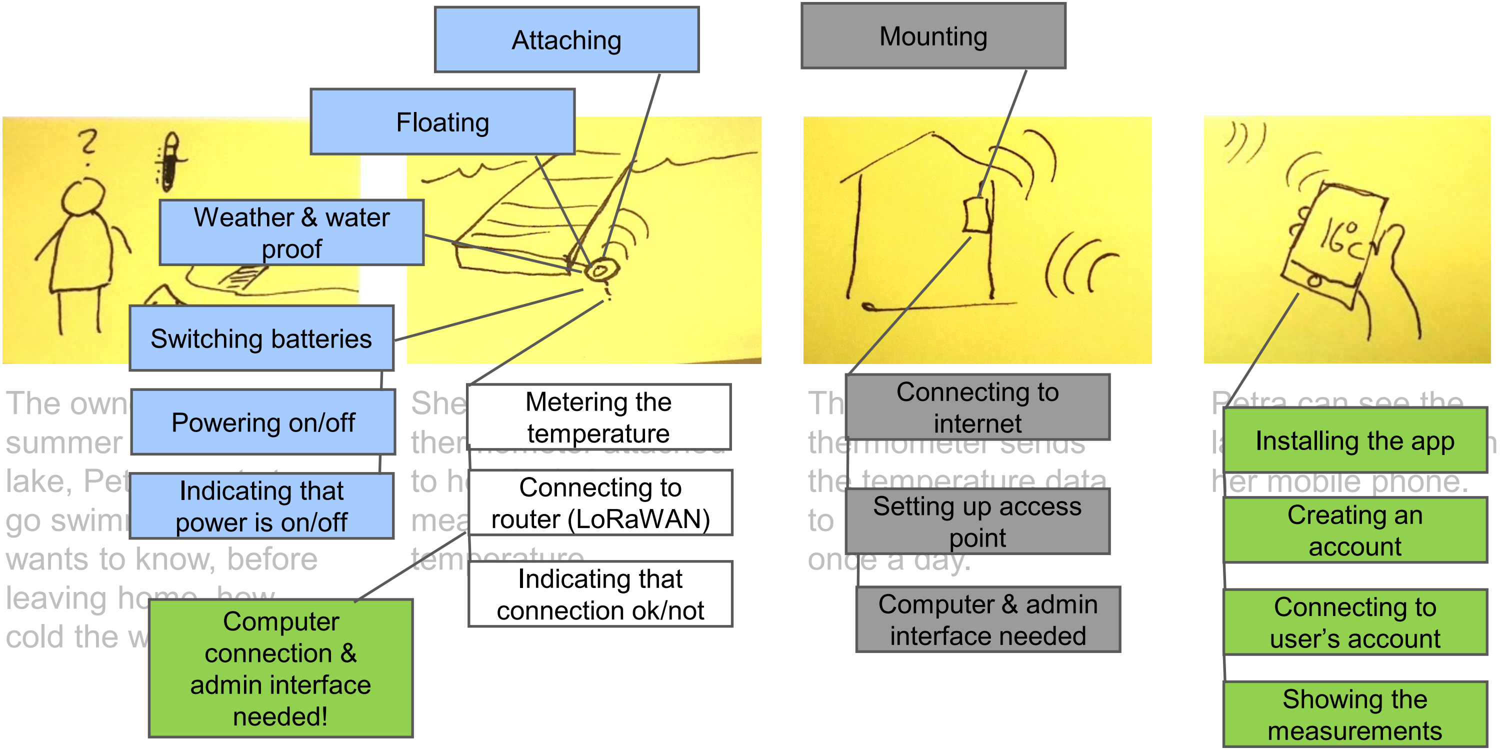
Creating an account

Connecting to user's account

Showing the measurements

Aalto University
School of Electrical
Engineering

Cloud?



