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ILERT - International Learning Environment for Real-Time Software-Intensive Control Systems

Andrew J. Kornecki [1] , Thomas B. Hilburn [1] , Wojciech Grega [2] , Miroslav Sveda [3] , Jean-Marc Thiriet [4]

[1]Embry Riddle Aeronautical University, Daytona Beach FL, USA
kornecka@erau.edu, hilburn@erau.edu
[2]AGH University of Science and Technology, Krakow, Poland
wgr@IA.AGH.edu.PL
[3]Brno University of Technology, Brno, Czech Republic
sveda@fit.vutbr.cz
[4]Laboratoire d'Automatique de Grenoble, Grenoble, France
jean-marc.thiriet@lag.ensieg.inpg.fr

Abstract. Due to heavily software-centric nature of modern reactive and time-critical systems, there is an increasing demand for efficient development of high quality Real-Time Software-Intensive Control systems (RSIC). The study discussed in this paper is focused on the creation of international curriculum framework centered on RSIC – this important aspect of the computer-system-control-software engineering education. The study explores the mechanism for involving students from multilingual geographically separated institutions in a coordinated educational experience. It exposes them to the problems, methods, solution techniques, infrastructure, technologies, regulatory issues, and tools in the domain of dependable real-time safety-critical software-intensive control systems. The ultimate objective is the creation of a model RSIC curriculum, which can be used by engineering schools both in the USA and the EU.

1 Introduction

There is an increasing importance and demand for efficient development of high quality Real-Time Software-Intensive Control systems (RSIC). Such systems need to meet stringent safety and reliability requirements and often are developed by companies operating across national boundaries. To educate modern engineers it is critical to establish a methodology for creation of multinational engineering programs, which will produce graduates capable of working efficiently in multidisciplinary teams engaged in international collaboration on industrial RSIC projects. Such projects typically require conformance to specific national and international standards mandated by regulatory authorities.

Modern systems are heavily software-centric, implementing reactive and time-critical software, where safety is the issue and the margin for error is narrow. Examples include aircraft avionics, air traffic control, space shuttle control, medical equipment, and nuclear power stations. It is vital for future software developers to understand the basic real-time applications concepts. The issues of timing, concurrency, inter-process communication, resource sharing, interrupts and handling external devices are of primary importance. The area of real-time safety-critical control systems is one of the most advanced and challenging fields of computer science and engineering, depending on designs developed according to the latest advances in science and modern principles of engineering practice.

The study discussed in this paper is focused on the creation of international curriculum framework centered on RSIC – this important aspect of the computer-system-control-software engineering education. The study explores the mechanism for involving students from multilingual geographically separated institutions in a coordinated educational experience. It exposes them to the problems, methods, solution techniques, infrastructure, technologies, regulatory issues, and tools in the domain of dependable real-time safety-critical software-intensive control systems. The ultimate objective is the creation of a model RSIC curriculum, which can be used by engineering schools both in the USA and the EU. This objective addresses the nations' needs for researchers and developers of real-time safety-critical systems who are capable of engaging in projects spanning the nations' boundaries and promoting a student-centered, transatlantic dimension to higher education and training.

2 Global Aspects of the Software Industry

The modern world, which relies increasing on international collaboration and globalization, is a key element for the nations of the world to come together in a peaceful way. Creation of common educational experience allows young engineers to find commonalities; it promotes teamwork and collaboration in joint projects crossing the nations' boundaries. Specifically, in the area of RSIC systems used in a regulated industry, it is critical to be familiar with the variety of regulations, standards, and guidelines required for designing, implementing and approving software-intensive systems. The proposed study creates a viable vehicle for such solutions.

There is a clear need to prepare professionals for international collaboration. Understanding critical issues related to RSIC, the tools and techniques used, and documentation required for approval of systems in a regulated industry is critical for the future global projects. One such example is the RTCA – Radio Telecommunication Committee for Aeronautics (`www.rtca.org`) charged with providing guidance to the Federal Aviation Administration. RTCA works jointly with EUROCAE (`www.eurocae.org`) representing the European aviation community. Special committees and working groups are formed to address the aviation community guidelines. This international forum including representatives from various countries needs to reach consensus to produce guidance documents. The study is meant to support such international collaboration and consensus building.

