Sustainable Electronics and IT

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1. Introduction

The Sustainable Electronics and IT – SUSIE (62562) is an elective course integrating sustainability for 5 or 6 semester IT and Electronics students. The course is offered in 3½ year B.Eng. Program, which includes a ½ year internship and Diploma engineering project in the industry

This poster present:

- the course curriculum.
- how ICT, low power design and LCA are integrated in students work
- some students projects and results

For our technical interested students, it makes sense to apply:

- the sustainable science in project work about energy consumption, monitoring and control of indoor climate in buildings.
- Design for low power, by practical examples

2. SUSIE curriculum

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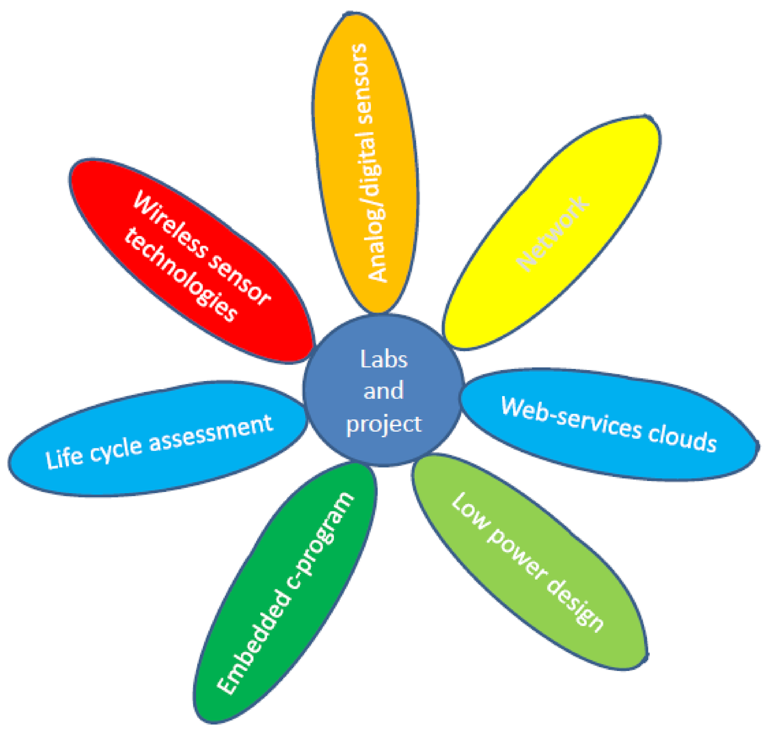

Fig. 1 Course contents (Ref 10)

The course Teaching:

- a weekly lecture during 8 – 9 weeks
- a weekly lab-exercise during the first 8-9 weeks
- 4-5 weeks for a group chosen project
- Teacher role is lecturer and supervisor in labs and project

3. SUSIE Project work

Open Project framework in SUSIE

Team based project work is undertaken with the purpose of using all the topics from the classes in solving a self-chosen problem: At Campus Ballerup we are used to give open project frames, hence this part of the project proposal in SUSIE:

"…Choose a problem domain for which it is relevant to monitor environmental data and controlling actuators, e.g. in a house, at Campus Ballerup, a green house, plant control, electrical vehicle, etc." …"One of the wireless nodes should be powered by a renewable energy source".

For prototyping and experiments each team is given a Box

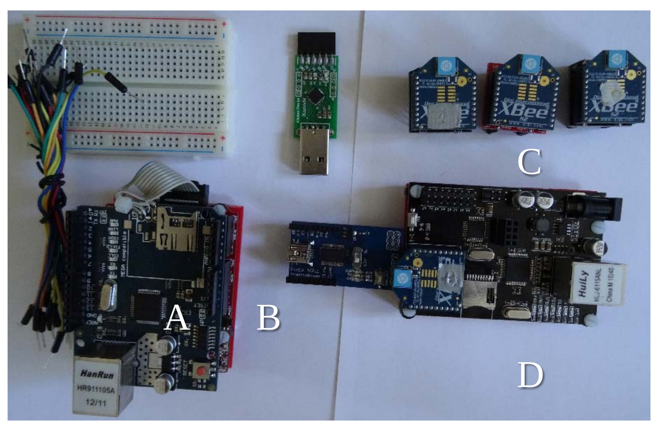

Fig. 2 SUSIE kit

A: LAN-shield for Arduino – W5100 tranciever
B: Olimexino board – Atmega 328p
C: Xbee , IEEE802.15.4
D: Iboard with LAN and Xbee

4. Energy and protocols

Exercise about power and power management in an embedded system:

a. Describe which main components and software parts a system contains.
b. Which strategies can be used for power management due to reducing the energy cost?
c. How can the energy Consumption be estimated?
d. Discuss and list the Dynamical opportunities for power management.
e. How should a design be carried out for best energy efficiency?