Aalto University
School of Electrical
Engineering

Cloud services for the remote water temp sensor

R1: Must receive the temp readings from the device

R2: Must store the temp readings for the app

R3: Must send the temp readings to the app

As learning goals

G1: Learn how to receive the temp readings from the device

G2: Learn to store the temp readings for the app for the device

G3: Learn to send the temp readings of the device to the app

G4: Learn how to serve multiple devices and users

As requirements

G1: Learn how to receive the temp readings from the device

R1.1: The service must provide an interface for submitting data (time + temp)

R1.2: The service must uniquely identify the specific device whenever new data arrives from a device

As requirements for Cloud = C

GC1: Learn how to receive the temp readings from the device

RC1.1: The service must provide an interface for submitting data (time + temp)

RC1.2: The service must uniquely identify the specific device whenever new data arrives from a device

As learning goals

GC2: Learn to store the temp readings for the app for the device

RC2.1: The service must store data readings from a uniquely identifiable device in a time-series fashion (deviceID, time, temp)

As learning goals

GC3: Learn to send the temp readings of the device to the app

RC3.1: The service must provide an interface for the app to fetch the latest temp data from the device

RC3.2: The service must provide an interface for the app to fetch data from the device within a given time-frame (start time – end time)

As learning goals

G4: Learn how to serve multiple devices and users

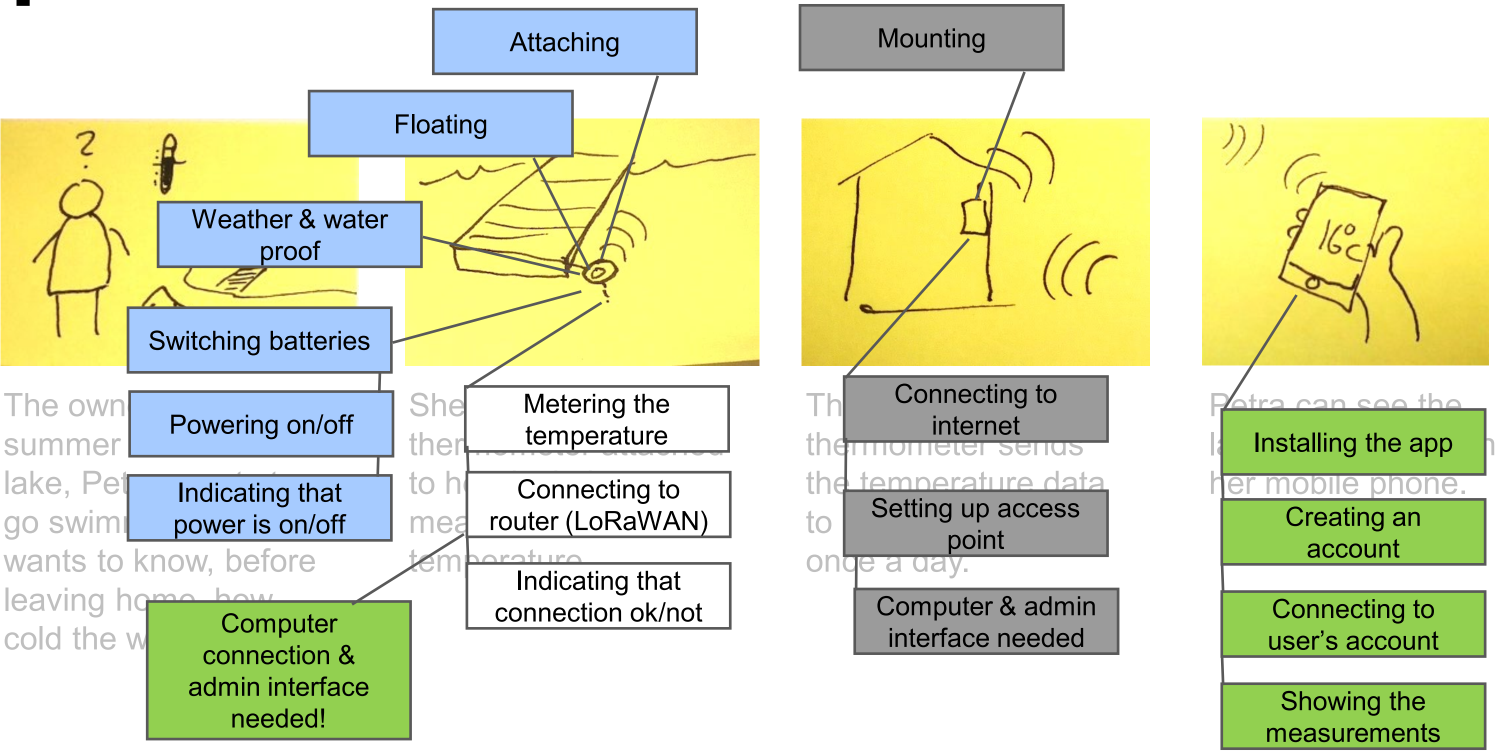
RC4.1: The service must match a device’s data with an authorised app

