i-MOCCA: Cross border cooperation in training for Engineers in Industrial Automation

J.-M. Vannobel[1]
Associate Professor
LAGIS, Université Lille 1 Sciences et Technologies
Villeneuve d'Ascq, France
E-mail: jean-marc.vannobel@univ-lille1.fr

M.-H. Bekaert
Associate Professor
LAGIS, Université Lille 1 Sciences et Technologies
Villeneuve d'Ascq, France
E-mail: marie-helene.bekaert@univ-lille1.fr

H. Benhammou
Design Engineer
Université Lille 1 Sciences et Technologies
Villeneuve d'Ascq, France
E-mail: hamza.benhammou@univ-lille1.fr

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INTRODUCTION

i-MOCCA (**i**nterregional **MO**bility and **C**ompetence **C**entres in **A**utomation) is a three years long INTERREG IVA 2 Seas project initiated in July 2011. The European Union INTERREG IVA 2 Seas Programme promotes cross border cooperation between the coastal regions of four Member States: France (Nord-Pas de Calais), England (SW, SE, E), Belgium (Flanders) and The Netherlands (South coastal area) [1].

i-MOCCA is thus an international network of skills that involves seven academic partners from Belgium, France and England: KAHOSL (Gent, BE, Lead Partner), HOWEST (Kortrijk, BE), University of Lille1 (Villeneuve d'Ascq, FR), University of Greenwich (Greenwich, GB), ISEN (Lille, FR), ICAM (Lille, FR) and HEI (Lille, FR).

[1] Corresponding Author
J.-M. Vannobel
jean-marc.vannobel@univ-lille1.fr

The aim of i-MOCCA is to provide high level education on "industrial data communication" and "embedded control" both to engineers in industry and services and to higher education students.

The project also offers business opportunities for lifelong learning and innovative applications using new technologies like machine to machine (M2M) wireless communication for instance.

The way choosen by i-MOCCA partners to achieve efficient cross border cooperation is to focus on common industrial equipment. This is done through the SIEMENS S7-mEC, a PC technology Programmable Logic Controller (PLC) based on the SIMATIC WinAC RTX software controller. The choice of this PLC is really a convergence point! It gives for instance the opportunity to train on the SIEMENS Profibus industrial data communication network, one of the most popular in the world, as well as on embedded algorithms computed with Matlab and then tested in the SIEMENS framework.

Much more educational content is proposed by the i-MOCCA partners according to their own expertise (control-command, energy efficiency, mobile robotics, building automation, ambient intelligence, EMC, RFID…) and specific equipment (real-time target machines like Speedgoat and xPC target, Khepera mobil robots, fuel cells, microcontrollers…). Consult the i-MOCCA website for more information [2].

The i-MOCCA academic network also offers students mobility for very short periods. It comes in addition to their initial training.

Finally, three user groups, one for each country, composed of industrial partners interested in the topics of interest, meet once a year. These user groups and technical days organised by and for i-MOCCA partners help to define and validate the academic content provided by the project.

To illustrate the work done in i-MOCCA, we detail in this paper activities proposed by the University of Lille1 partner in the Profibus network framework.

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1 I-MOCCA AT UNIVERSITY OF LILLE1

1.1 Topics of interest

University of Lille1 is mainly involved in industrial data communication, building automation, energy efficiency, ambient intelligence, RFID and microcontroller based embedded systems.

1.2 Staff members

The University of Lille1 team is composed of ten people. Seven of them are involved both in the different teaching topics and in hardware or software engineering. Among them there are two design engineers hired specially for the project. Three other people are involved in administrative and technical tasks.

1.3 Teaching cycles

i-MOCCA teaching cycles in University of Lille1 usually are half day events corresponding to:

- Basic information. These sessions are overall presentations of a topic so no prerequisite is needed. Industry partners and equipment sellers are also welcome to organise technical workshops. Two events were held at University of Lille1 in 2012 and over thirty participants attended each of them. These

events dealt with “Heat sensors in building automation, data logging and thermal energy recovery” and “Introductory course on Profibus and building automation”.

- High level information. High level courses and tutorials are dedicated to practicing engineers. Here the goal is to supply very specific training for experts. High level courses and tutorials need technical and academic prerequisites.
- Laboratory setups. From our point of view these hands-on components of theoretical courses are extremely important. So each learning cycle ends with practical works.

Teaching activities are proposed in half a day sessions to take into account the timetable of trainees. We expect then to accommodate a maximum of people each time.