(Read chap. 3 and 7 in litt. Ref 1)

Practical lab-work

"Purpose is to estimate the power required for two boards which can full fill the user's needs and to do experiments with the XBEE in sleep mode together with the coordinator_controller board .

By practical measurement as shown in Fig. 3 and 4 the students are taught what to consider when designing low power wireless systems.

Students are encouraged using alternative Wi-Fi devices such as ex. CC3000 from Sparkfunk with a TI CC3000 on board (IEEE 802.11 b/g and – Embedded IPv4 TCP/IP stack ref 2.) – Or the ESP8260 to compare WIFI with low-power protocols.

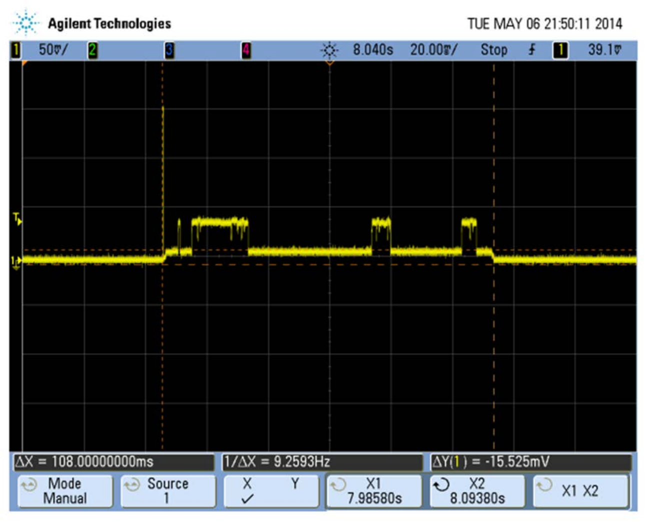

Fig. 3 Measured voltages across 1 ohm in serie with power supply for a Xbee wireless node(Ref 7)

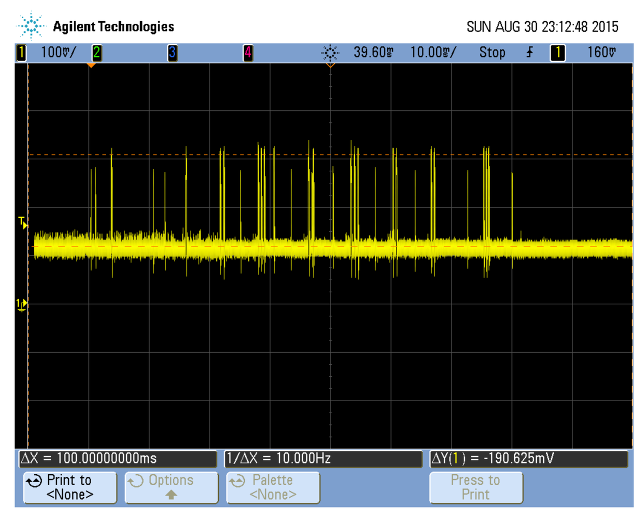

Fig. 4 Measured voltages across 1 ohm for a CC3000 - each pulse is app. 140 μsec long

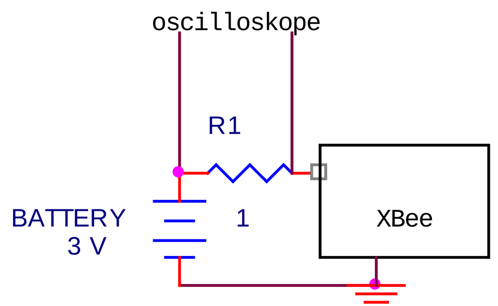

Fig. 5 Comparison of power consumption in transmit, receive, (ref 8)