RC4.2: The service must provide authentication functionality (user accounts)

RC4.3: The service must provide authorisation functionality (user account mapping with specific devices)

Let’s put this in Prototype V2

App?



Attaching

Floating

Weather & water proof

Switching batteries

Powering on/off

Indicating that power is on/off

Computer connection & admin interface needed!

Metering the temperature

Connecting to router (LoRaWAN)

Indicating that connection ok/not

Mounting

Connecting to internet

Setting up access point

Computer & admin interface needed

Installing the app

Creating an account

Connecting to user's account

Showing the measurements

The own
summer
lake, Pet
go swim
wants to know, before
leaving home, how
cold the w

She
ther
to h
mea
temperature

Th
thermometer sends
the temperature data
to
once a day.

Petra can see the
la
her mobile phone.

Aalto University
School of Electrical
Engineering

App functionalities for the remote water temp sensor

R1: Must receive temp readings from the device

R2: Must enable seeing temperatures over time

R3: Must enable users to specify which device is theirs

R4: Must be discoverable online and installable on user’s device

As learning goals (App)

GA1: Learn to fetch a temp reading from the cloud

GA2: Learn to fetch a series of temp readings from the cloud

GA3: Learn to pair an app with a specific device

GA4: Learn to make the app accessible online

GA5: Learn to make the app installable on user’s device

As requirements (App)

GA1: Learn to fetch a temp reading from the cloud

RA1.1: The app must connect to cloud service through an online interface provided by the cloud service

RA1.2: The app must be able to fetch data packets that consist of time and temperature readings from the device

As requirements (App)

GA2: Learn to fetch a series of temp readings from the cloud

RA2.1: The app must be able to fetch a series of data readings from the device

RA2.2: The app must be able to fetch a series of data readings from the device within a specified time-frame (start time – end time)

As requirements (App)

GA3: Learn to pair an app with a specific device

RA3.1: The app must enable user to add a new device to their app

RA3.2: The app must provide a user to create a user account (username + password)

RA3.3: The app must provide user to add a device to their user account

RA3.4: The app must fetch data (see RC2.1, RC2.2) from the specific devices that are added to a specific user account

As learning goals (App)

