

A Networked Information Processing System for Student Mobility Support in European Higher Education Area

Streszczenie. Artykuł opisuje Student Connectivity Module (SCM), sieciowy system przetwarzania informacji wspomagający międzynarodową wymianę studencką. System został zrealizowany jako część projektu European Educational Connectivity Solution, wykonywanego w latach 2009-2011 w ramach 7 EC Framework Programme. Omówiono architekturę i działanie systemu oraz wyniki testów prototypu przeprowadzonych przez grupę pracowników i studentów Politechniki Łódzkiej oraz Waterford Institute of Technology z Irlandii (*Sieciowy system przetwarzania informacji do wspomagania wymiany studenckiej w Europejskiej Przestrzeni Edukacyjnej*).

Abstract. The paper describes Student Connectivity Module (SCM), a networked information processing system supporting student international exchange between European universities. The SCM was developed as a part of European Educational Connectivity Solution project under 7. EC Framework Programme. The SCM architecture and operation was presented along with trials of the prototype system performed by staff and students of Technical University of Lodz and Waterford Institute of Technology, Ireland.

Słowa kluczowe: system informatyczny, międzynarodowa wymiana studencka, bezpieczna autoryzacja, karta elektroniczna.

Keywords: information system, international student exchange, secure authorization, campus smart card.

Introduction

The aim of the Bologna Process is to create a European Higher Education Area (EHEA) based on international cooperation and academic exchange that is attractive to European students and staff (as well as to students and staff from other parts of the world). One of the ways to achieve this aim is to promote cooperation between European universities and to facilitate mobility of students, graduates and higher education staff.

The student and teacher mobility is strongly supported by the Erasmus programme, being a part of EU's Lifelong Learning Programme (LLP) [1]. The Erasmus actions include financial support for studying and working abroad, foreign language preparation, multilateral projects, and university cooperation. National agencies define rules of the mobility, based on EC policy and regulations, in conformance with the local law. The recognition of students achievements is facilitated by the European Credit Transfer and Accumulation System (ECTS).

At present, more than 5 thousand European higher educational institutions offer opportunities to study a variety of courses. To make the international cooperation between them feasible, the partner universities need to be equipped with a dedicated system for gathering, processing, exchange, and storage of all the information related to student/staff mobility. Such a system is to help higher educational institutions to organize periods of studies at a foreign university, in conformance with numerous European, domestic and internal regulations. As examples, qualifications and study outcomes of students from different universities and countries should be properly recognized, periods of study and exams passed at partner universities have to be approved, et cetera. Moreover, a system of this kind should be of assistance at every stage of the complex process of organization of the international exchange, covering selection of candidates for mobility grants. It should be easily accessible by all its users, including students, academic and administration staff members. It should allow secure electronic information transfer via Internet and ensure full data integrity.

Existing standards and solutions

The only existing "quasi-standard" application for European student mobility support is the "moveon" system developed by QS-unisolution [2] which is used by about 300 European Higher Educational Institutions (HEI). Almost all the procedures required by Erasmus mobility regulations

are supported by several modules of the system, i.e. "Mobility grants application filling in and management", "Electronic Learning Agreements", and Mobility Certificates. The system is not integrated with any of the academic information systems (AIS) currently used at the European HEIs, so student's data have to be re-entered or imported manually by the use of text files of the given, strictly defined format (direct information from Sales Department). This is the only way of the data synchronization implemented in moveon. Security of the system is ensured by HTTPS protocol along with authentication of the users based on username and password credentials.

Despite ten years of existence on the united European market, the use of the system is limited mainly to Germany (153 HEIs) and France (100 HEIs). The only Polish HEI using moveon software was Technical University of Opole which has recently abandoned its use.

The problem of standardization of the trans-national learning documents and certifications has been addressed by the European Parliament, and the Europass Mobility initiative was established as soon as in 2004 to increase mobility of citizens [3]. Until now, only the paper form of the mobility certificate has been standardized. To support the process of issuing the document, a prototype system to exchange the electronic data between the sending and the host HEIs has been designed and implemented. The system does not support the management of student mobility process in any way, and it is focused on secure exchange of the final data concerning mobility periods which have been already completed.

