DeLC – Distributed eLearning Center

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Abstract. This paper presents the functionality and the overall architecture of a Distributed eLearning Center (DeLC), which provides distance eLearning facilities available to all registered users (e.g. students, educators, and other staff) independently of their affinity, current location, and time of using it. A DeLC network is considered along with defined virtual structures within it. A model of a DeLC Node consisting of two main parts (namely meta-model and subject models) is proposed. A DeLC Node's architecture specifying technological framework for the integration of electronic services (eServices) is also proposed and explained. Finally, implementation issues regarding DeLC development are considered.

1 Introduction

Different eLearning models support basic education units in different ways, e.g. as learning objects [1] or reusable learning objects [2]. In [3] the eLearning systems and their usage are considered as specific digital market places with much in common with eCommerce applications. An interesting architectural proposal is considered in [4], in which an eLearning system is developed as an upgrade of the standard tool for processing, personalisation, and control of HTML and XML documents.

The Distributed eLearning Center (DeLC) presented in this paper may be viewed as an example of a Network-Based Education [5], where interaction between cooperative physically dispersed programs, tools, students, educators, and administrators takes place. A services oriented approach was chosen, where the DeLC is developed as an open infrastructure offering electronic services (eServices) deployed on different servers with an inbuilt capacity for partial automatic-controlled integration (within the frames of predefined virtual structures). *Basic eServices* are those services visible to the users which can be activated, saved, customized, personalized, classified, removed etc. All these operations with the *Basic eServices* are performed by the means of *Monadic eServices* transparent to the users. *Basic eServices* only are further considered in this paper.

The DeLC proposed here is further refinement of the ideas presented in [6, 7, 8, 9, 10, 11, 12]. The DeLC is a collaborated project established between the Department of Electronic and Computer Engineering (ECE) at the University of Limerick (UL) and the eCommerce Laboratory (eCL) of the Faculty of Mathematics and Informatics (FMI) at the University of Plovdiv (PU).

The DeLC project is pursuing the following three main goals:

- Development of an evolutional eLearning prototype infrastructure, which will be used to achieve practical expertise for future overall integration and exploitation of such systems by the project's two participating university partners. The development is being undertaken in a manner so as to minimize the need for any changes in the existing educational processes.
- To synthesize a common architecture and a business model of the eServices offered by the DeLC, which takes into account the specifics of the educational process in the two universities. The eServices design and implementation should be flexible enough to be adapted and effectively used by both partners. At the same time the resultant architecture should be independent of the business model evolved so that it is truly open to the integration and support of new eServices.
- Search for appropriate infrastructural solutions for the integration and joint usage of the different eServices implemented and on offer.

2 The DeLC Network

A network model is proposed in [6] which aids in the development and modeling of the DeLC (Figure 1). The nodes of this network (called DeLC Nodes, DeLCNs) are established and supported by real administrative units (laboratories, departments, faculties, colleges, universities), which offer a complete educational cycle. The functionality of a DeLCN is presented as a set of eServices. The configuration of the network edges is such as to enable the access, incorporation, use and integration of eServices located on the different DeLCNs.

The remote eService activation and integration is possible only by the means of preliminary defined virtual structures. The following two types of virtual structures are defined in the DeLC network:

- *Virtual DeLC Unit* – the nodes of this structure belong to the same real administrative unit (for example laboratory, department, faculty etc).
- *DeLC Cluster* – the nodes of this structure correspond to different real administrative units.

In the DeLC network we can easy create new structures, reorganize or remove the existing structures (the reorganization is done on a virtual level, it does not affect the real organization). For example, the reorganization of an existing virtual structure can be made not by removing a node but by denying the access to the corresponding eServices offered by it. The reorganization does not disturb the function of other nodes (as nodes are autonomous self-sufficient educational units providing one or more integral eServices).