GA4: Learn to make the app accessible online

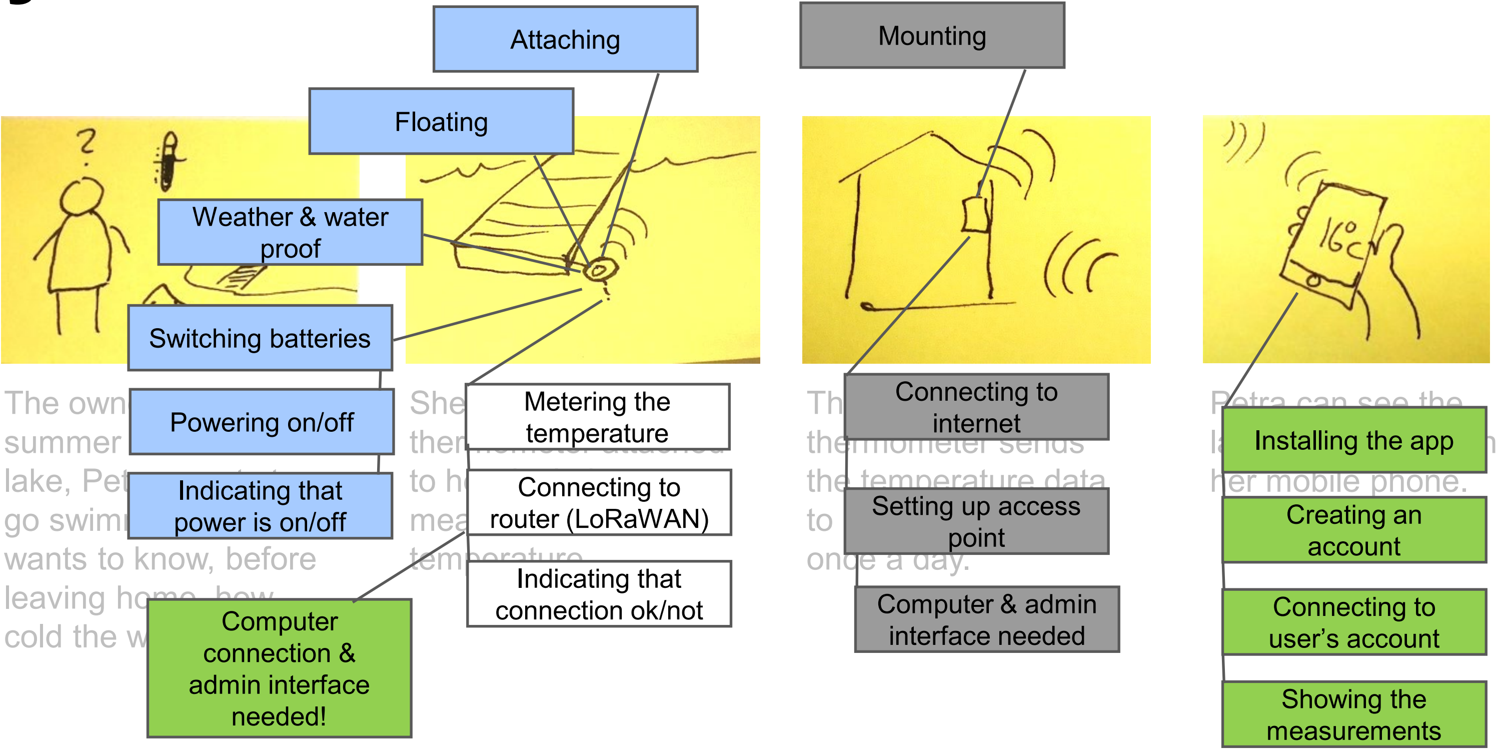
RA4.1: The app must be available as a web app at URL …

As learning goals (App)

GA5: Learn to make the app installable on user’s device

RA5.1: The web app must be implemented as a Progressive Web App (i.e. with proper web manifest)

Physical?



Attaching

Floating

Weather & water proof

Switching batteries

Powering on/off

Indicating that power is on/off

Computer connection & admin interface needed!

Metering the temperature

Connecting to router (LoRaWAN)

Indicating that connection ok/not

Mounting

Connecting to internet

Setting up access point

Computer & admin interface needed

Installing the app

Creating an account

Connecting to user's account

Showing the measurements

The own
summer
lake, Pet
go swim
wants to know, before
leaving ho how
cold the w

She
ther
to h
mea
temperature

Th
thermometer sends
the temperature data
to
once a day.

Petra can see the
la
her mobile phone.

Aalto University
School of Electrical
Engineering

Physical features that are necessary

R1: The device must float on water (to enable data transmission)

R2: The device must enable temp readings on water (with a specific temp sensor, see REx.xx for dimensions and thermal conductivity needs) while the device is afloat

R3: The device must have space for electronics (see REy.yy for dimensions) and power source (see REy.zz for dimensions)

R4: The device must have visual indicators for on/off status and online status

R5: The device must have on/off switch

R6: The device must have opening to replace power source

R7: The device must have opening for USB-C (see REå.åå for dimensions)

R8: The device must be sealed against dust and water (IP67)

As learning goals

GP1: Learn what are the best shapes for floating devices (on leash)