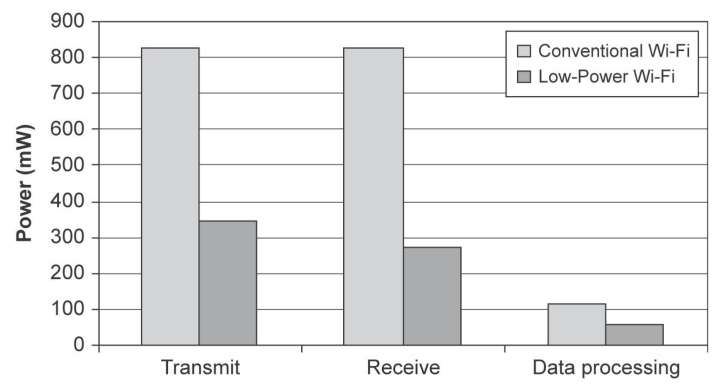

Fig. 6 Comparison of power consumption in transmit, receive, (ref 8)

Discussion based on fig 3 and 4: From fig. 3 Xbee using a UART 9600 baud – 26 ms for TX and fig. 4 shows app. 5.4 ms high spikes, transmitting a webpage with "Hello world! You accessed path: /" – http protocol using standard html

- Energy Xbee => TX energy 2.8 mJ + idle 5 mJ -> **8 mJ**
- Energy for CC3000 Sparkfunk => TX/RX energy 3.5 mJ + idle 21mJ -> **25 mJ**
- The low power Xbee device is more energy efficient even the transmission time is slower

5. Life cycle screening - MECO

Students are asked to do a Life Cycle Assessment (LCA) using the MECO$_{(1)}$ screening method (Ref 3)

An Example: An Xbee module is dismounted and its main parts identified.

1. **Production-Data for main parts are found** in SimaPro database (www.pre-sustainability.com)
   - resources
   - energy used per kg unit.
2. **They use the MECO$_{(1)}$ method for:**
   - calculating the resource load in mPR$_{(2)}$
   - the primary energy consumption for the production, transport, usage and disposal phase for the Xbee.

XBEE module			
Raw materials	Total quantity [kg]	mPR/kg	mPR
Aluminium	4.54E-03	1.5	0.006812
Chromium	1.50E-04	2.3	0.000346
Copper	8.90E-04	16.5	0.014682
Gold	5.96E-06	90000	0.536000
Iron	6.63E-03	0.08	0.000530
Lead	1.45E-05	80	0.001163
Nickel	3.73E-04	106	0.039544
Silver	9.07E-06	19000	0.172322
Tin	7.99E-05	90	0.007191
Zink	4.72E-05	33	0.001558

XBee module		
Energy resources	Total quantity	Total Energy Consumption
Renewable	0.604 MJ	0.60 MJ
Crude oil	0.0432 kg	2.16 MJ
Natural Gas	0.0575 m^3	0.20 MJ
Coal	0.21 kg	6.32 MJ
Total		9.28 MJ

Fig. 7 Resource and energy for a Xbee (ref 5)

3. The results are normally used by the students:

- comparing the found results with alternatives for the service of the functional unit
- Discussing the environmental impacts of substituting materials with a high resource load in mPR
- Energy in use-phase found in the lab-exercise

4. The results are based on an rather old dataset for materials?

For discussion – where to find newer data – and easy for students to get?

(1) MECO: Materials, Energy, Chemical and Others. (2) (milli Person Reserve)

6.1 Room monitoring

How is a class room used? That was monitored using the SUSIE kit and the knowledge gained in the first part of the course and using a free cloud service Xively.com for storage and visualization. **The prototype was made by SUSIE for the students in SDTU and that leaded to an energy saving campaign in 2013.**