3 Curricular Issues

Despite well established computing curricula [1,2], the variety of excellent engineering offering in colleges and universities on both sides of the Atlantic, at this time, there is no international, interdisciplinary curriculum that directly focuses on real-time control systems, dependable software development, safety, reliability and the certification issues in highly regulated industries like aerospace, medicine, transportation, and nuclear energy – a curriculum that would also include globalization aspects of the modern engineering profession. The current study will lead to the design of such curriculum framework, identification of implementation and assessment mechanisms, collection of data necessary to evaluate the process, and guidelines for expansion of the proposed approach to other engineering programs. These objectives are consistent with the following complementary goals:

- Identify a methodology for design and implementation of a transatlantic, multidisciplinary engineering program.
- Stimulate students to follow careers by encouraging them to consider the area of real-time safety-critical control systems and expose them to opportunities of international collaboration.
- Encourage the exchange of staff and students between collaborating institutions.
- Offer multidisciplinary and multicultural experiences to students who would not otherwise have such opportunities.
- Provide a forum for the faculty exchange of ideas on the issues of curricula building, laboratory experiments, and assessment activities.
- Create a foundation for Internet-based laboratory educational experiences, which will expose students from different countries to tools, methods, and techniques used in the creation of highly dependable safety critical systems for regulated industry.
- Stimulate the teaching staff of the European partners to develop and introduce English versions of lectures and teaching materials.
- Foster a strong technological and education research base.

4 Activities

The two-year study, supported by the US Department of Education Fund for Improvement of Post-Secondary Education (FIPSE) and the EU European Commission, is dedicated to creation of a unique RSIC curriculum focusing on real-time software-intensive control and safety-critical dependable systems. The study involves international collaboration of four universities, which allows for exploration of global implication of offering transferable engineering curricula. The partners include one American and three European universities located in three different EU countries, where English is not the language of instruction (Poland, France, Czech Republic). These partners have adequate educational/research potential; and, through their industry and international outreach, they also recognize the needs of the current and prospective labor market for real-time control education, both in Europe and in the USA. They have published on the issues related to engineering curricula improvement [3-8].

A two-pronged approach is used. The first includes active partners' collaboration on identification of the learning objectives and outcomes, description of the curriculum core and supporting units, development of

guidelines on the implementation and assessment, identification of the technology infrastructure, and the description of faculty and staff requirements, pedagogy and delivery concepts, accreditation issues and constraints, etc. On-site research by the project faculty and selected students will be enhanced by frequent communications and dedicated working sessions at the partners' sites. The second part of the approach is a practical case study on how the proposed framework can be implemented by the partner institutions. This will include identification of the existing or easily modifiable courses, which can be used as units in the RSIC curriculum, The case study will also include a description of the laboratory infrastructure, necessary administrative procedures (admission, scheduling, and credit transfer), an assessment methodology, and experimental development and delivery of a selected RSIC unit to partner institutions. This experimental concurrent delivery will engage on-site students only. The observations collected in the case study will be an integral component of the project. The knowledge gained from the experience and relevant observations will constitute a base for establishing a dedicated international transatlantic program in Real-Time Software-Intensive Control and as a framework for development of other global engineering curricula.

To facilitate the participating partners' collaboration during the project, a dedicated website (via Blackboard) has been established to exchange files, provide a discussion forum, and post progress reports. The site is a test for use in a classroom setting for distance courses offerings, which allows the students from geographically distant sites to engage in a common educational experience.

The following deliverables are expected to be achieved at the project completion:

- An analysis of industry requirements for graduates of the RTSC domain
- An international, interdisciplinary Real-Time Software Intensive Control Systems curriculum framework
- A design for a selected unit supporting the proposed RSIC curriculum with the draft of lecture materials and laboratory handouts
- A plan and a pilot implementation of a laboratory infrastructure allowing students to actively participate in class activities and experiments on a remote basis
- Experimental concurrent delivery of the designed unit at the four partner sites
- Identification of activities and data for program assessment and evaluation, and those issues and elements required to consider program accreditation
- Reflection on a process and methodology for creation of multidisciplinary, transatlantic engineering programs, including guidelines for extension of the approach to other engineering programs,

5 Assessment

Quantitative and qualitative indicators need to be used to assess the degree of fulfillment of the planned objectives in the proposed time-frame, based on the detailed plan of work with specific timeline and detailed deliverables. Three categories of indicators, related to the output, results, and impact will be identified and tracked. The output indicators will provide information elaborating the immediate and short-term effects resulting from the planned execution of the project. These will include curricula design, educational events, external institutions that have benefited from the project outputs, created artifacts, and presentations shared with external audiences. The results indicators will provide information on the project output and the immediate results: new cooperative initiatives, published papers, position documents generated, etc. The impact indicators will measure the long-term effects: institutions implementing the proposed framework, learning tools and services created by the project, citations and references to the project documents and papers, third-party references to project outcomes, etc.

