# Introduction to IoT: Autumn 2019

Exercise set: 4

Due on 2nd October 2019 by 16:00.

**Instructions:** All course participants are requested to submit their exercise solutions (in English) electronically to the instructors Agustin Zuniga (agustin.zuniga at helsinki.fi) and Prof. Petteri Nurmi (petteri.nurmi at cs.helsinki.fi) by the due date. Use the following subject in your email: *IoT_week[#]_[last name_first name]_[student number], (i.e. IoT_week4_Zuniga_Agustin_12345)*

Your submission have to contain no more than **four (4)** single-spaced and numbered pages. Use font type Arial or its equivalent with size no smaller than 10 points. Include the exercise set number, your full name and student Id in the upper right corner of the first page.

In all the exercises, do not just give the answer, but also the derivation how you obtained it. Participants are encouraged to review course material to answer the problems and in some cases write computer programs to derive solutions.

**Learning objective:** In this set of exercises you will understand better the networking layer of the *Internet of Things, IoT*. The tasks will help you to be more familiar regarding the use of different networking technologies and communication architectures in IoT applications.

## Networking in IOT contexts

**Task 1 (4 pts.)** Write simple pseudocode for (a) device discovery and (b) keep alive. Refers to slides 10, 11, 22, 23 and 24 of Lecture 8: IoT Networking II

### Task 2 (3 pts.)

Select two application domains, one focused on consumer level IoT and one focused on enterprise IoT (you can choose the ones you used in the previous week exercises). The difference between consumer and enterprise levels is explained in Lecture 6: Sensing and the sensing pipeline.

1. Describe one smart object for each domain and its functionality (for maximum points, the system should have control, sensing, and actuation).
2. What requirements would the objects impose on the networking technology? Refer to the categorisation parameters on slide 26 of Lecture 7: Networking Technologies on IoT.
3. Which networking technology, architecture and network range would be best suited and why?

### Task 3 (3 pts.)

The following IoT applications are taken from the previous weeks' exercises:

- **Application 1.** Besides of having a temperature sensor, Xin's fridge includes features like touchscreen interface, microphone, internal camera and RFID reader. Before going home, Xin gets a reminder that the milk in his fridge expires soon. At the supermarket, Xin uses his mobile to connect to the internal camera of the fridge and checks if there is something else he should buy.
- **Application 2.** A car manufacturer wants to implement IoT features on its vehicles. The provider plans to use cars' elements as smart objects to improve driving quality and safety while driving. For instance, speed limit information will be automatically displayed according to GPS coordinates using on-line street maps and police information. Additionally, the manufacturer is periodically collecting smart objects' data to evaluate cars' condition on-line. This information is used to inform drivers about possible issues and suggest how to solve them in real-time. Additionally, information is also used to automatically re-calibrate cars' sensors.
- **Application 3.** A startup company wants to use IoT for monitoring forest condition. To achieve this, the company uses two kinds of smart objects: (1) one monitoring air quality, including temperature, relative humidity, air pressure, gas and particulate matter sensors; and (2) one monitoring animal movements through infrared and sound sensors. Under normal operating conditions, sampling air quality once every ten minutes suffices as air quality does not abruptly change. However, simultaneous abrupt changes in gases (CO or $NO_2$) or particulate matter can reflect possible abnormal conditions and hence they are sampled every two minutes. For the second sensor, transit of animals is higher from 10 PM to 5 AM with around five animals moving around every ten minutes, while during the rest of the day transit decreases to around one animal per ten minutes.

Choose one of the applications and describe the following information (justify your answers to get the full points):

1. What are the requirements that the objects and the application impose on the networking technology? Refer to the categorisation parameters on slide 26 of Lecture 7: Networking Technologies on IoT.
2. Which networking technology, architecture and network range would be best suited and why?
3. Which offloading model would you use, which tasks would you offload/delegate and why? Justify your answer taking into account latency, energy, amount of data and money/computation cost requirements. Refer to the models in slide 52 of Lecture 8: IoT Networking II.

## Bonus Task

Consider last week bonus task, an air quality sensor that integrates a MOX gas sensor, a LSP particulate matter sensor, and environmental sensors measuring temperature and relative humidity. The MOX sensor requires heating to take measurements. Heating the sensor from sleep state requires 5 seconds, and it takes up to 10 seconds for the sensor to cool down. Both the values of the gas sensors and the values of the particulate matter sensor are corrected using a calibration pipeline that use external humidity and temperature as input. Correcting the measurements requires operating a microcontroller for 1 second period, during which heat is released into the sensor. Consider also that the number of bits transmitted per second are 2 bits for heating, 1 bit for cooling and 5 bits for correcting the measurements.

- What would be the optimal bandwidth for this application and why? Assume that in the communication channel 1% of packets collide and need to be retransmitted during the night, and 3% the rest of time.
- What is the throughput of the channel?