In the year 2008, two consortia of Polish and Italian universities, MUCI and Cineca respectively, started a new mobility project aimed at developing a prototype infrastructure to exchange data about student mobility between two universities [4]. The prototype was completed in 2009 and connected the University of Parma in Italy and the University of Warsaw in Poland. It was based on Java Web Services, Glassfish application servers, and Oracle database. The experiment revealed a lot of incompatibility problems of information processing systems already at use in both HEIs and a need for standardization was concluded. The next step in the project was to start cooperation with RS3G (Roman Student Systems and Standards Group), EUNIS (European University Information Systems) which is a big federation of European university directors of information technology, and some companies from Europe and the USA [5].

European Education Connectivity Solution

The need for developing a computer-based solution for secure information exchange between universities has become apparent for a number of years already. In particular, it was a topic of frequent vivid discussions among the members of the European Campus Card Association, ECCA (www.ecca.eu). ECCA is a non-profit educational association that provides learning and networking opportunities for campus electronic (smart) ID cards and card industry professionals. The association offers a newsletter website, annual conferences, and regional workshops on topics related to campus cards. It was the initiative of ECCA to apply for European Commission funds for an R&D project aimed at integration of multinational efforts on defining a common basis for development of standardized information exchange systems for European Higher Education Area.

Following the ECCA members proposal, in 2009, a relevant EU 7th Framework research project has been launched under the name European Education Connectivity Solution (EECS), (<http://www.eccscard.eu/index.php>). The project was researched and developed by a consortium which consists of 3 European SMEs (small and medium enterprises) and 3 Technology Research Centers. The main aim of the project was to develop a prototype campus card management system to serve the unique needs and requirements of European Higher Education Institutions. The prototype system provides a secure, standardized campus card system to overcome the current barriers to expansion of the campus card market and support academic mobility within Europe.

The concept of developing a European standardized card system was initially researched among the members of ECCA. This research clearly identified the need for operability and mobility across the EU. The creation of a standardized campus card system facilitates secure access to a range of campus services. It also provides academic mobility by allowing higher education institutions to share information using a common identification card that acts as a student's "electronic key" and enables access to a student's records on secure databases.

A standardized campus card enables more efficient electronic exchange of data amongst HEIs. In Europe, many universities operate campus card systems in order to facilitate access to services for students, academics and visitors: points of sale, library access, access to classrooms/residences, printing/photocopying, etc. However, these systems operate in isolation on a stand-alone basis, providing no interoperability with other HEIs card systems due to the lack of system standards. The EECS project was successfully completed in May 2011. An EECS system prototype has been designed and live-tested by a team of students of Waterford Institute of Technology who travelled to Poland and students of the Technical University of Poland who went for the test in Ireland. The project outcomes have been passed to the SMEs, for future commercialization.

The EECS information processing system architecture is of a decentralized type – there is no single server for student information processing, since the personal information protection policies of most European countries do not permit data storage and processing on the territory of another country. Thus the cooperating university servers communicate with each other on the peer-to-peer basis. This solution reduces the costs of EECS deployment (no investments in common server are required) and offers good scalability (demand for a common server computational efficiency would increase with the number of HEIs connected to it). For mutual verification of university

servers the Public Key Infrastructure is used, with trusted X.509 certificates (e.g. issued by VeriSign, Thawte, etc.). A block diagram of the EECS system components for any HEI is shown in Fig. 1.

Student Connectivity Module function and architecture

The Student Connectivity Module (SCM), developed at the Institute of Electronics, Technical University of Lodz, is a web-based application designed to feature all the information processing, exchange and storage functions necessary to support organization of student mobility by cooperating universities. It is a part of the European Connectivity Solution (EECS) system, developed under 7. EC Framework Programme. In its prototype, proof-of-concept version, it is based on the rules of Erasmus programme framework. The module can be easily modified to assist in organization of students exchange under other frameworks, e.g. between universities of a single country.

