

## Virtual Campuses – Architectures and Design Solutions<sup>1</sup>

*Danail Dochev<sup>1</sup>, Radoslav Pavlov<sup>2</sup>, Otto Hutter<sup>3</sup>, Istvan Simonics<sup>3</sup>,  
Polyxeni Arapi<sup>4</sup>*

<sup>1</sup> *Institute of Information Technologies, 1113 Sofia*

<sup>2</sup> *Institute of Mathematics and Informatics, 1113 Sofia*

<sup>3</sup> *Computers and Automation Institute – HAS, Lagymanyosi u. 11, H-1111 Budapest*

<sup>4</sup> *Laboratory of Distributed Multimedia Systems and Applications – Technical University of Crete,  
P.O.Box 133, Chania 73 110, Greece*

**Abstract:** *The article describes briefly the characteristics, architectures and usability of the modern e-Learning systems, based on the virtual campus paradigm. In the last years the authors have developed e-Learning environments, designed as virtual campuses. Their functionality and specific features are discussed.*

**Keywords:** *e-Learning, Virtual campus, Local training centre, Learning Management Systems.*

### 1. Introduction

As we get deeper in the information age we observe global networking, virtualisation and learning-on-demand affecting the role of learning institutions in our society. Traditional barriers between universities, schools etc., caused by distance, regional and national borders are disappearing. New web technologies make possible to organise and network knowledge acquisition and exchange ubiquitously through digital learning infrastructure. The education (academic, vocational, continuous etc.) has gradually migrated towards the World-wide web under the device of free accessible education, to and from any place, at anytime.

The term “eLearning” is defined in EU documents as follows: “the use of new multimedia technologies and the Internet to improve the quality of learning by facilitating access to resources and services as well as remote exchanges and collaboration”

---

<sup>1</sup> This work was partially supported by Leonardo da Vinci projects HU/01/B/F/PP-136029 ADONIS, EL/2002/B/F/PP-114025 KNOSOS and by project IIT-010061 “Technologies of the Information Society for Knowledge Processing and Management”.

(“Communication from the Commission to the council and the European Parliament, the eLearning Action Plan: Designing tomorrow’s education”, COM(2001)172, Brussels, 28.3.2001). The customisation of Internet for educational delivery has enabled an entirely new modality of education to emerge – online education – profoundly distinct from traditional distance and classroom education. In traditional distance learning students receive a set of educational materials by mail, broadcast radio or TV programs, work alone and then communicate with the tutor for clarification or further directions. In this scheme the Web is used typically in a similar way: the learners receive and submit course packages and comments electronically, but the tutor operates on one-to-one or one-to-many (broadcast or lecture) mode.

The network technologies provide more powerful opportunities for organising teaching and learning in a new phenomenon: network-mediated online collaborative learning environment. Its conceptual framework includes the following innovative features:

- group communication (many-to-many),
- anyplace (place independence),
- anytime (time independence),
- multimedia-based,
- computer-mediated communication.

Technologically these features can not be provided only by the general communication tools (e.g. e-mail systems even with group mail services), as was demonstrated by the very first attempts to introduce networking in distance learning. New forms of computer-mediated communication such as computer conferencing tools, and new system architectures such as virtual classroom/campus are necessary.

## 2. Functionality of Virtual campuses

**Virtual Campus** is a paradigm for Web-based networked collaborative online learning environment, customised for post-secondary and/or workplace education. It provides a framework for designing, delivering and managing individual courses or whole programs. This paradigm is mostly applied for the needs of learning institutions, but there is a number of examples of virtual campuses for vocational and/or life-long learning, addressing non-formal and even informal learning. The virtual campus is like a real university campus in its mission and educational process - the principal difference is in the student access. Students in the virtual university can gain access to the courses from anywhere, at any time, convenient to them and appropriate to the course.

