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Teaching IoT: Use Case from a School of Engineers

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ABSTRACT

The main benefit of teaching IoT in today's classroom is that students are learning crucial skills they'll need in the future - whether that's at work or at home. Schools can also benefit from the Internet of Things in several ways. This article presents some techniques of teaching on connected objects. Our work is focused on active pedagogy wich is widely integrated in order to involve students in the theoretical part and to create a prototype of an object having an application purpose. The integration of this teaching into a school of engineers illustrates its implementation.

Key words: Internet of things, scrum methodology, course, Connected objects, educational device, teaching.

1. INTRODUCTION

Connected objects are increasingly present in our daily lives, offering a multitude of advanced features such as data collection, remote control and connectivity in real time. The teaching of these technologies is therefore become a major issue in preparing students [1] for their use and these technologies can be taught at different levels of study and at different types of training [1][2]. Project-based teaching is a tool perfectly suited to teaching objects connected. This type of teaching allows students to put their technical knowledge into practice working on a concrete project. In this article, we present a course framework on connected objects, project-based teaching used for this course and an assessment of its production][3].

2. OBJECTIVES AND AUDIENCE

2.1 A varied audience

Having an advanced culture on connected objects is essential for integrating the job market around IoT. There are training courses in embedded systems or in networks which are directly linked to this market of employment. However, other schools wish open up to this theme: computer scientists want be able to understand the issues related to embedded systems and energy consumption; electronics engineers to understand the transmission of data and network aspects [4].

This teaching is directly addressed to them. Indeed, the theoretical part is based on elementary notions mathematics, physics and electronics. These notions are acquired from the first years of study scientists in computer science or electronics.

The practical part is based on platforms of open-source prototyping such as Arduino. The prerequisites for using these platforms are a knowledge of basic programming concepts (variables, loops and functions) [5].

With these prerequisites, our course can be modulated from several ways depending on the objectives teaching and the number of hours. In engineering school, in the 3rd year of a apprenticeship training in IT for an opening to the IoT.

2.2 Course organization

The course is composed of a theoretical part and a practical side. The theoretical part is carried out through several 2-hour courses on different technical themes and of a flipped classroom so that students learn to become familiar with a communication standard. The hourly volume is therefore around 10 hours but perhaps extended either by deepening the themes or by offering other themes [6].

The practical part consists of carrying out a prototype with a role play between students and teachers starting from the application (defined or validated by the teachers) and the technical realization (per team of 4 to 6 students). The hourly volume can be extremely variable ranging from around ten to one twenty hours with potentially hours in autonomy.

3. IOT: FROM SENSOR TO NETWORK

3.1 Theoretical courses

The aim of the course is to have a comprehensive overview of elements making up an IoT network [7]:

- IoT and sensor networks: generalities, market perspectives, application examples, Network architectures & protocols
- Communications for IoT, Physical layer techniques for IoT: wireless transmission, propagation channel,
- Anatomy of a sensor node: sensors, embedded computing, energy management.

Themes on data collection, processing of information and secure transmission are little discussed and could be a complement interesting.

3.2 Flipped classroom on technologies for IoT

The course introduces transmission concepts and networks allowing us to understand the standards for IoT and choose them according to needs applications. Details of the different technologies are presented in a flipped classroom format. This approach promotes a better understanding of standards, as well as greater student involvement.

A standard is studied by a group of students and a oral restitution allows them to present their study to the whole group. If the form and content are rather free, a framework of characteristics to present is everything similarly provided to students. The technologies currently being studied are [8]:

- Bluetooth Low Energy (BLE)
- Zigbee
- LoRa and LoRaWAN
- Sigfox
- LTE CAT-M and NB-IoT
- RFID and NFC
- Emerging technologies (WiFi halow, 802.15.4g, …)

4. TECHNOLOGY PROJECT

4.1 Objectives: a target application

The practical part of the teaching consists of technological project in order to create a prototype of connected objects. This project is based on 3 concepts [9]:

- a target application guided by an industrial need
- an agile development methodology Scrum
- open-source prototyping hardware and easy to use.

The choice of application can be free (but with a justification of the technical need), guided by a need societal (health, environmental monitoring, security, education) or an industrial need. In all cases, teachers validate the need application and students must propose a solution technology meeting this need.

4.2 Scrum methodology

The Scrum methodology defines an iterative and incremental development that promotes close collaboration between team members and focuses on timely delivery of product to customer [10]. Scrum has defined roles (Scrum Master, Product Owner, and the development team), planned events (planning meetings, review and retrospective), and artifacts (backlog of the product, sprint backlog and product increment). There production of a prototype is carried out by a set successive sprints with technical deadlines for every sprint. These different elements are arranged in figure 1.

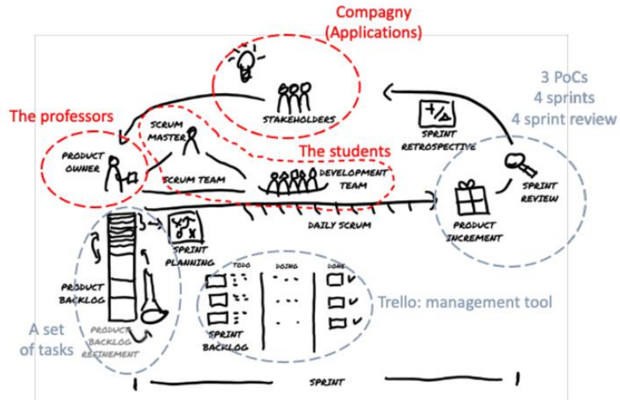

Figure 1: Application of the scrum methodology to a project teaching

The application of this methodology for a project student is obviously simplified, especially if they do not have no concept of Scrum methodology. The role of Product Owner (and Stakehorder) is ensured by the teachers. Students appoint a Scrum Master who defines the sprint objectives with the Product Owner and distribute work tasks (a management tool of tasks, e.g. Trello, can be used). User stories thus concentrate mainly on the files product (technical advancement) and a set of tasks to be carried out per sprint including those of management team.