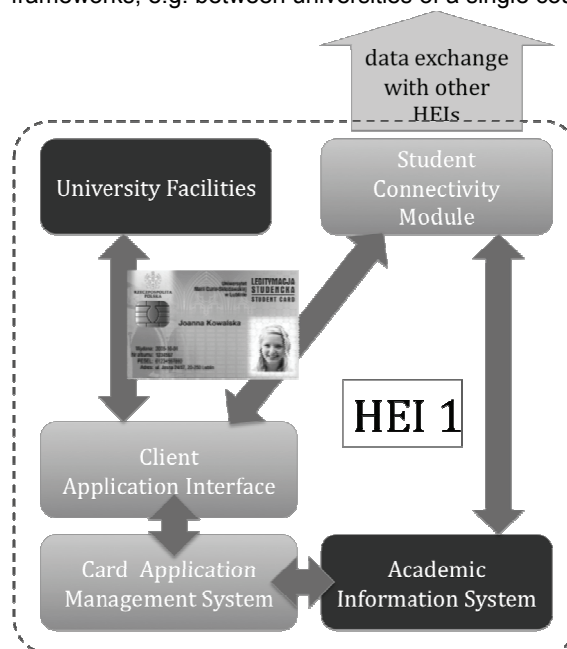


Fig. 1 The structure of the EECS system in given HEI

The SCM can retrieve information from existing Academic Information System (AIS) or other databases containing data needed for organization of student exchange (defined in Erasmus and/or other mobility programme procedures). On the other hand, from the point of view of a campus card system, the SCM is an application linked with the university Card Application Management System (CAMS) by the use of Client Application Interface (CAI). Authentication and authorization of users (staff or students) is performed with the use of smart cards by CAMS. The SCM module receives data from the university database (not from the card itself). The relation between SCM, CAMS, CAI, and other components of the university information system is illustrated in Fig. 1.

The security of the prototype system – a key issue of almost all information systems [6] remained an open question – no advanced cryptographic technologies were implemented. The main goal of the EECS project was to develop a prototype system for student mobility management support with a high level of data security based on smart cards and PKI technology. When the project was started it was clear that the student mobility electronic data exchange standardization would be a long and difficult process, so the project was not aimed at setting these standards. Indeed, in 2010 MUCI/CINECA made a serious update in their system (major changes in data

formats and web services, a shift from Glassfish to Tomcat application server), but no significant progress was made in solving the security issues [7].

Student Connectivity Module operation

The SCM interacts with two main groups of end users:

- Students;
- Administration/academic staff of the universities involved in the exchange.

The users have access to the SCM system through web browsers. The SCM software allows that through PHP scripts run by an Apache www server. The data is stored in the SCM database. Two alternative versions of the SCM database were designed and tested in the EECS prototype version. They are based on Oracle Database 11g Production Standard Edition One and Microsoft SQL Server 2008 R2 database management systems, respectively.

Different system functionalities and datasets are available to the SCM users. A student logs-in to the SCM by tapping her/his card on a card reader and then entering a PIN number. Contactless Mifare cards are used as the authorisation token in the EECS system. Thus the student computer has to be equipped with a Mifare contactless card reader. The staff members authorised to operate the SCM have to enter their login name and password – no smart card token is needed in their case.

Any two cooperating universities have their own SCM modules installed on their SCM-dedicated servers. All the data exchanged between the two SCMs is related to the information that is required to fill the forms defined by Erasmus procedures. It is assumed that there is only one source of primary information related to student mobility – it is his/her university SCM database. Some data can be entered/modified by operators of cooperating HEI, such as approval of study periods abroad. The Erasmus-defined documents can be generated in a pdf format for paper printing, signing and posting. The information exchange between SCM servers is based on the WebService technology with the use of standard ports: www http (80) and https (443). The https protocol ensures confidentiality while X.509 certificate provides strong authentication in the Internet environment (of limited trust).

The SCM users are assigned different roles related to functions they perform while involved in the international student exchange within the Erasmus framework. The user categories are listed below:

- Students
- University President/Rector
- Exchange Programme Coordinator (EPC)
- Faculty Erasmus Coordinators (FC)
- International Exchange Office (IEO)
- Dean/dean officers (DO)
- Agreement coordinator (AC)
- University Financial Office

To fulfil the formal requirements of Erasmus (and majority of other student exchange programmes), the SCM module allows preparation, storage and delivery of the following documents:

- LLP Bilateral Agreement
- Erasmus Exchange Application Form
- Transcript of Records, TR
- Learning Agreement, LA
- Erasmus Grant Agreement
- Changes to LA, CLA
- Application for prolongation of mobility period
- Stay Confirmation
- Reports

The SCM supports procedures that allow implementation of the standards required by Erasmus rules during the international student exchange.

