KNOWLEDGE ALLIANCE IN MICROELECTRONICS

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Abstract

The paper presents the MicroElectronics Cloud Alliance (MECA) project which brings together eighteen partners from higher education institutions and enterprises to develop Cloud-based European infrastructure and organisation for education in micro- and nanoelectronics providing a range of open educational resources, remote access and sharing of educational and professional software, remote and practice-based learning facilities. Each university will provide remote access to its facilities, laboratory experiments or software systems for the partners in a cloud teaching system, giving them access to new resources. The common ones can be optimized, reducing the singular cost per institute and increasing the available computational and structural power.

Keywords: European Cloud-based learning environment and infrastructure; Nanoelectronics; Open educational resources.

1 INTRODUCTION

Neither university can afford the necessary infrastructure, clean rooms, technology and experts in all fields of this multidisciplinary science. Sharing of laboratory experiences, CAD tools, project ideas, and a common infra-structure represents a sort of “educational cloud” on top of the cloud soft-ware/hardware infrastructure.

Eighteen European higher education institutions (HEIs) and enterprises are developing e-learning materials for twenty one courses on: computer aided design of nanoelectronic systems, microelectronics technologies, test, characterisation and application of integrated circuits and systems, and we will provide them as open educational resources to strengthen the virtual mobility. Each university will provide remote access to its facilities, laboratory experiments or software systems for the partners in a cloud teaching system, giving them access to new resources. The common ones can be optimized, reducing the singular cost per institute and increasing the available computational and structural power.

2 WHY THIS PROJECT IS NEEDED

The project’s focus is on jointly development of MSc degree level courses for the new skills needed for the new jobs in the multidisciplinary sector of micro- nanoelectronics to be delivered as open educational resources in a cloud-based e-learning environment. The addressed problems and needs were identified through: literature study of European policies in the field of education [1, 2] and the needs and priorities of partner higher education (HE) institutions and enter-prises in the sector [3], analysis of subject of area (microelectronics design, fabrication and application), labour market needs, study of the state of the art in cloud computing.

Specific needs and problems of HE in microelectronics that we intend to solve:

- little reference is made to the needs of the work place and changes in the work place are not met with changes in education,
- curricula need to be updated and universities need to collaborate to share course materials, intellectual property blocks and ideas.

So, we need a new partnership between education and work to address the need of synergy between the education and industry, to foster the development of competencies, technological and entrepreneurial skills.

There are few individual research teams, laboratories or companies that can reasonably claim to be able to respond to the technological challenges in the sec-tor of micro- nanoelectronics. Even the big companies in the sector work with a common use of R&D resources (as Motorola & ST

Microelectronics etc.). No one university or SME can afford the necessary infrastructure, clean rooms, technology and experts in all fields of the multidisciplinary science of microelectronics.

Sharing of laboratory experiences, of CAD tools, of project ideas, of common infrastructures represents a sort of “educational cloud” on top of the cloud soft-ware/hardware infrastructure. The advantages in terms of education effectiveness are course organization efficiency, instructors focusing on the area of expertise, common experiences of students of different countries based on similar infra-structures, tools, lab organization, learning improvement, thanks to the optimization of laboratories and courses.

The main step necessary to obtain these results is the implementation of an e-learning framework rooted on the tools developed for cloud management, allowing the cooperation and distribution of lab sessions, CAD tools and teaching experiences.

3 PROJECT OBJECTIVES

The aim of the mClouds project is the definition and development of cloud-based European infrastructure and organisation for education in micro- and nanoelectronics providing a range of open educational resources, remote access and sharing of educational and professional software, remote and practice-based learning facilities. Its specific objectives are:

1 Analysis of institutional, teachers’ and students’ needs in shared IT infra-structure, teaching materials and learning resources, meeting the requirement of the enterprises in micro-nanoelectronics and translation into functional specifications of mClouds.

This objective targets the challenges of the multidisciplinarity of the subject area and the needs of powerful CAD systems and servers, of sophisticated equipment and laboratories.

2 Networking of project partners from HE institutions and SMEs, to share ide-as, methodologies and experiences in order to improve the HE programmes to face the rapid technological change in the sector and joint development of job-specific training modules.

This objective addresses the needs of more responsive HE to the needs of the labour market.

3 Development of the mClouds system and realization of a shared server infrastructure, shared e-learning resources and the remote access to the CAD tools.