The Virtual Campus may support a wide range of flexible learning technologies (learning-by-doing, collaborative and group learning, individualised learning, project-based learning). It provides advanced facilities for: personalised mix of courses, virtual learners mobility, new ways for interaction between learners and tutors. *Individualised learning* focuses on student abilities to select the mode of delivery and timing of course material. It addresses essentially different learning styles and aptitudes of the students. *Co-operative learning* represents a paradigm shift in thinking that encourages students to learn from each other, not only from the teacher. It includes simultaneous interaction, equal participation, positive interdependence, individual accountability, group skills etc.

Innovative learning environments require flexible pedagogic approaches and activities, such as “learning by doing”, and collaborative and group learning through different types of interaction. However, in order to achieve their maximum potential, it is essential that the content and the context of learning platforms can be structured and standardised.

That results in requirements to developing the building blocks for the underlying support services in order to assemble distributed learning systems in such a way that learning objects (courses, modules etc.) can be flexibly archived, described and retrieved for re-use. Resulting platforms and tools support content packaging, the production of meta-data, learner information profiling, and interfacing with enterprise systems. Nowadays R&D work focuses on the development and validation of re-usable components, and is closely linked to component software engineering. New tools and processes are being developed for the production and maintenance of re-usable learning objects at different levels of detail. Tools and processes for locating and sharing learning objects are also being developed, including solutions for operational issues such as intellectual property rights, accreditation and payments. In technological terms, the main development areas include: learning object manipulation (metadata generators and retrieval systems); learning object authoring systems; security and trust infrastructures (APIs, smartcards); knowledge repositories.

### 3. Architectures for Virtual campuses

The Virtual campuses are organised around learning management systems and contains the following main subsystems:

- **Virtual training centre.** This is the core of the Virtual campus, ensuring the systematic learning/teaching process and servicing the common long-term learning activities in a training institution. It also acts as a virtual structure to organise qualification courses and skill acquisition outside the curricula structures (short term courses, focus on hands-on experience, courses on demand). The virtual training centres are normally organised as virtual learning environment – integrated Intranet and/or Internet-based software systems, implementing course delivery to learners, course assessments, course-learners management etc..

- **Learning content management system (LCMS)** with author’s studia, producing all kind of multimedia learning materials. The modern content management systems apply international standards (SCORM, IMS) and organise the courseware as re-usable shareable content objects.

- **Communication system,** allowing synchronous/asynchronous communication between learners and instructors and between learners themselves during the training process. Some developers work with Virtual class technology, permitting live class experience to be conducted over the web and including functions as shared whiteboards, application screen sharing and live feedback, videoconferencing, voice over IP, archiving of classes as Learning Objects, inter connectivity with the Learning Content Management System.

- **Virtual library/repository** (dataware house for reusable multimedia learning materials), storing various types of courseware or documents required by the actors to fulfil their functions. Normally it is implemented as a distributed multimedia database with metadata presentation of the learning objects (e.g. LOM standard).

- **“Public relations” department** with personal learners guides, which act as information mediators for the users (admission advisers, carrier advisers, employing consultant etc.). This module also presents the available courses for the web site guests and organises in general also virtual tour of the campus for potential new users.

A learning management system also takes charge of the administrative activities, document management etc. of the training institution. The result of this integration is that having access with a single sign-on into administrative, e-learning, and communications systems speeds access to services and information for all users. Faculty, staff, administrators, and students do not need to make multiple entries, bookmark pages, or memorize URLs.

The main actors in a Virtual campus are:

- **Learner** – transfers the information into knowledge. S/he uses the courseware from the distributed repository acting as learning scripts navigator, repository resources explorer, self-evaluator of personal assessments, participant in collaborative forms of learning.

- **Trainer/advisor** - assists the learners in the educational process, acting as producer of diagnoses, mentor, assignment evaluator, coach.

- **Manager** – manages the actors and events in the educational process, acting as a planner, decision maker, supervisor, team or group organiser.