As an example, prior to any mobility action, a bilateral agreement is prepared, printed and signed by the Vice Rectors of the cooperating universities. Then, student fills in a web-based application form indicating the HEI, the preferred study area and mobility period. The International Office (IO) staff gets access to the list of candidates and provides information on their language skills, as schematically illustrated in Fig. 2.

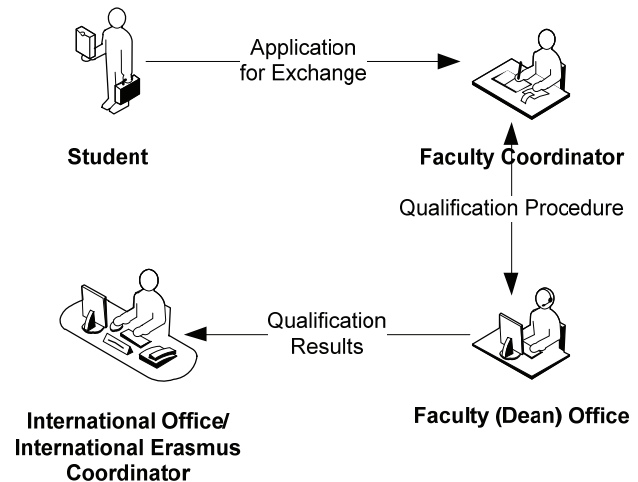


Fig. 2. The actors taking part in the mobility procedures at a home HEI

Students have access to the status of their applications and the results of the qualification procedure (submitted, verified, lacking data, qualified, rejected, grant ready to be signed). A complete list and details of the exchange procedures implemented in the SCM module are available in its documentation (SCM User Manual).

The procedures implemented in the SCM are follow the Erasmus standards. Implementation details conform with the rules for international student exchange that are in force at the Technical University of Lodz, in agreement with Polish Ministry of Science and Higher Education standards.

Not all universities have their Academic Information System (AIS) implemented to support organization of the learning activities. Therefore, the Student Connectivity Module is designed to either be used at a given university as a standalone application or collaborate with university AIS. As the rule, one university uses single SCM. The cooperating universities SCM servers communicate with each other through a secure encrypted channel.

The SCM module can be operated by users of the following categories:

- System Administrator (SA) registers other users, assigns roles to them; updates and modifies system dictionaries.
- Educational Programmes Coordinator (EPC) – Staff member of the International Exchange Office (IEO); registers university agreements concerning the exchange; assigns coordinators to agreements; takes final decision on student Mobility Grant applications.
- Dean's Officer (DO) – staff member of the Dean Office; enters, modifies and approves data related to applicant's studies (e.g. average mark, Transcript of Records, enrollment for relevant year/semester).
- Agreement Coordinator (AC) – university/faculty staff member; co-ordinates actions resulting from an

exchange agreement between universities; evaluates student application for Mobility Grant, produces a ranking list of the applications.

- Student – Mobility Grant applicant.

With the use of a typical www browser (MS Internet Explorer and Mozilla Firefox have been tested for compatibility with the SCM) the users invoke windows/forms relevant to the roles they play in the exchange enterprise. Most of the forms produced by SCM use data grid components.

The module is designed to implement the listed below procedures carried out as part of the exchange process.

- 1) Introducing new users to the system and assigning them roles.
- 2) Modifying and updating the SCM dictionaries.
- 3) Adding a new bilateral agreement.
- 4) Filling in and updating the student application for mobility grant.
- 5) Processing and updating the student application for mobility grant by university staff members.
- 6) Filling Changes to Learning Agreement, Prolongation of Mobility Period and Host Transcript of Records forms.

- 7) Accepting the filled forms.
- 8) Issuing Stay Confirmation.