This objective targets the needs of innovative and multidisciplinary approaches to teaching and learning in the interdisciplinary sector of micro- and nanoelectronics and the needs of closer cooperation between HE and business using the infrastructure, technology of partners’ universities and expertise of practitioners.

4 Pilot test of the virtual services and training teachers and technical staff in their use.

This objective addresses the needs of the main users of the project results: the students and teachers in high quality educational resources and services.

5 Implementation of jointly developed cloud-based open educational re-sources in micro-nanoelectronics in the partners’ educational contexts.

This objective addresses the necessity of striking a balance between what is offered in the educational system and what is needed by the enterprises in the sector.

4 WHAT WE HAVE TILL NOW AND WHAT IS THE INNOVATION?

This project is based on the experiences of almost all HE partners in development of e-learning courses [4] and on the experiences of UNED [6] and TUS [5] in development of training through remote laboratory access. At POLITO the experiment with a cloud based architecture started two years ago with a couple of microelectronics and microsystems courses which require the use of complex CAD software. A WEB-based CAD tool TAMTAMS was developed at POLITO [8, 9]. This tool is based on an open, flexible and simple structure, which allows predicting microelectronic system level features starting from technology variables. The tool is now limited to a specific subject, but it is an evident example of the framework to be developed in this project, and it is one of the already present solutions that will be used as starting point for project development.

The innovation is mainly in the involvement of companies in a collaborative update of existing and development of new courses; sharing of laboratory experiences, of CAD tools, of project ideas, of common infrastructures in a sort of “educational cloud” on top of the cloud software/hardware infrastructure.

The advantages in terms of education effectiveness are course organization efficiency, instructors focusing on area of expertise, common experiences of students of different countries based on similar infrastructures, tools, lab organization, learning improvement, thanks to the optimization of laboratories and courses.

The main step necessary to obtain these results is the implementation of an e-learning framework with open educational resources, rooted on the tools developed for cloud management, allowing the cooperation and distribution of lab sessions, CAD tools and teaching experiences. The cloud computing approach, created mainly for Internet application needs, can be adapted to IT architectures for e-learning, but not only. In fact, the design of an efficient training infrastructure based on a cloud approach can be also a key solution for traditional class-room training through sharing server and software resources.

5 METHODOLOGY

For defining the necessary knowledge, skills and competences we started with an extensive job analysis, i.e. work process analysis in companies in microelectronics and electronics packaging. The learning outcomes were defined for each course with the corresponding credits after an assessment adopted by all partners.

The curricula are being reviewed in collaboration with the experts from the companies and joint practice-oriented modules are under development. Jointly with SMEs business-oriented courses are also developed: on quality assurance in the enterprises, management of projects, entrepreneurship. Later, the e-learning materials will be developed/adapted in such a way that substantial parts can be used in a self-instructive manner.

After training teachers and trainers in the Cloud system, the pilot test will be conducted with small groups of learners – minimum 10 per country. The field trial will be performed during the last 9 months of the project with minimum 240 students. Specific evaluation methods will be used and corresponding tools designed for assessment of knowledge (e.g. knowledge tests for the basic components, assembling procedures, defaults, automated machines etc.); of skills (e.g. tasks for finding solutions for routine problems); of competences (e.g. tasks to take responsibility for completion of tasks in work or study).

The evaluation and valorisation activities are planned for the whole project’s lifetime. Project quality assessment is based on a careful procedure of self-evaluation. Based on evaluations, the management of the project makes the necessary decisions and plans activities for their implementation. The evaluation is more oriented to the end users, i.e. to obtain feedback to help developers to improve the products and services, as well as to optimise the project development process through early diagnosis of defects, to reveal of unforeseen circumstances in the training environment, to ensure better communication in the development team, to measure whether training objectives have been achieved and trainees needs have been met and that results could be used for decisions about the implementation on European level and dissemination of the products.

6 WORK IN PROGRESS

At this stage of the project, we have done the need analysis and the feasibility study for each target audience:

- Students in microelectronics. They need high-quality educational materials and continually brought up-to-date courses, because of the essence of the science - the most rapidly advancing sector nowadays. They need education related to their further work and for the complexity of the knowledge and skills, necessary to perform successfully the tasks in this multidisciplinary area. The virtual mobility will provide them access to the CAD systems and courses existing in other European HE institutions.
- Their teachers. They need infrastructure, techniques for course delivery al-lowing easy changes and upgrade because of the fast developing science of the subject matter, i.e. ICT-

based materials. Sharing IT resources and e-learning courses will support them a lot and the project will contribute to the virtual mobility of teaching staff.