- **Author of learning materials**, using the facilities of authors studio and the repository of courseware materials.

- **Counsellor (mediator - information broker)** – facilitates the navigation of the other participants, acting as information communicator, user profiles producer etc. Normally this user role is implemented by intelligent agents technology.

The following list of instrumental tools in a virtual campus is recommended:

- **Video conferencing system** – a synchronous communication system giving the ability to set up collaborative groups easily and to define structures, tasks and objectives.

- **Chat system** – a real time synchronous communication system that enables users to chat in “rooms” they create for the purpose. It allows the incorporation of multimedia in the messaging options.

- **Course structuring tool** – allows the instructors to create courses without having programming knowledge by templates and to send multimedia files to the virtual university servers.

- **Gradebook** – database of students’ grades.

- **Personal workspace** for users own resources.

- **System administration tools** for creating and maintaining accounts, defining access privileges and establishing courses on the system.

#### 4. Some usability issues

Nowadays one may find in Internet hundreds of sites for virtual campuses of universities and colleges all over the world. There are also portals, giving access to associations of (regional) virtual campuses (e.g. California Virtual campus – [www.cvc.edu](http://www.cvc.edu), Swiss Virtual Campus – [www.virtualcampus.ch](http://www.virtualcampus.ch), Virtual Campus Tour – [www.campustours.com](http://www.campustours.com) and many more). Most of the virtual campuses are developed by using commercially available Learning Management Systems (LMS) and Authoring Systems. WebCT ([www.webct.com](http://www.webct.com)) – and BlackBoard ([www.blackboard.com](http://www.blackboard.com))

are two of the most used LMSs in the higher-education sector, but many other products/solutions are available on the market. There is not just one *best* product, but all of them offer many similar services and some specific ones. The products may widely differ in their licensing and user-support policies. Open-source products are a possible alternative, where some cost advantages are counterbalanced by the disadvantage of not being backed by a company supporting their development and maintenance.

The academic lecturers, actively working on development and especially on maintenance of Virtual campuses stress on the fact that modern technology play an important role in supporting the virtual campus - but it is only a supportive role. The Virtual campus has to be founded on an understanding of: how adults learn, the different mechanisms needed to support people while they are studying, the roles, responsibilities and processes that support the delivery of any educational programme, the needs and requirements of learners studying at a distance. In order to develop really useful virtual campus, the development team in a training institution has to begin by focusing on the learner and asking a number of key questions:

- What did their learners' need?
- What could staff do to maintain student motivation across distances?
- Is it possible to deliver entire existing courses flexibly?
- How could staff ensure all the learning outcomes were met?

These questions gave rise to others, concerning the concrete educational technology to be applied:

- How do the learners access the resources?
- What sort of induction and counselling would learners receive?
- Who would students contact with questions and queries once they were enrolled in the virtual campus? What if that person was unavailable or on leave?
- How would staff work as a team?
- Who would be responsible for “filling in the paperwork” and monitoring the budget?
- How would they go about purchasing materials?
- How would they ensure consistency in practices and procedures across the different campuses?

Analyses of the RTD work in the field of Virtual campuses, which tries to address more generic questions, non limited to a single implementation for a given training institution, demonstrate that the most important success factor for the projects was the *ability to customise the products* and ensure that user needs are properly addressed. Partly related to this is the aspect of *ease of use* and *flexibility*. Most of the projects highlighted the importance of creating user-friendly applications that can be adapted to match the demands of different users. This is particularly relevant in relation to products aimed at users with no specialist knowledge or skills. Flexibility means being capable of meeting the needs of multiple users and customers; it is crucial in order to maximise the potential of a particular application. In order to ensure the customisation of the products and their ease of use, the majority of the projects involved users in the development process through feedback mechanisms.

The thorough *knowledge of learning technology standards* and of the activity of standardisation bodies is an obligatory condition for the development of innovative platforms and flexible learning methods. Knowing the “rules of the game” appears to be as important as knowing the learning content and context, irrespective of the fact,

that different e-learning actors are more knowledgeable in the former or the latter, according to their background.