As an illustration example for the eighth procedure on the list, after student returns home, the host University issues the Stay Confirmation. This is done by the host EPC by pressing Print Confirmation of Stay button of the relevant form (Fig. 3). The EPC needs to log in to his home SCM and then select the University that sent given student abroad.

Validation and trials

The SCM was designed in cooperation with the administrative and academic staff members of the Technical University of Lodz, Poland. The detailed functionality of the module was discussed with the staff of the International Office, Technical University of Lodz, to cover all the aspects of the organization of the exchange under the Erasmus Programme rules.

The module operation was tested by emulating a real-life exchange of students from two universities – Waterford Institute of Technology (WIT, Ireland)

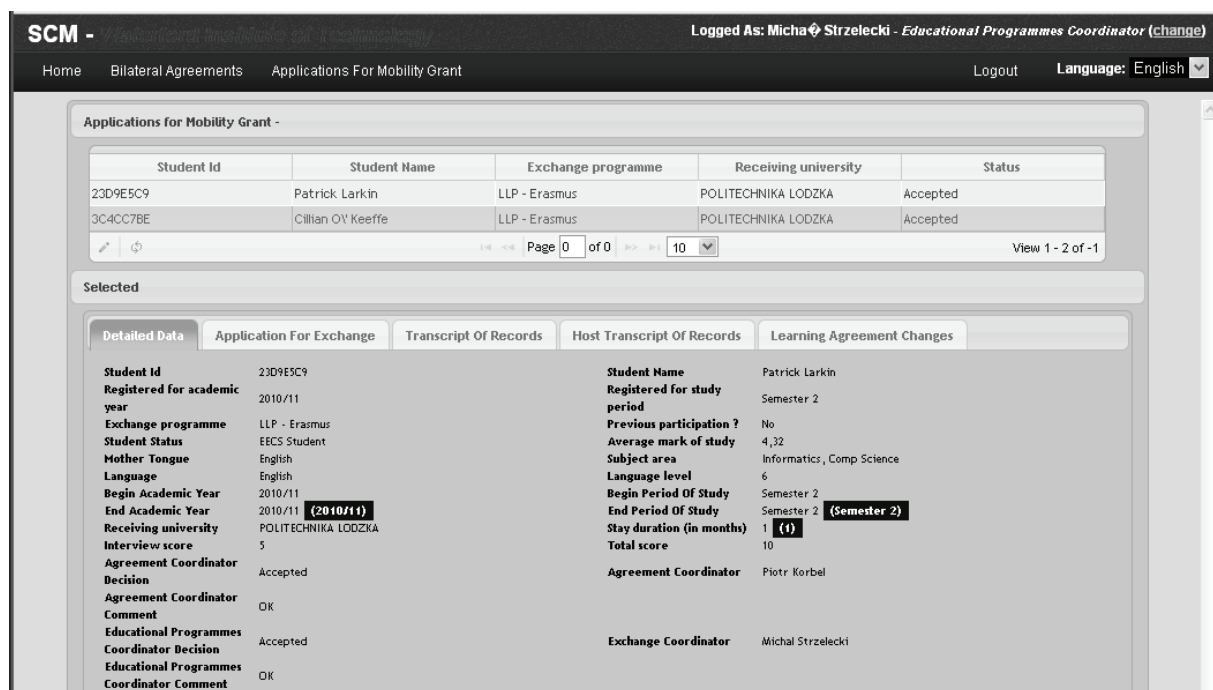


Fig. 3. An example of the Confirmation of Stay form generated by the SCM

and Technical University of Lodz (TUL, Poland). Two students of WIT came to Łódź for a week in March 2011, 3 students of TUL went to Waterford for the same period. The student ID smart cards were registered in the system prior to the test; then the cards were properly recognized by the cooperating SCMs (WIT student cards at TUL and TUL student cards at WIT).

The students and staff members of the two universities went through the Erasmus-complaint procedures and were guided by the SCM interfaces. Every aspect of the tested exchange was in agreement with the Erasmus rules, except of the period of study which was shorter for economic reasons. The students attended selected classes, received marks and were issued confirmations of stay at the end of the test.

