BOEIend!
Lab Assignment – Mobile Communications

Gilles Callebaut
gilles.callebaut@kuleuven.be
Guus Leenders
guus.leenders@kuleuven.be
KU Leuven, Ghent Technology Campus — October 9, 2018

Introduction

Navigation in water ways is aided by thousands of buoys. As they are used for navigation and to mark shallow water, it is important that they are in the right place. To manually check this is time consuming, and thus there is now a plan to make these smart so that they can automatically report their position. This makes it possible for them to also report additional information, such as temperature, current direction and amplitude of the waves. As buoys have a lifespan of 5 – 10 years, the design must be energy efficient, and possibly make use of some energy harvesting methods. The scope of the lab sessions is to develop the design and specifications for the communication element of such a buoy, and to build and test a prototype.

1 Problem Statements

A typical scenario is depicted in Figure 1. The buoys are placed in an operating zone. The system should detect if a buoy is drifting. A buoy is considered out of place when the distance to his original location is larger than a certain predefined threshold. This can be detected with different localization or proximity-based mechanisms. Due to the limited energy budget of the buoys, continuous collecting GPS measurements is infeasible. It is thereby imperative that low energy strategies are employed to ensure a long lifespan. In addition to the drifting detection scheme,

the buoys periodically send sensor data to monitor the amplitude of the waves and the temperature of the water. Some larger buoys will be equipped with larger batteries, these buoys can be used to do more energy-heavy tasks.
In this project, you may assume the following distances:

- between the coast and the buoys (A): 100m – 1km
- between neighboring buoys (B): 10m
- between immobile buoy and drifting buoy (C): $>$ 20m

The results from this project will be used to develop low cost and low energy hardware in the course Embedded Systems 2. Hence, the assumptions, the used strategies and other considerations should be well documented!

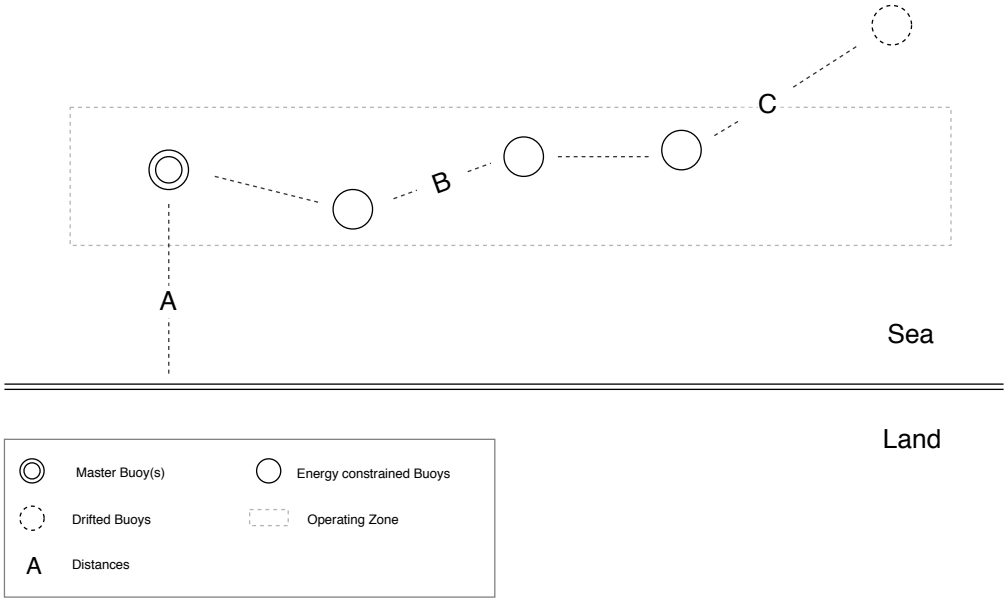

Figure 1: Problem scenario

2 Project outline

In order to aid in the research and development process, we outlined different tasks you need to complete:

- Understand the problem statement
- Break the problem in smaller sub-problems

- Define the requirements for each problem, e.g. for communication between the coast and the master buoy we need a range of "A" (see Figure 1).
- Parameterize each problem as much as possible (most often there are some assumptions you need to make)
- Select the wireless technologies based on the defined requirements
- Design strategies to detect drifting
- Utilize approaches to lower the overall energy consumption. You may also include recommendation for hardware related energy improvements.[1]

3 Assignments & Deadlines

Info: The students are not required to be present at 5/11/2018 due to the absence of the lab teachers. The assistance of a lab teacher can be requested through e-mail. The lab will 'always' be available for students to work at their own pace and at their convenience.