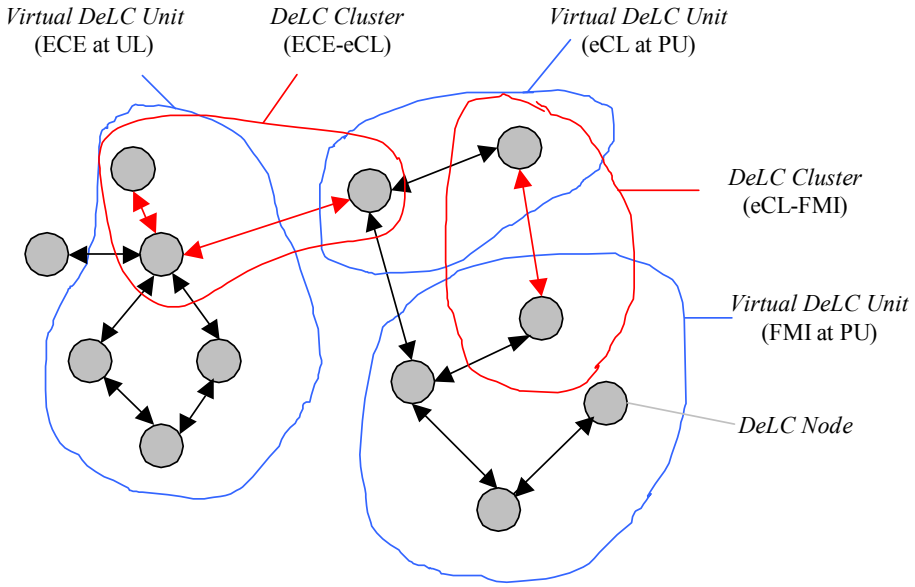

Fig. 1. Two types of virtual structures are defined in the DeLC network: (i) *Virtual DeLC Unit* with nodes belonging to the same real administrative unit (e.g. ECE at UL), and (ii) *DeLC Cluster* with nodes corresponding to different real administrative units (e.g. ECE-eCL)

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From the client's point of view the DeLC Node contains two main modules:

- *Client Module* – visible to the users; by directly contacting it the users can subscribe and use all desired eServices offered by this node.
- *Server Module* – transparent for the users. The main task of this module is to support and provide eServices to the Client Module.

The DeLC Nodes (DeLCNs) are described by:

- *DeLCN Model* – specifies the functionality of the node as a set of eServices.
- *DeLCN Architecture* – specifies a technological and architectural framework for the integration of the different eServices.

This dual strand development strategy means that there is flexibility for independent development of the two components. Moreover within the specified architectural framework different approaches and designs may be used for the actual node development itself of the architecture, as well as for the definition of the content and structure of the eServices. This dual strand decomposition approach also is helpful in facilitating easier the re-engineering of the existing applications, and additionally enhances the possibility of structural flexibility and adaptability.

3 DeLCN Model

The DeLCN functionality model may be conceptually considered to consist of two main parts:

- A ***meta-model*** for eService classification, which builds the functional framework of the DeLCN model;
- A set of sub-models of the supported services, which here are called ***subject-models***.

The two parts of the model are created by using the Unified Modeling Language (UML) [13,14].

3.1 Meta-model for eService Classification

The eServices in our model can be classified according to their content/nature, type of invocation, and mobility features. Each eService exists within a 3D discrete space defined by these three characteristics (Figure 2).

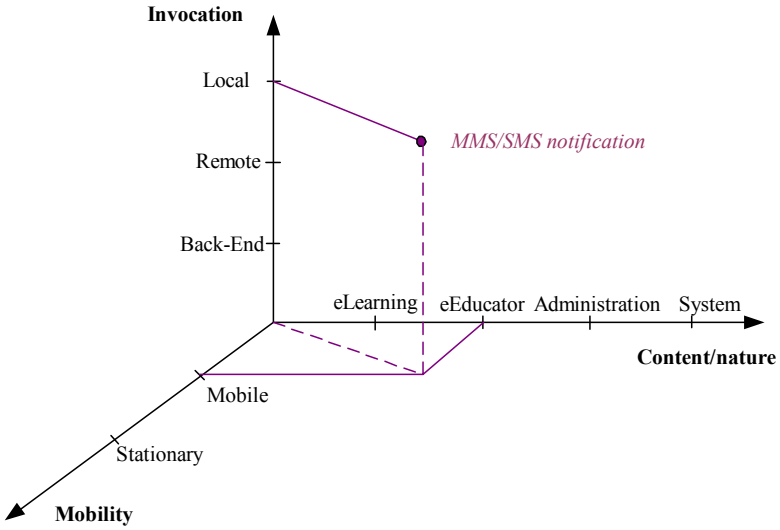

Fig. 2. The eServices exist within a 3D discrete space defined by the following characteristics: content/nature, type of invocation, and mobility features of the eServices. For example according to its projections on the axes of this space, the eService *MMS/SMS notification* belongs respectively to the group of eEducator services, the group of local services, and the group of mobile services

According to their content/nature the eServices are grouped in the following four classes (Figure 3):

- *eLearning Services* – intended mostly for students in different forms of learning, but could be used by educators as well. These services are used mainly in a real-time on-line mode of processing. Typically the eLearning Services would include eLecture, eTest, eTutorial, eLab, eAssignment,

eSeminar, eGradebook, Discussion Board, Chat Room, eDiploma Thesis, eConsultation, eLearning Pack.