## 5. Development of Learning management systems – local solutions

In the last 6 years the authors and teams from their institutions worked as partners in a number of international projects in the field of e-learning, applying directly the Virtual campus paradigm. A thorough consideration of the specific training needs of the potential customers, their background and available infrastructure was seen as a precondition for success of the developed local context-oriented training solutions. The work on these projects demonstrated that further improvement of the Virtual campus functionality may be achieved essentially by specialising the generic functionality towards the needs of more specific learners groups and learning modes.

**Archimed Knowledge Village (AKV)** is a generic open learning environment, organised around the metaphor of “virtual campus”, was developed under the international project *ARCHIMED “Advanced Multimedia-System Architectures and Applications for Educational Telematics”* (1998-2000) [3]. The environment ensures sufficient functionality and is relevant to the modern pedagogical approaches and tendencies for teacher-assisted and learner-centred education in local and global computer networks with some collaborative learning possibilities. The pilot implementation of AKV multimedia environment organise distant training centres which integrate a set of necessary methods, services and tools assuring a self-paced and/or remotely monitored learning in a given knowledge field with the help of available courseware materials and the pedagogical interactivity between a teacher/instructor and a student/learner. All real implementations of systems, dealing with multimedia content, have to compromise between the requirements for full functionality and the constraints imposed by the available resources. The AKV environment contains two types of distant training centres:

- Intranet-based distant training centre, build upon a local computer network of an institution in Client-Server mode and accessed also through remote terminals. This organisation takes into account the state-of-the-art of the public communications on a part of the ARCHIMED partner countries, where on-line access to multimedia courseware is not always feasible.
- Internet-based distant training centre: this version of the system has as its objective to serve the needs of working people who have no capability to move and remain for extended time periods at the premises of the teaching organisation. The technologies used for the implementation of the Internet version include: a) Relational database management system (SQL server) for the backbone of the system and for supporting the model (data model plus operation’s model – transactions) of the learning environment; b) Access to the functionality of the learning model and tools from distance using the standard Internet protocols (HTTP, web browser, web server).

The experiments with the pilot application with different user groups demonstrated the AKV potential and shortcomings and led to some decisions about the further development and improvement of the environment. They revealed that further improvement of the functionality of the Virtual campus may be attacked essentially by specialising the generic AKV functionality towards the needs of more specific learners groups and learning modes.

**ADONIS Virtual Campus** is developed under LdV project *PP-136029 ADONIS “Advanced on-the-job e-Training solutions in e-Business for SME’s”* (2002-2004) ([www.adonisproject.hu](http://www.adonisproject.hu)) for e-training of vocational trainees of tourism SME’s. The functional characteristics of the ADONIS learning environment, build up as adaptation and enhancement of the ARCHIMED platform, consider the specifics of: 1) the form of learning processes – On-the-Job Training (OJT); 2) the target group – personnel of tourist-oriented SME’s; 3) the learning content – IT and other knowledge and skills, allowing and stimulating successful e-business activities. The analysis of these specific topics led to formulation of three main requirements, necessary or desirable for the ADONIS environment:

- Operation in Internet mode by distance learning delivery of OJT courses/modules;
- Support of learning-by-doing practice;
- Operation in working conditions (with real software systems).