Notice: Reports need to be submitted before 22h00 at the day of the deadline. You can send the documents to `gilles.callebaut@kuleuven.be`.

3.1 Preparation – 8/10/2018

Bring your individual notes concerning the questions from the preparation slides located on Toledo[2]. This will be checked. The notes will be your starting point for examining the use case. You will collectively analyze the problem per group; as defined in Table 2. Hence, before getting your hands dirty, the system needs to be designed and thoroughly discussed:

- Which problems could occur and how do you plan to tackle them?
- Furthermore, an economical point-of-view of the project needs to considered, i.e. what is the cost and the gain? Are there legal limitations?

[1] Note, that this is not a requirement nor the focus of these lab sessions.

[2] Mobiele communicatie: hoorcollege [JLI40C] > Course Documentation > Voorbereiding project

- What are the technical limitation of the designed system?
- How to take energy efficiency and robustness into account?

The resulting system needs to be developed based on the available hardware, see Table 1. You can request additional hardware if required or deemed necessary; substantiate why.[3] To request hardware, send an e-mail to `guus.leenders@kuleuven.be` containing:

- Group Number
- Product
- Links to purchase the goods
- Number of product required
- Why the additional product is needed

3.2 Intermediate Report – 22/10/2018

After the first session, each group must submit a report. This report must demonstrate that you have examined the use case and are capable of designing a viable solution. This includes a plan for a specification of the interfaces, selection of communication technologies (and why). The report needs to be submitted via e-mail to `gilles.callebaut@kuleuven.be`.
More information:

File name format `mobile_comm_group<nr>_intermediate_report.pdf`

Language Dutch or English (recommended)

Number of pages Write your report in a compact but concise way, following the strategies presented in [1, 2].

Info: The report is expected to be structured and styled as described in [1, 2]. The structure of the report will be taken into account when grading the report. This also holds for the final report.

[3] Note, that this will not guarantee that we will be able to purchase the hardware. Also, be aware that this will most likely result in some time delay to build the prototype.

3.3 Final Report – 19/11/2018

The final report will reflect on the specifications described in the intermediate report and additional contributions to the project.
Be sure the following things are discussed in the report:

- Problem description, analysis and assessment
- Selection of wireless communication technologies
- Strategies designed to be energy efficient
- Technical issues addressed or resolved when building the prototype
- Detection mechanism(s) for drifting buoys
- Possible sensors and data measurements

More information:

File name format `mobile_comm_group<nr>_report.pdf`

Language Dutch or English (recommended)

Number of pages Write your report in a compact but concise way, following the strategies presented in [1, 2].

3.4 Presentation – 3/12/2018

In the last session, each group will give a presentation to explain **what** you have done, **how** you have done it and **why**. In this presentation, you will focus on technical issues you have addressed. Begin by introducing the assumptions you have made and the main aspects of your project. Target a 30 minute presentation.

References

[1] Barbara J Hoogenboom and Robert C Manske. How to write a scientific article. *International journal of sports physical therapy*, 7(5):512, 2012.

[2] Elena D Kallestinova. How to write your first research paper. *The Yale journal of biology and medicine*, 84(3):181, 2011.

Table 1: Available hardware.

Product	Extra Information	Resources
EFM32 RN2483 LoRa Node	Happy Gecko + LoRaWAN modem (RN2483)	Source and Schematics
LoRaWAN EFM32	Happy Gecko + LoRa chip (SX1272)	Source and Schematics
A6 GPRS GSM Shield		Wiki
Bluefruit LE	nRF8001	Adafruit Product Page
GPS module	GY-NEO6MV2	Arduino Example
NFC module	PN532 NFC RFID	Manual v3.1
DRAMCO ZigBee Arduino Shield	ZigBee, temperature, accelerometer, sound, light,...	Information and Schematics
DRAMCO LoRaWAN Arduino board	LoRaWAN, temperature, accelerometer	Source code

Table 2: Groups.

GROUP 1	GROUP 2	GROUP 3	GROUP 4
Arne De Geeter	Birgen Vermang	Ruben Mechelinck	**Pelle Reyniers**
Axel Willekens	Sander Thierens		Arne De Brabanter
Jorik De Bruycker	**Brecht Van Eeckhoudt**	Gilles Verbauwhede	Hannes Buyle
Pieter Wielandt	Louis Devreese	**Matthias Alleman**	Niels De Moor
	Sarah Goossens	Thomas Poppe	Tom Lierman