GP2: Learn what is the best placement for the temp sensor

GP3: Learn what are the best placements for the electronics and power source

GP4: Learn what are the best ways to indicate on/off and online states

GP5: Learn how to best switch the device on/off

GP6: Learn how to make the opening to replace power source in the best manner

GP7: Learn how to best place and seal the opening for the USB-C connector

GP8: Learn how materials and forms enable making the device IP67 rated

As learning goals

GP1: Learn what are the best shapes for floating devices (on leash)

RP1.1 The device must float on water with payload of 50 grams

RP1.2 The device must not flip even with wavy water, or it should automatically turn up

As learning goals

GP2: Learn what is the best placement for the temp sensor

RP2.1 The device must enable temp readings on water (with a specific temp sensor, see REx.xx for dimensions and thermal conductivity needs) while the device is afloat

As learning goals

GP3: Learn what are the best placements for the electronics and power source

RP3.1 A 3D model that explicitly demonstrates the best location for electronics and power source, and shows the support structures inside the device

As learning goals

GP4: Learn what are the best ways to indicate on/off and online states

RP4.1: As part of the 3D model (in RP3.1) the model must show where the indicator LED(s) are placed (NOTE: the amount and sizes of the LEDs come from REx.xx)

As learning goals

GP5: Learn how to best switch the device on/off

RP5.1: The device must feature a button / other physical mechanism to turn it on/off

RP5.2: The on/off mechanism must mount onto the electronic switch (specified as part of REx.xx)

As learning goals

GP6: Learn how to make the opening to replace power source in the best manner

RP6.1: The physical cover must allow the replacement of the power source (specified as part of REx.xx)

As learning goals

GP7: Learn how to best place and seal the opening for the USB-C connector

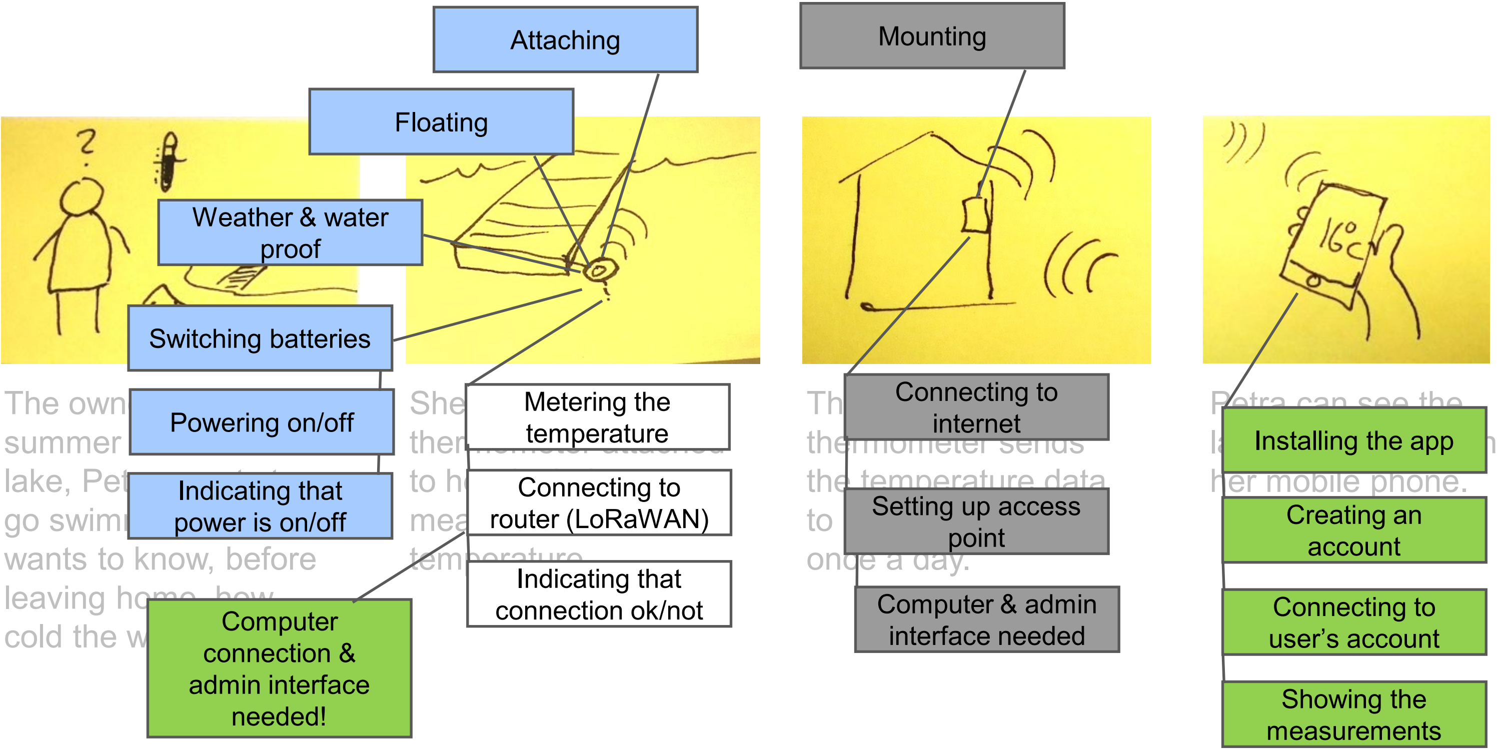
RP7.1: The device must have an opening for USB-C (dimensions specified as part of REx.xx)