- *eEducator Services* – intended for educators preparing necessary information resources for the eLearning Services, adding new eServices, modifying or removing existing eServices etc. This class of services is used mainly in an off-line mode of processing.
- *Administration Services* – a set of eServices intended for the administrators in order to maintain the system or to work with integrated applications within their bailiwick.
- *System Services* – with primary function to organize access and support of other eService types. These eServices are provided as an integrated part of the DeLCN architecture.

According to the type of invocation the eServices may be classified as followed (Figure 3):

- *Local eServices* – located on the Server Module of a local DeLCN and accessed directly through the DeLCN Navigator (see Figure 5). These eServices usually realize the specific functionality of the DeLCN.
- *Remote eServices* – located on a remote DeLCN and accessed through a Remote DeLCN Gateway (RDeLCN Gateway in Figure 5), located on the local DeLCN.
- *Back-End eServices* – provided by the integrated back-end systems (faculty administration systems, library information systems etc). The access to them is provided through an appropriate Back-End Gateway (BE Gateway in Figure 5), realized in the DeLCN.

According to mobility features the eServices are divided in two main groups (Figure 3):

- *Mobile eServices* – for users with mobile devices. This requires development of a new subgroup of context-aware eServices that understand the users' context [15] (e.g. user location, mobility attributes required/requested, courses/modules users are engaged in, issues of time-criticality, serialisation, goal-driven sequentialisation of tasks engaged in by the user; environmental context issues such as classmates and/or educators interactions).
- *Stationary eServices* – for ordinary users (e.g. other employees) without a need of using mobile devices.

Figure 4 presents the common use-case block diagram for the meta-model of this eService classification.

3.2 Subject Models

Each eService provided by the DeLC has a common unified structure that allows easy development of the system by adding new eServices and integrating them with the existing eServices. The eServices can be represented as containers, which consist of *profile* (meta-information) and *functionality*. The *profiles* give information about eService's content (semantics), user's group, interaction with other eServices etc. The *functionality* can be presented as a set of rules specifying the actions to be performed.