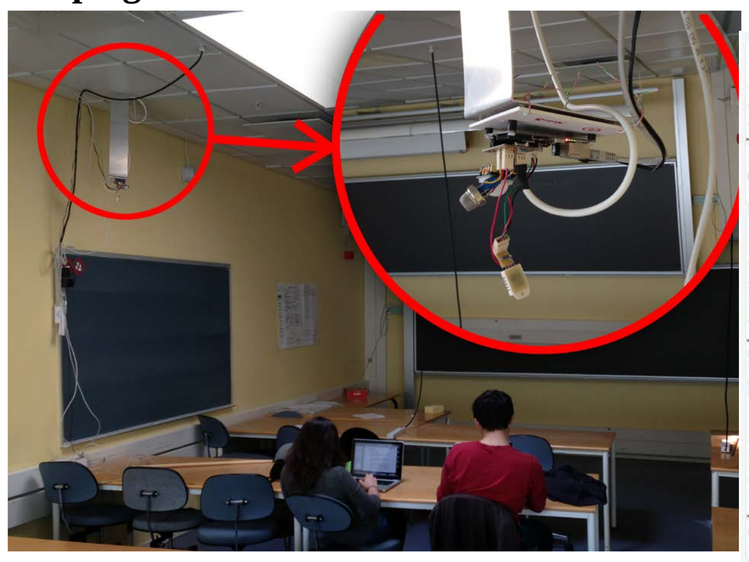

Fig. 8 Test setup in a class-room(ref 4)

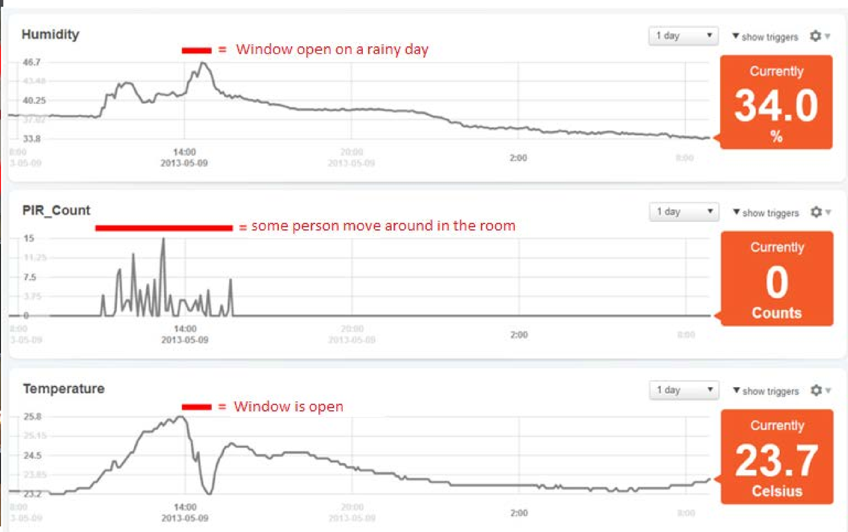

Fig. 9 Some measurements in the room(ref 4)

6.2 In-door climate monitoring

The project is about building a working prototype of an in-door climate monitoring system.

- temperature, humidity and light level
- collected through a sensor node device and transmitted to a master device.

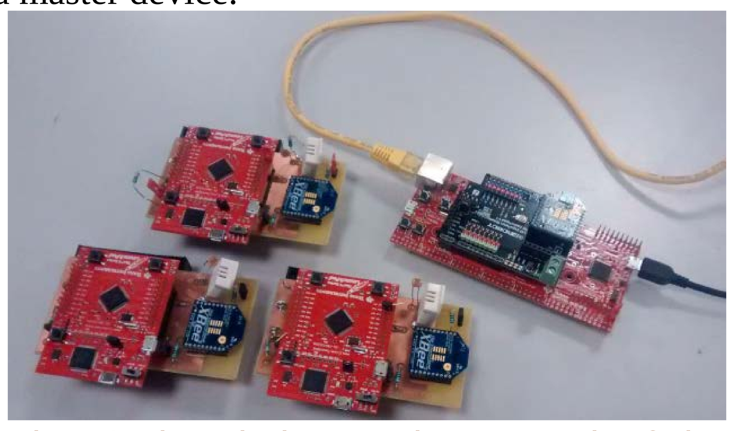

Fig. 10 The wireless node system (Ref 5)

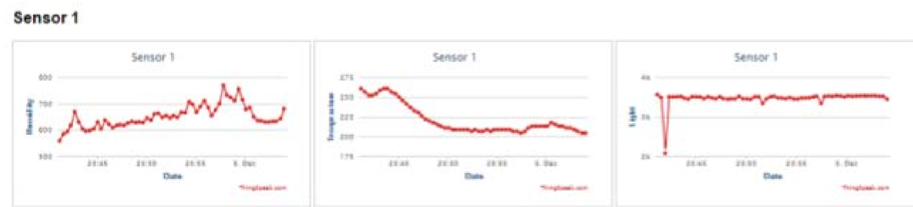

Fig. 11 Some results on the thingspeak.com cloud – (unit on y-axes is in the digital decimal representation) (Ref 5)

6.3 Light control

When lights are turned on in a classroom, all light sources are turned on with 100 % light output.
Ambient light from windows etc. also needs to be taken into account. The main scope of this project is to save power by controlling the light output through sensors.