Finally, participation to teaching activities is free of charge for participants.

1.4 Learning cycles schedule

Learning cycles occur outside the existing formal educational curricula proposed by our university and thus represent a complementary skill for students who participate. Each i-MOCCA learning cycle provided at University of Lille1 is composed of three independent parts as shown *Table 1* (General information, High level lecture and tutorial, laboratory setup). General public just want to discover the topic when beginners are motivated to follow the cycle. Both of them are advised to attend the general information course. Confirmed users already know about the topic and are casual users of the topic underlying technologies. These people need to attend the high level event before to practice. Experts are regular users of the topic underlying technologies and want to practice differently from everyday life as proposed with the laboratory setups.

Table 1. Learning cycles schedule

Student’s status	General information (1x4h)	High level lecture & Tutorial (1 or 2x4h)	Laboratory setup (1 to 6x4h)
General public	Yes	No	No
Beginner	Yes	Yes	Yes
Confirmed	No	Yes	Yes
Expert	No	Yes	Yes

1.5 Prerequisites

As seen above no prerequisite is needed for basic information activities. It is different for high level courses, tutorials and laboratory setups. Of course, it is difficult to expect a uniform level of knowledge from all since the audience is diverse. To fill individual knowledge gaps, additional documents are thus provided for self-learning. We hope this help gives everyone the possibility to attend to the events.

1.6 Teaching cycle assessment

Two different assessments are implemented. The first one is only for the laboratory setups and is done upstream during technical days as described below. The second is made by trainees. This assessment is not performed just at the end of the teaching

cycle for a practical reason. Because a teaching cycle takes several months all students do not attend the entire cycle despite this the benefits that accrue to each of them must be evaluated. So each participant to a teaching cycle will fill an assessment survey sent to him six months after the end of the cycle.

1.7 Technical days

Technical days are restricted to i-MOCCA partners and represent the best moment for cross border exchanges. Partners show the current state of their demonstrators and course equipment during these sessions, leading to in-depth discussions with colleagues. Two or three technical days are organized per year and represent thus very important meetings for a best practice of relevant laboratory setups.

2 PROFIBUS NETWORK LEARNING CYCLE AT UNIVERSITY OF LILLE1

2.1 Members of the Profibus/Profinet organisations

Three i-MOCCA partners are involved in industrial data communication. These partners are KAHOSL, University of Greenwich and University of Lille1. Each of them is member of the respective Profibus International organisation in his country as is University of Lille1 [3]. Conversely the three concerned Profibus organisations are members of i-MOCCA local user groups. This partnership gives us access to the documentation on SIEMENS Profibus network and is a source of professional advice on courses content.

2.2 Why Profibus?

SIEMENS Profibus is one of the most popular fieldbuses in the world. Profibus (PROcess FIeld BUS) is described according to the EN 50170 part 2 standard [4] and is designed for manufacturing industry (Profibus DP [5]) as well as for process automation (Profibus PA [6]). A third version of Profibus exists based on the Ethernet network (Profinet [7]). This last version is also used by the PROFIenergy profile dedicated to energy efficiency and green economy.
For all these reasons, the Profixxx networks (as well as other fieldbuses) contribute to the economic development of the 2 seas area. That is at last a good reason to study it.

2.3 Teaching goals

The teaching of Profibus is commonly limited to basic information on the network different profiles, the physical layer, the medium access control as described in [4, 5, 8, 9] and the Profibus configuration and use in a SIEMENS PLC through the STEP7 software. More complete and certified learning is only provided by the Profibus and Profinet training centres as done in France by AGILiCOM [10]. This certified learning is expensive and not justified for all users in industrial automation.
Our goal is to teach Profibus at an intermediate level between basic information and certified training through lectures (*Fig. 1)* or tutorials (*Fig. 2)* on Profibus communication practice using our own educational communication software (*Fig. 3)* or the basic common equipment *(Fig. 4),* Profibus slave programming on Arduino *(Fig. 5)* and finally wireless communication with an Arduino based Profibus basic master *(Fig. 6)*.

2.4 Profibus teaching cycle prerequisites

As mentioned previously, no prerequisite is expected to attend the basic information presentation. Knowledge on industrial networks and fieldbuses, on C programming and on Arduino prototyping boards [11] is required to attend the high level lecture and laboratory setups.