Real-time software-intensive safety-critical control systems represent a rather narrow and specific education and research area. Not many courses are offered at the undergraduate and graduate level, since appropriate coverage requires a significant amount of diverse domain knowledge difficult to include in typically overloaded computer science and engineering programs.

6 Conclusions

Nearly all engineering disciplines are ultimately engaged in creation of RSIC systems. The systems are implemented worldwide, which requires a well prepared workforce of scientists and engineers, who can cooperatively address issues in a multi-disciplinary and international fashion. This project is intended to strengthen international co-operation and the global links in engineering education. An interdisciplinary specialization in RSIC was selected to produce not only a number of educational artifacts in a domain in high demand by the industry, but also (what is more important) a process and a methodology for creation of engineering programs with a compatible quality assurance and assessment process. The graduates of such program will be better prepared to work on projects requiring interdisciplinary and multicultural viewpoints. This enhances mobility of the future workforce and facilitates their advancement and career changes.

The objective of the proposed activity is not only to serve the critical population of safety-critical real-time control system developers, but also to disseminate results and provide guidelines to a broader audience of engineering education faculty. The project will capture the process and methodology used by this multidisciplinary and geographically diverse activity for potential re-use by others. Through internet-discussions and face-on meeting activities, this project will develop the platform and materials to create RSIC curriculum framework acceptable on both sides of Atlantic. The collected observation and data will provide the base and guidelines for future implementation of complete coordinated multinational engineering programs.

7 References

1. *Computer Engineering 2004, Curriculum Guidelines for Undergraduate Degree Programs in Computer Engineering,* The Joint Task Force on Computing Curricula, ACM IEEE Comp. Society, December 2004 (`http://www.acm.org/education/CE-FinalReport.pdf`)
2. *Software Engineering 2004, Curriculum Guidelines for Undergraduate Degree Programs in Software Engineering,* The Joint Task Force on Computing Curricula, ACM IEEE Comp. Society, August 2004 (`http://www.acm.org/education/curricula.html`)
3. W. Grega, Towards the Bologna-BMD Model: Poland, in: *Towards the Harmonization of Electrical and Information Education in Europe* (J.M. Thiriet editor), Nancy University 2003, ISBN 972-97738-3-1, 152 – 158
4. T. B. Hilburn, W. S. Humphrey, *The Impending Changes in Software Education,* IEEE Software, Vol. 19, No. 5, September / October, 2002.
5. A. J. Kornecki, *Real-Time Computing in Software Engineering Education,* Proceedings of 13th SEE&T Conference, Austin, TX, March 2000, pp. 197-198
6. A. J. Kornecki, *Real-Time Systems Course in Undergraduate CS/CE Program,* IEEE Transactions on Education, CD-ROM Supplement, Vol. 40, No. 4, November 1997, pp. 295-296.
7. J. M. Thiriet, M.J. Martins, Editors, Monograph: *Towards the Harmonization of Electrical and Information Engineering Education in Europe* - Ed. EAEEIE, August 2003, 350 pages, ISBN, book version: ISBN 972-97738-2-3, ISBN: CD-ROM version: ISBN 972-97738-3-1.
8. J. M. Thiriet, M. Robert, P. Lappalainen, M.Hoffmann, M. J.Martins, A.Seoane, *Toward a Pan-European Virtual University in Electrical and Information Engineering,* IEEE Trans. on Education, May 2002, Vol.45, n. 2, pp.152-160.
9. F. L. Whetten, A. J. Kornecki , *Distance Teaming: A Bi-located Undergraduate Program in Computer Engineering,* Proceedings of 13th Annual Conference on Distance Teaching and Learning, Madison, WI, 1997, pp. 361-364.