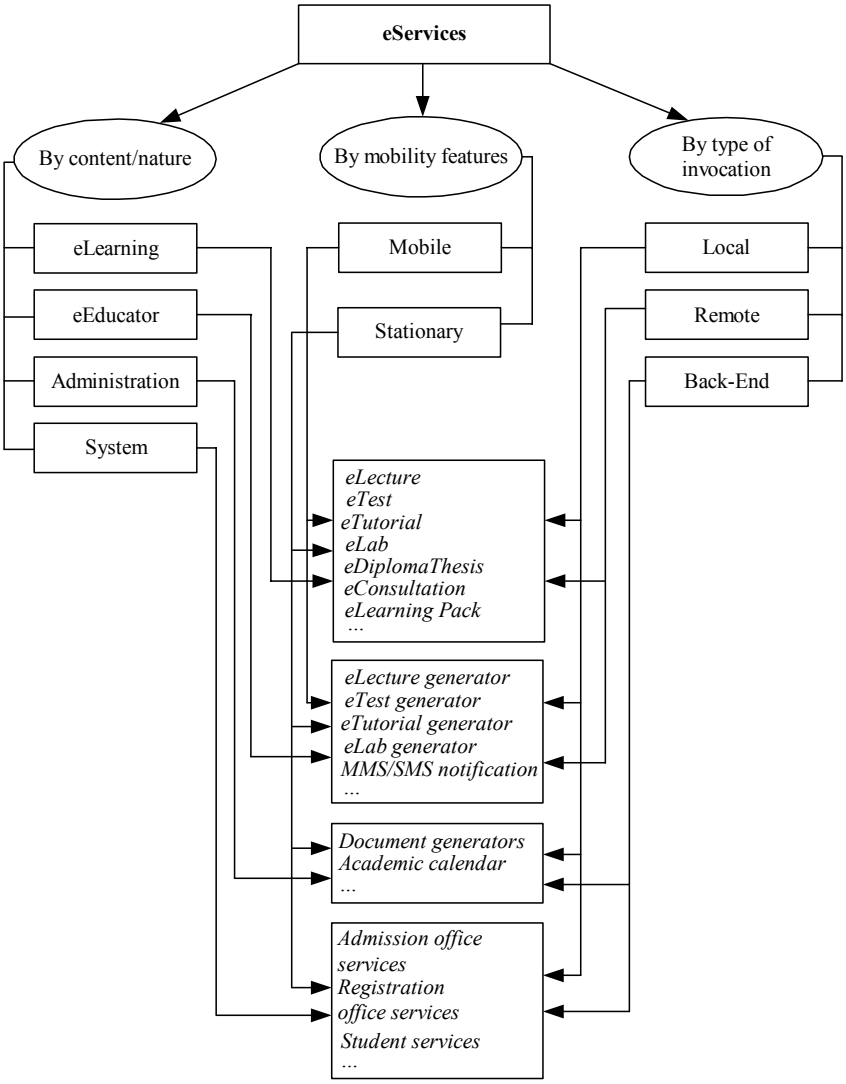

Fig. 3. According to their content/nature, type of invocation, and mobility features the eServices are grouped respectively in four classes (*eLearning, eEducator, Administration, System*), three classes (*Local, Remote, Back-End*), and two classes (*Mobile, Stationary*). Among the *eLearning* services there are examples of both local and remote services, some of which are mobile and others stationary