The distant training centres in ADONIS virtual campus implemented the following functional characteristics:

- Controlled access to learning resources to support structured on-the-job-training with possibilities for self-directed learning and testing, i.e. mixed initiative in activating the learning tasks.
- Automatic fixation of the current status on exiting the learning environment in order to allow fast restoring and continuation of the e-training on the work place
- Execution of assessment/self-assessment tests and projects.
- Support for the teachers/trainers acting in their specific roles and activities in on-the-job training mode (as “master”, “supervisor”, “coach”).
- Asynchronous connection with the teacher/tutor.
- Sufficiently intuitive interface for the end-user, removing the need of special training how to use the environment.
- Work with standard/not excessive computer resources and moderate data exchange rate in order to consider the limitations of the local computer and communication infrastructure
- Use of a standard browser from the learner’s part, avoiding the need to download programs/ files on the learner’s computer (imposing lesser requirements to the learner’s computer resources and increasing learner’s trust in the security of his company confident information).
- Allowing the learner to work and practise with real software system on a remote computer without the need to purchase the system for his exercises.

These characteristics were implemented at each distant training centre of the ADONIS Virtual campus at different level and details due to the local specifics of the partners. The Bulgarian local training centre [4] was developed on relational database management system (SQL server), supporting the data model and operation’s model of the virtual training centre. It uses WEB server for the middle tier logic and standard browser for presenting the user interface functions. The specific requirement to work with real software system without installing any additional software on the learner’s computer was achieved by using remote server accessible through web interface (Figs. 1, 2). The learned products and the trainees workspaces for intermediate and final results of their exercises and projects are located on a server in the training centre and are accessible through web interface. This solution facilitates and makes more flexible the OJT e-learning. In the same time it requires additional interface



Fig. 1. Presentation of Learning Material in the Bulgarian ADONIS Distant Training Centre

functions to support the work of the courseware authors – for preparation of exercises and projects and of the system administrator – to organise the trainees workspaces.

The wish to help the learner, who has only an asynchronous connection with the teacher, lead to inclusion of some additional facilities – e.g. explanation of terms and possibility to use annotations in learning presentation mode (Fig. 1) or displaying hints and recommendations how to do the exercise when working with the real software product on the remote server (Fig. 2).

Exchange and re-use of the developed courseware materials is possible due to their shaping as shareable learning objects in SCORM standard – a set of specifications for developing, packaging and delivering high quality education and training materials. SZTAKI SCORM LCMS [5], developed for the Hungarian local training centre, is an XML/SQL database platform with web based editor and administration modules, workgroup supporting tools, export/import modules and a learning material library which can be accessible through the web. The database platform has a native SCORM support which means that the inner database package specification and the LOM metadata structures. The present technology of the system is based on Linux/Java platform with MySQL and Xindice database management system. To any elements of any pages in the learning material in the database can be assigned write/read right separately and in groups too. Developers can upload and replace the content elements (assets, SCOs) according to their rights, and can modify the structure of the learning material. The export-import modules are able to generate SCORM 1.2 compatible