To ensure that each trainee has the minimum knowledge required, a lot of documents have been built for self-learning. These documents consist in:

- A thick introductory slideshow on industrial networks and fieldbuses.
- A “C programming survival kit” booklet summarizing the fundamental principles of procedural programming using C language.
- A slideshow presenting the Arduino prototyping platform which is very popular in education, hobby electronics and mobile robotics. Arduino is based on convenient standard format boards using Atmel microcontrollers and a C++ derived programming language.

Trainees have time to upgrade since the courses are spread over time. In any case they can contact us to get some advice or help.

2.5 Basic information on Profibus

Basic information is done through a slideshow based lecture. Slides are in English language to be reused by the other i-MOCCA partners but oral language is French when only French people attend to the event. This course presents the Profibus network history, its world level of dissemination, the physical layer, the bus access protocol, the GSD device description file and the frame content as found in [5].

2.6 High level lecture and tutorial on Profibus

This course is intended to deepen the understanding of Profibus protocol, message exchange and especially message content. A reminder of the end of the basic course is conducted. Therefore beginners can attend the high level course without having attended to the basic course although we highly recommend it.
The course contains two parts: a lecture and a tutorial. The tutorial is a great way to interact with students and is focused on message exchange. Students are invited to analyse existing data frames and to produce new once. Both syntaxic and semantic levels are covered.
At the end of this course, participants well understand the sequence of network frames and can easily decode each data frames. This is at last a prerequisite to the first laboratory setup.

2.7 Laboratory setups

Six laboratory setups are proposed all along the learning cycle:

- Arduino based Profibus network spy.
- Arduino based Profibus slave including GSD configuration file [12].
- Arduino based Basic Profibus master.
- S7-mEC PLC.
- Arduino based WEB process control.
- Androïd and Apple applications for wireless interaction with smartphones and tablets.

The S7-mEC PLC laboratory setup is the only one using specifically the SIEMENS hardware and software tools. This laboratory setup is dedicated to the mastering of SIEMENS products and is found in all curricula in industrial informatics using SIEMENS PLCs.
All other laboratory setups provide unusual and highly specialized skills for new industrial products designing benefiting from the latest technologies.

Finally, participants acquire a very high level of expertise providing them much working opportunities in industrial informatics engineering companies. Many of them exist in the 2 seas area. We hope so that i-MOCCA helps in the economic

development of this dynamic area with recognized skills in industry. It is our declared objective.

Fig. 1. Powerpoint based Lecture

Fig. 2. Tutorial

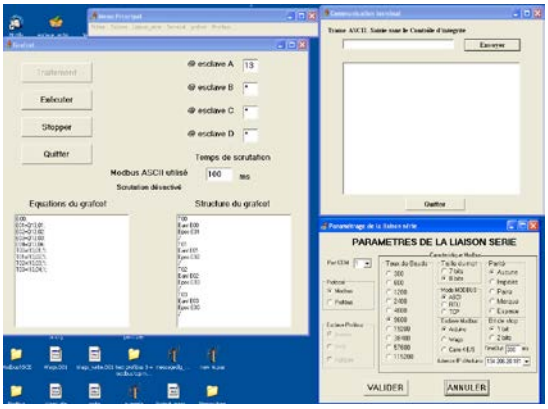

Fig. 3. Own communication software

Fig. 4. S7-mEC PLC

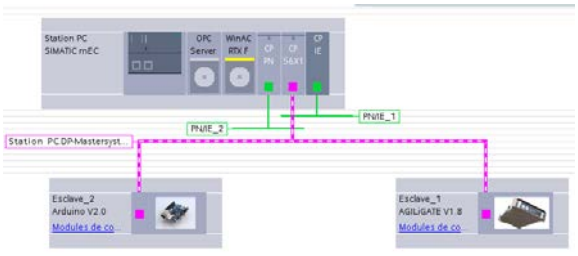

Fig. 5. Profibus slave designing

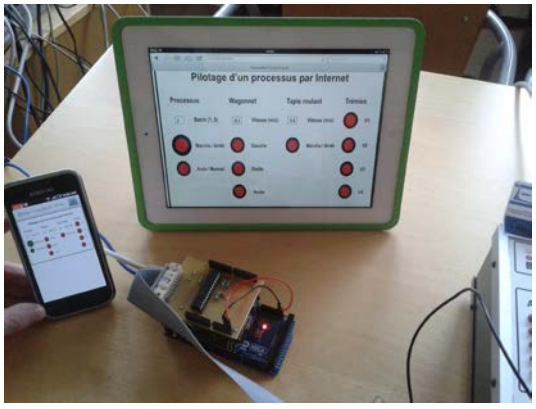

Fig. 6. Wireless communication

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