4.3 Material available

For the technical realization, Arduino platform is offered to students. Arduino [4] offers object platforms connected open source, which allows students to easily carry out electronic projects personalized: Arduino boards are compatible with numerous sensors and electronic modules, which allows you to create a wide variety of projects. There Arduino community is very active and provides many tutorials and code examples. Microcontrollers are more or less powerful, ATmega328P for Uno and ATSAMX8E (ARM 32 bits) for the Due and are programmed in C language. be able to interact remotely with the platforms, students can rely on Bluetooth modules (HC-05, HC-06) or LoRa (Mbed shield SX1261) [7].

4.4 Examples of implementation

When the theme is not imposed, the number of applications has no other limit than the imagination of the students. Recent achievements include example a connected greenhouse, a home automation center, a weather station, a weather management system parking, an exploration robot, a brewery automated [5].

For illustration purposes, figure 2 represents the diagram of connection of a connected greenhouse

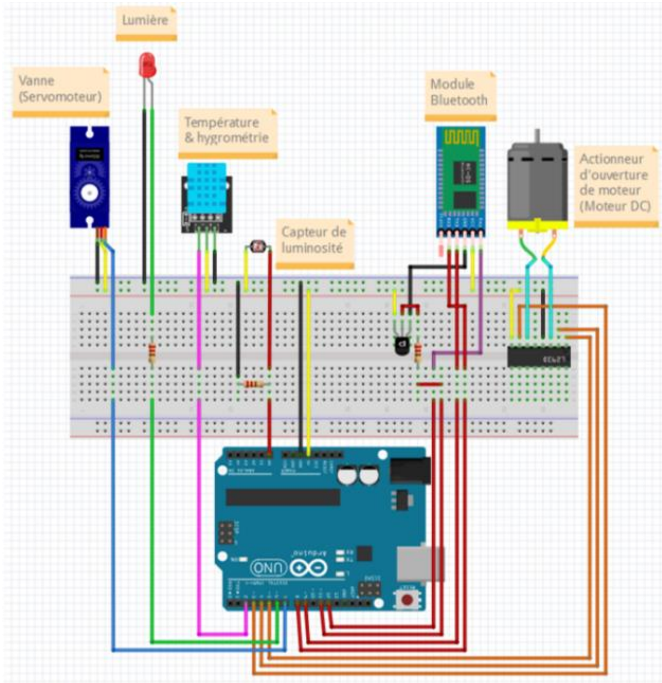

Figure 2 : Schéma électrique d'une serre connectée

Some teams even sometimes call on others related lessons to approach applications more complicated. This is for example the case of a system monitoring a data center with NFC access, display data with InfluxDB/Grafana and interaction with a model in Unity (see fig.3).

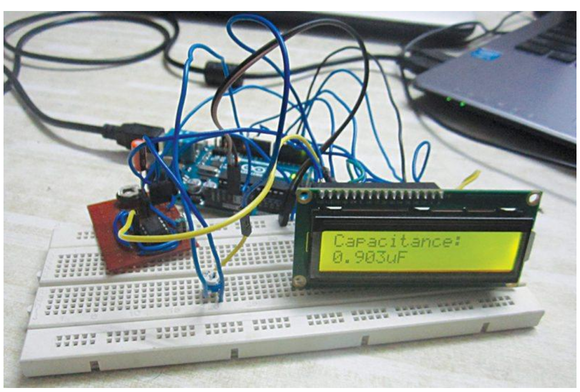

Figure. 3: Example of project based on Arduino

Finally, technical challenges may be imposed to students (this is the case for the variation of this course in engineering school) with for example: multiloop sending of messages, the use of an Arduino robot, creation of a mobile application (with Bluetooth Electronics or Appinventor for example), the use of a LoRa transmission…

5. REVIEW

To assess the interest of students in this type of education and consider avenues for improvement, we submitted a questionnaire to students.

The answers show that overall, the teaching has was appreciated by the students. This course was however at the heart of the school, therefore fully chosen by students and not "imposed" within the framework of a more comprehensive training. Some students would like other themes to have been addressed. The target application linked to the company EcoCompteur seems to be relevant. Free comments allow you to highlight some points. "The time allotted for the completion of the project is too short": the students spent a lot of time on the project but have produced models quite accomplished, it is generally difficult to limit the involvement of students in relation to a final objective which is not very precise and depends on the application carried out. "The choice of radio technologies is limited": students only had Bluetooth available to simplify handling of the equipment. It is true a choice among several communication standards choice would make it possible to adapt to the heterogeneous level of students. Using LoRa expansion cards allows to use another technology while keeping the Arduino platform as a basis. Finally, echoing the survey on the themes covered, students would have wanted to study other subjects (including safety of IoT).

The feedback was generally good, on all aspects (organization, courses, social events…). the project part is greatly appreciated with a role play allowing develop students' creativity. The part theoretical is undoubtedly more difficult to assimilate because sometimes outside the initial training of students.

However, it remains very complementary to the part project and essential for the industrial deployment of a connected object.

6. CONCLUSION

This article introduces teaching about objects connected based on a role play between students and teachers in order to develop a prototype with a realistic application. The major interest is its modularity making it possible to broaden the spectrum of targeted students and its implementation. If it can deploy perfectly in a classic way throughout an academic semester, student feedback also validates an adaptation more concentrated in the form of a summer school.

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