**Exercises – Applications and Hardware**

**Exercise 1**

Describe how the sensor network application characteristics given in class (environment, lifetime, cost, sensed data, network topology, user interaction) apply to the following application areas:

- Warehouse monitoring
- Health care
- Structural monitoring (e.g., a bridge)

**Exercise 2**

Given an application example that requires the use of a multi-hop network.

**Exercise 3**

Consider the Nissin warehouse with the following key characteristics:

<table>
<thead>
<tr>
<th>Temperature Control Zone Details</th>
<th>Temperature Zone</th>
<th>Storage Spaces</th>
<th>Storage Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant temperature: -5 oC to +15 oC</td>
<td>12</td>
<td>7,412 m²</td>
<td></td>
</tr>
<tr>
<td>Rapid freezing room: -40 oC</td>
<td>1</td>
<td>37 m²</td>
<td></td>
</tr>
<tr>
<td>Pre-cooling room: +10 oC</td>
<td>4</td>
<td>2,423 m²</td>
<td></td>
</tr>
<tr>
<td>Inspection room: -5 oC to +15 oC</td>
<td>2</td>
<td>175 m²</td>
<td></td>
</tr>
<tr>
<td>Preparation room: room temperature</td>
<td>1</td>
<td>132 m²</td>
<td></td>
</tr>
</tbody>
</table>

Describe the infrastructure needed to monitor and control the temperature in this warehouse:

- What are realistic temperature range, accuracy and response time for a temperature sensor (NTC) ? -- check on the Internet
- How would you place temperature sensors in the preparation room?
- What is the expected data rate for the sensors?
- When should the actuators (thermostat) be activated?
- How should the actuators be activated?
- What are the arguments in favour of battery-driven sensor/actuator nodes?

**Exercise 4**

Consider a vulcano. Vulcanic activity can be measured with seismic sensors or infrasound sensors. Seismic sensors measure vibrations due to earthquakes. Infrasound sensors measure the low
frequency acoustics (1-50Hz) that results from shock wave due to gas emission from volcanic conduit. Those shock waves have a very high amplitude (130db at 1km).  

A – Consider a sampling rate of 100 Hz. Each sampled data item occupies 16 bits. Data is stored on flash before it is sent over the radio. How large should flash memory be if data is to be transmitted every 5 minutes. What should be the radio data rate then if we want to transmit for 10 sec?  

B - The sensor node is equipped with a 128 Kb flash and with a radio whose data rate is 40 kbps (kilo bits per seconds). Sampled data items occupy 16 bits. What is an appropriate sampling rate? What can be done to increase the sampling rate?  

C – (*) You are using sensor nodes equipped with a microphone.  
- How do you choose an appropriate microphone?  
- What is the output of the microphone?  

Exercise 5  
Consider the following AA battery.  
- Nominal voltage: 1.2 V  
- Rated discharge capacity: 2000 mAh  
The sensor node you consider consumes an average of 5 mW.  

What is the expected lifetime of the sensor node when it is connected to 1 such AA battery? What is the expected lifetime of the sensor node when it is connected to 2 such AA battery connected serially?  

Exercise 6  
Consider the following chart tracing current consumption (in ampere on the y-axis) for the duration of a TinyDB experiment (time on the x-axis).  

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1 See the Tungurahua experiments for more info on using wireless sensor networks for monitoring volcanic activity.  
2 The graph is extracted from The Design of an Acquisitional Query Processor For Sensor Networks (SIGMOD ’03) by Madden et al.
The sensor node is powered with the following AA battery.
- Nominal voltage: 1.2 V
- Rated discharge capacity: 2000 mAh

What is the power consumed by the sensor node during the experiment?
How long is the sensor node life time is the experiment is continually repeated?