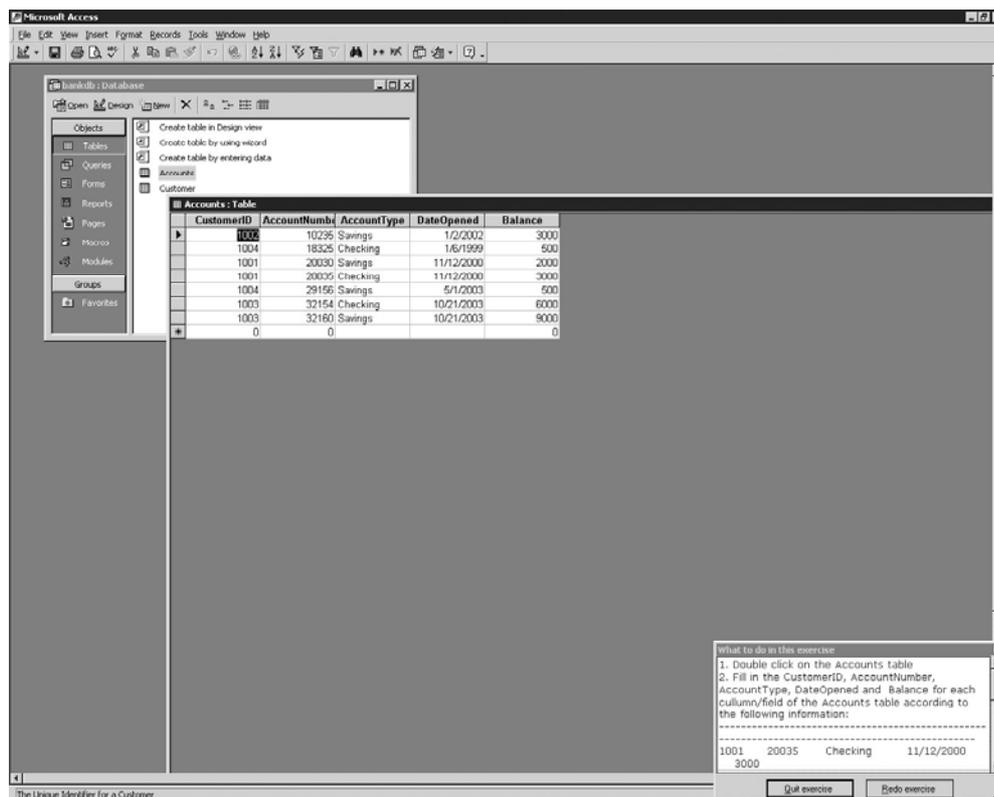


Fig. 2. Doing Exercises in the Bulgarian ADONIS Distant Training Centre

packages from the learning materials from the database and import such packages. The LCMS also supports some non-standard learning material formats of an eLearning framework popular on the local market. The system supports SCORM eLibrary module – a SCORM compatible “store” of training packages users can view and download according to their rights. The LCMS system does not support the interaction, but it is a cheap entry point to the deployment of SCORM compatible learning materials.

**New Media Knowledge Village** is another virtual campus developed under LdV project *PP-114025 KNOSOS “New Media Knowledge Village for Innovative E-Learning Solutions”* (2003-2005). The aim of the project is to create a network of virtual training and resource centres of expertise for development of competence in integrated web and digital TV Anytime-Anywhere technologies. This virtual campus covers web-based means for training without dealing with more specific training modes as on-the-job-training and facilities like executing exercises on remote computer. Attention is paid on the development of more detailed and standardised learning content concerning interactive TV standards and educational applications of digital TV. The Virtual campus “New Media Knowledge Village” is oriented to address the vocational training needs of ICT and new media professionals, working for educational content providers through digital TV devices, as well as for electronic mass media, advertising agencies etc. The local training centres of the distributed environment will exchange and reuse not only the educational content as shareable learning objects, but also