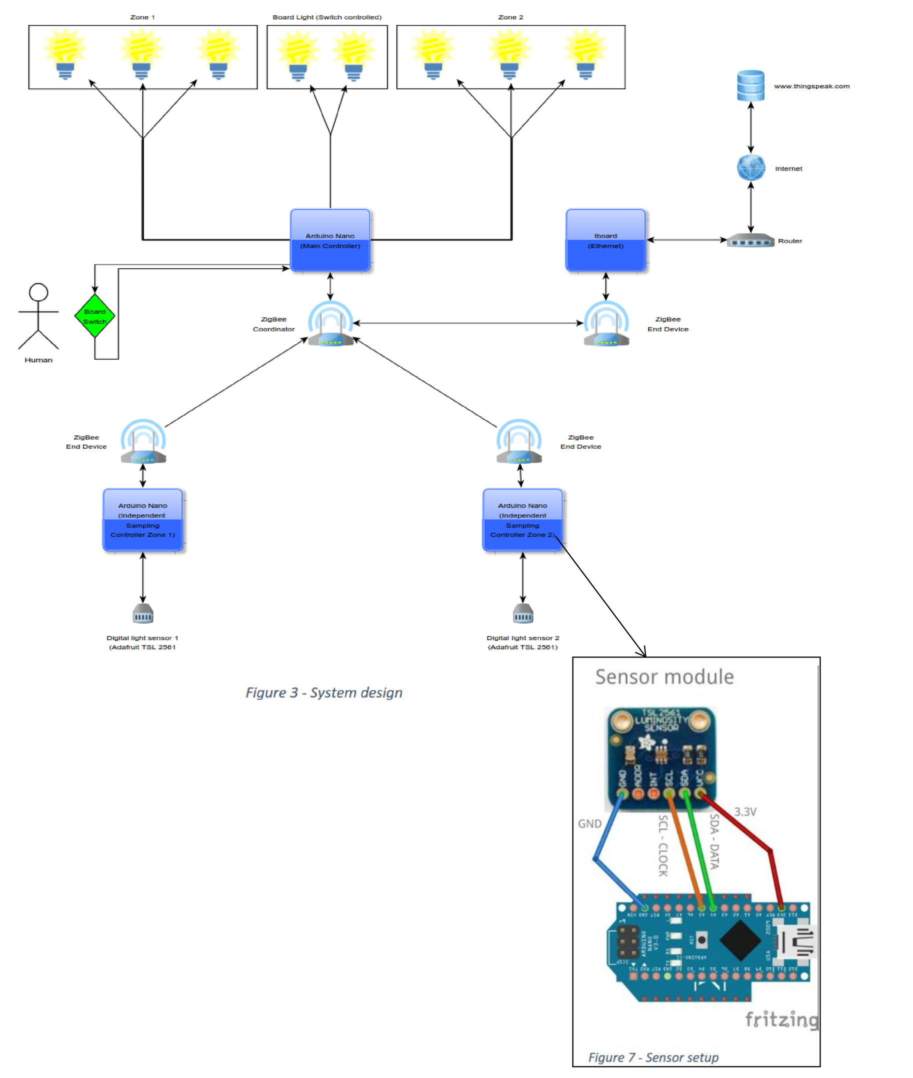

Fig. 12 The light sensor projekt system (Ref. 6)

7. Preliminary results

Exams and practical prototypes proves

- In SUSIE the students obtain knowledge and can design for low power and get awareness about resources used in electronic devices
- Courses have inspired students to bring their project to Green challenge.
- Some diploma thesis within the sustainable domain

Relations to other courses

- In parallel with the SUSIE course, a cross disciplinary optional course is given in Sustainable product development (SDTU) and students from the two courses meet and get inspiration for projects and prototypes which can support SDTU – mostly Civil engineering students.

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