- University management is convinced of the necessity of European dimensions in higher education, particularly with regards to curricular development, interinstitutional co-operation, virtual mobility of students and academic staff and integrated programmes of study, training and research.
- Future employers of the students who need young specialists empowered with the new skills necessary for the new jobs in microelectronics sector.
- Practitioners from SMEs in the sector for which the collaboration with HEIs in supervising MSc students and PHD students will be beneficial for their re-search activities and innovations in the enterprise.
- From the institutional point of view, the targets are the higher education institutions providing accredited MSc degrees in micro- and nanoelectronics and enterprises in the sector. As no single university or SME can afford the extremely expensive infrastructures, equipment and maintenance of clean rooms for micro-electronics, collaboration and sharing of facilities and expertise on European level is of high institutional interest for both, universities and SMEs.

After a detailed literature study [7] and analysis of the needs, both in term of interest and in term of potential trainees, 21 course topics were selected: Design of Nanoscale MOS ICs, Nanomaterials, Microelectronics literacy and Technologies, Integrated circuits and design, Superconductive materials, Survival in Labour Market, Project management, Effective communication with groups, presentation techniques, Modelling and Design of ULSI circuits and systems, Design and realisation of Micro-Nano-BioSensors, Electromagnetic Compatibility of Integrated Circuits, Design for manufacturing of microsystems, Electronic packaging and assembling technologies of microsystems, PV Power Electronics maintenance, Technology of Electronics Products, Virtual Laboratory Support for Microelectronics Packaging Education, Multi-Media Enhancement of Teaching Sensors and MEMS, Assembling and Inspection Technologies, Design, Prototype Fabrication and Applications of Silicon Microsystems with Piezoresistive Feedback, MEMS Sensors, Actuators, and Control Techniques, Semiconductor Device Modelling.

Recommendations related to the training content which is focused by the MECA project were to regularly (at least once per year) up-date the training materials because of the rapid development of nanoelectronics.

The results of the analysis of eWorks GmBH [10] and the conclusion of the SWOT analysis about the choice of e-learning environment for mClouds is that in Moodle the implementation of the virtual training in microelectronics is feasible and that it is the right choice for the realization of our project.

As a part of the need analysis and with the involvement of all stakeholders (non-formal interviews with managers and professionals from the enterprises in the sector, and the university teachers) the necessary skills and underlying knowledge were defined, the competences for job performing were determined and the matrix of learning outcomes was developed. This analysis was done in collaboration with the department and laboratories from higher education institutions to identify the overlapping areas of the competence profiles of vocational and educational training and higher education programmes.

Now we are implementing the mClouds system and the shared server infra-structure, shared e-learning resources and the remote access to the CAD tools according the following three schemes:

1 Infrastructure as a Service model: private Cloud of each partner institution for sharing institutional IT infrastructure. Then a hybridization or federation of several Clouds will be applied to support temporary peak requirements, eliminating the need to oversize the private infrastructure.

2 Platform as a Service: Cloud-based WEB based e-learning applications in micro-nanoelectronics to share contents at European level, related to the deployment of WEB based e-learning applications.

3 Software as a Service model: mClouds for sharing CAD software, remote access to the partners' CAD laboratories. Expensive software will be shared be-tween academic institutions and infrastructure costs can be shared accordingly.

7 SUMMARY AND EXPECTED IMPACT OF THE PROJECT

A work in progress is presented of a large European Knowledge Alliance project on it's design stage after the need analysis. Expected impact will be on the

- students – the highest quality of the specialised courses developed by the best departments in the field, the opportunity to train practical skills and competences with remote access to laboratories with advanced equipment and facilities;
- teachers – rich infrastructure and new shared teaching materials;
- universities – the European dimensions in HE: curricular development, virtual mobility of students and academic staff, integrated programmes of study, training and research;
- university-business alliance – the education responsive to the labour market needs, graduated students prepared for the job, enterprises satisfied by the knowledge and skills of young specialists.

ACKNOWLEDGEMENTS

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission can-not be held responsible for any use which may be made of the information contained therein.

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