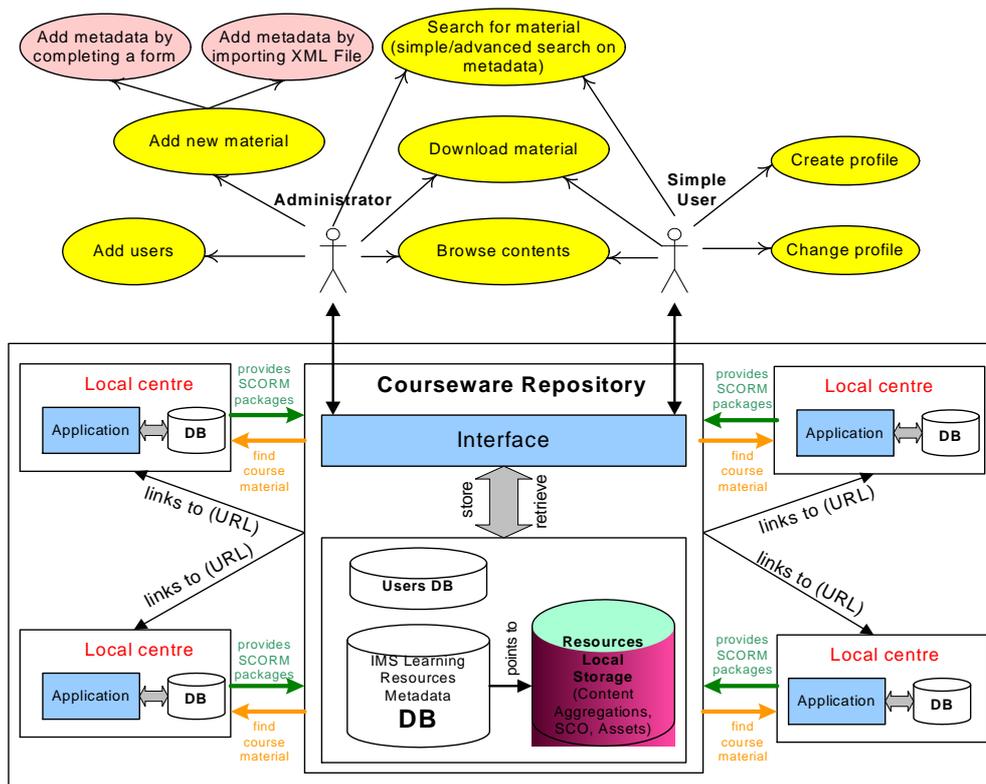


Fig. 3. General Architecture of the New Media Knowledge Village

information about this content (metadata) and about the learner profiles. Fig. 3 presents the general architecture of the New Media Knowledge Village.

## References

1. European Union-Supported Educational Research 1995-2003. Briefing papers for policy makers, EUR 20791, 2003, 209 p.
2. Harasim, L. The virtual university: a state of the art. – In: Advances in Computers, Vol. 55, 2001. Academic Press, 2001, 2-47.
3. D o c h e v, D., R. P a v l o v, R. Y o s h i n o v. An open distributed computer environment for educational telematics. – In: Proc. of the EDEN Fourth Open Classroom Conference, Barcelona, 20-21 November 2000, 247-252.
4. D o c h e v, D., R. P a v l o v, M. M o n o v a - Z h e l e v a. Principles, quality requirements and solutions for on-the-job e-training in SME. – In: Proceedings of the EDEN Annual Conference 2003, Rhodes, 15-18 June 2003, 518-523.
5. H u t t e r, O., T. S a r v a r y, I. S i m o n i c s, B. W a g n e r. E-Learning: frameworks, contents and standards. – In: Third EDEN Research Workshop, Oldenburg, March 2004.
6. A r a p i, P., N. M o m o u t s i s, S. C h r i s t o d o u l a k i s. Supporting Interoperability in an Existing e-Learning Platform Using SCORM. – *ICALT 2003*, 388-389.
7. How to create and to manage e-learning activities (2004). – In: 3rd Report of the Educational Management in the Swiss Virtual Campus Mandate, Lugano, February 2004, 63 p. (<http://www.virtualcampus.ch/display.php?lang=1&zname=news#71>)

## Виртуални кампуси – архитектури и проектни решения

*Данаил Дочев<sup>1</sup>, Радослав Павлов<sup>2</sup>, Ото Хутер<sup>3</sup>,  
Ицван Шимонич<sup>3</sup>, Поликсени Арапи<sup>4</sup>*

<sup>1</sup> *Институт по информационни технологии, 1113 София*

<sup>2</sup> *Институт по информатика и математика, 1113 София*

<sup>3</sup> *Computers and Automation Institute – HAS, Lagymanyosi u. 11, H-1111 Budapest*

<sup>4</sup> *Laboratory of Distributed Multimedia Systems and Applications – Technical University of Crete, P.O.Box 133, Chania 73 110, Greece*

### (Р е з ю м е)

Статията описва накратко характеристиките, архитектурите и използваемостта на съвременните системи за електронно обучение, основани на парадигмата за виртуален кампус. В последните години авторите са разработвали среди за електронно обучение, проектирани като виртуални кампуси. Обсъдени са техните функционалност и специфични черти.