The test included also a trial access to campus card applications – Library, Class Attendance and Vending

Machines. The WIT students borrowed books at TUL Main Library, and TUL students bought some cold drinks from a vending machine at WIT canteen, as examples. All the trial tasks showed full operability of the EECS. Using the smart cards issued at their home university, students going to a foreign university can have access not only to academic studies, but also to campus services. The only requirement is a seamless preregistration of their smart cards that should be of Mifare type.

Implementation issues

Prior to the design of the SCM module a research was made on the availability of standards for mobility information exchange. There were (and still are) only a few documents and projects known in this area. One should mention the RS3G recommendations, the USOSWeb (MUCI) solution (not integrated with campus card services) and the moveon

product (not integrated with the AIS). Definitely, there is a need for extensive work on setting standards of mobility information exchange. To make room for further developments in this area, the SCM was designed such that the exchange of raw data between universities was limited only to those needed by the Erasmus requirements (e.g. Europass Mobility document). So, it is expected that most of the SCM program code will remain unchanged once further standards are established or the few existing modified.

It follows from the analysis of the questionnaires conducted in the research phase of the EECS project that there exists a huge variety of different IT solutions at European universities – from a simple solution with no database system at all to complex systems combining study programs, students assessment, teaching staff assignments, class cost analysis and campus card services. Keeping this in mind, the SCM has been built as a flexible information technology system – easy to integrate with existing solutions. As an example, the XML language is used for the exchange of data between different subsystems, with no need for extensive changes in their architecture, functions and technical specifications.

Although the SCM prototype databases were implemented in commercial environment (Oracle and Microsoft SQL systems), they can be made fully operational in open source frameworks (e.g. Postgres, MySQL) which is the likely choice for many universities.

Technical specification

The SCM module can be implemented on standard hardware/software computers; the prototype was tested on machines running MS Windows and Linux operating systems. A more detailed specification of the computer hardware properties and applications installed is given below.

- 1) SCM application and web services server - AMD Phenom II X4 945 3GHz processor, 4GB RAM, 2x320GB RAID 1 HDD, Proxmox 1.4 kernel Linux OS;
 - a) Virtual machine (SCM application server) - Debian 4.3.2, 512MB RAM, Apache 2.2.9, Tomcat 5.5, PHP 5.2.6-1+lenny3 with Suhosin-Patch 0.9.6.2, ADODB 5.11, Smarty 2.6.7, TCPDF 5.9.067;
 - b) Virtual machine (SCM web services server) - Debian 5.0, 2GB RAM, Java EE 1.6.0_18, OpenJDK Runtime Environment (IcedTea 1.8.3), OpenJDK Client VM 16.0-b13.
- 2) Student ID cards: Mifare Classic
- 3) Card readers: OMNIKEY CardMan 5321
- 4) SCM DB server - Xeon 3.0, 1MB cache, FSB800, Intel Brandon SE7520BD2SCSi, 512MB RAM DDR 400MHz, 73GB HDD, Intel SRCZCRX RAID controller, Oracle 10g Release 10.2.0.1.0 Production Standard Edition One DBMS.
- 5) Web browsers: MS Internet Explorer 7.0.5730.13 Mozilla Firefox 3.6.16 Google Chrome 11.0.696.65 (with Java VM Plugins).

The abovementioned hardware/software specification meets highest information technology current standards. The validation and trial tests confirmed its full functionality and reliability real world campus environment (both in Ireland and Poland).

Summary

The Student Connectivity Module (SCM) of the European Education Connectivity Solution (EECS) system facilitates organization of students mobility. It helps to manage the international exchange and transfer of students' academic information. It securely sends and receives data to and from other Higher Educational Institutions, cooperating in the field of students exchange. The module communicates with the Academic Information System (when available at given university) and/or other databases containing information necessary for student exchange. Student users of the SCM are authenticated with their ID smart cards via Card Application Interface and Card Application Management System which are parts of the EECS. In the future, other authentication methods including e.g. biometry [8] will be considered. The cooperating 3 modules of the EECS system (CAMS, CAI and SCM) form a unique innovative solution that supports management of students mobility and makes the campus card services seamlessly available to students visiting foreign universities. The SCM is designed to be easily integrated with a variety of different type information technology systems available at European universities. The SCM has been implemented at the Technical University of Lodz, as a part of existing academic information system [9].

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