As learning goals

GP8: Learn how materials and forms enable making the device IP67 rated

RP8.1: The device must survive in-water conditions, rain, and dust.

Embedded?


Attaching
Floating
Weather & water proof
Switching batteries
Powering on/off
Indicating that power is on/off
Computer connection & admin interface needed!
Metering the temperature
Connecting to router (LoRaWAN)
Indicating that connection ok/not
Mounting
Connecting to internet
Setting up access point
Computer & admin interface needed
Installing the app
Creating an account
Connecting to user's account
Showing the measurements
16°C
The own
summer
lake, Pet
go swim
wants to know, before
leaving home, how
cold the w
She
ther
to h
mea
temperature
Th
thermometer sends
the temperature data
to
once a day.
Petra can see the
her mobile phone.

What are the requirements for the embedded electronics?

R1: Must run on 3 x AA batteries (3.5 - 4.5V)

R2: Provide on/off switch

R3: Provide LED indication for A) power on, B) LoRaWAN connection status, C) cloud service connection ok/fail

R4: Read the temperature of water (range 0°C – +50°C)

R5: Connect to LoRaWAN router

R6: Connect to an interface of the online cloud service

R7: Submit temp reading to the cloud (deviceID, temp in C, battery level – no timestamp needed!)

R8: Set up a sleeping cycle and submit new reading every hour (test different sleep cycle lengths, up to ~24h sleep)

As learning goals

(see: not all make sense as learning goals)

RE1: The device must run on 3 x AA batteries (3.5 - 4.5V)

GE2: Learn what is the best on/off switch for the purpose (mounted or hanging)

GE3: Learn what is the best way to indicate the three states (on/off, LoRaWAN, service connect)

RE4: The device must be able to read the temperature of water (range 0°C – +50°C)

GE5: Learn how to connect the device to LoRaWAN router and if there are possible signal strength issues

GE6: Learn how to connect to an interface of the online cloud service

RE7: Submit temp reading to the cloud (deviceID, temp in C, battery level – no timestamp needed!)

GE8: Learn how to put the system to sleep, to set up a sleeping cycle and to submit new reading every hour (test different sleep cycle lengths, up to ~24h sleep)

-- Presence Check --

Workshop:
Present your chosen concept

Present Your Concept

- **Name**
- **Purpose**
- **The essential parts & functionalities (CAPE)**

This week

- **Project: Focus on one idea – presentations next week**
- **Write your weekly diary and submit it (the periodical diary is due on Fri 17th)**
- **Exercises (Fri 14-16, Mon 14-16, Tue 10-12)**
    - There are REQUIRED – and you need to reflect on them in your diaries