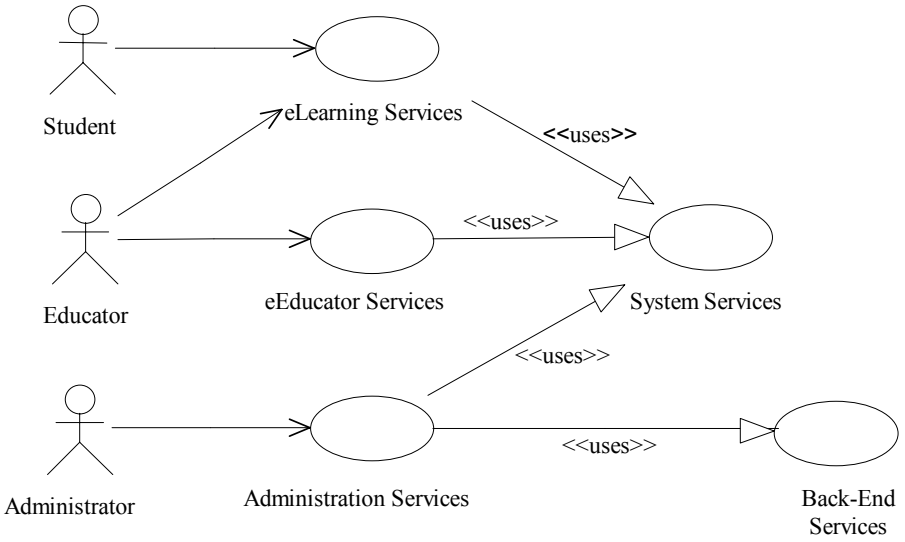

Fig. 4. Use-case block diagram for the meta-model of eService classification

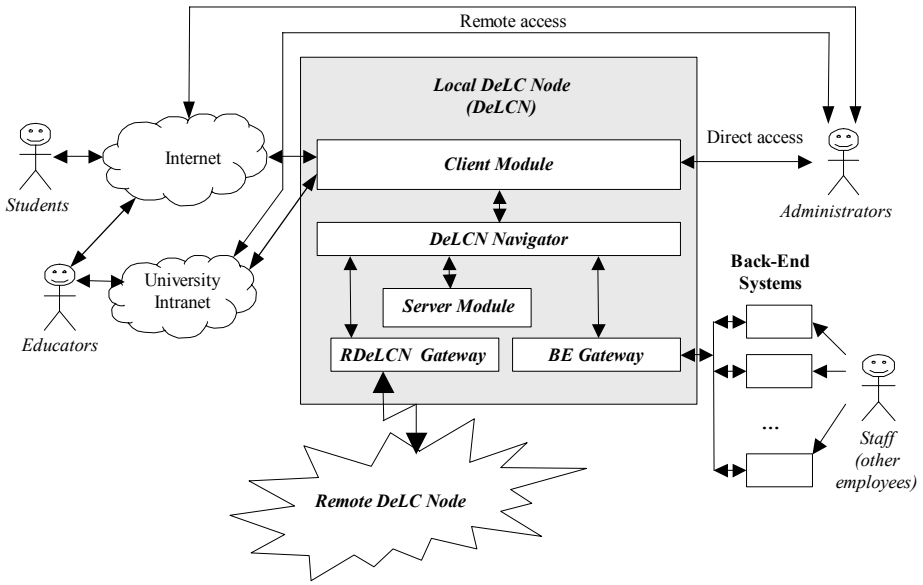

Fig. 5. The DeLCN architecture consists of *Client Module* (generates a plan for the execution of user request), *DeLCN Navigator* (manages and controls the plan generated by the Client Module), *Server Module* (provides local eServices), *RDeLCN Gateway* (provides remote eServices), and *BE Gateway* (provides back-end eServices)

4 DeLCN Architecture

A general DeLCN architecture is shown in figure 5. It consists of Client Module, DeLCN Navigator, Remote DeLCN Gateway (RDeLCN Gateway), Back-End Gateway (BE Gateway), and Server Module, which provides specific eServices of the node.

The Client Module performs the following functions:

- Support of user access to the DeLCN;
- User requests receiving and processing;
- Generation of a plan for the execution of user requests;
- Obtaining the results and generation of the final responses to the user requests.

The Client Module is implemented as an intelligent portal, which can be easily adapted and integrated into the DeLCN architecture.

The DeLCN Navigator manages and controls the plan generated by the Client Module for the execution of user requests. It activates in an orderly sequence all eServices required for the satisfaction of user requests. These are provided by the Server Module usually. If some of the required eServices are located on a remote DeLCN, the RDeLCN Gateway ensures their provision. If others are provided by external Back-End Systems, they are accessed through the BE Gateway.

The range of the eServices is supplemented by those sourced through external Back-End Systems and associated services:

- University/faculty/department administration systems;
- Library information systems;
- Financial (accounts) systems;
- Student enrollment systems;
- Systems for automatic document exchange etc.

The following kinds of DeLC users are distinguished:

- *Students* – these users can avail of node's eServices through an Internet access (by using thin clients, e.g. browsers). They do not have direct access to the node's eServices. They can communicate with the system only by issuing and sending of requests (to the Client Module).
- *Educators* – these are users (lecturers, instructors, tutors, graders, lab conductors etc) that plan, organize and manage the educational process in the DeLC Node. These users have access to the application part of the system through the Internet or University Intranet (by using thin clients). Different programming tools are under development, which can support an off-line work of the educators.
- *Administrators* – their task is to support the system part of the DeLCN always in functional condition. They have mainly direct access to the Client Module of the DeLCN (by using thick clients) or, as an option, could use remote access through the Internet or University Intranet. There are a lot of tools for off-line work of administrators.
- *Staff (other employees)* – these users (e.g. personnel, student service officers etc) can access the eServices of the DeLCN indirectly by the integrated Back-End Systems.

5 Implementation Issues

The development of the first J2EE-based version of DeLC is in progress. J2EE [16, 17, 18] provides standard architecture for development, deployment and execution of applications in the distributed environment. Applications created on this platform use a set of standard services such as: threads, distributed resources, transaction management, security, client and database access. Moreover Java is an independent platform, which is a good reason to choose it for realization of DeLC Nodes. The client module of the system is implemented as an intelligent portal (based on the Cocoon framework [19, 20]), which can be easily integrated and adapted in the architecture of the DeLC Node.

6 Conclusion

Developing a Distributed eLearning Centers (DeLCs) that will offer in integrated way electronic services (eServices) available from geographically spread eLearning systems is a very complex, sophisticated and time-consuming process even though using the advantages of the IT developing tools. This paper aims to describe the functionality and the architecture of the DeLC nodes (DeLCNs), virtual structures within the DeLC network, and the DeLC network itself. A meta-model, subject models and architecture of a DeLCN are proposed and described. Finally, implementation issues concerning the development of the DeLC as a platform for the creation of distributed eLearning systems are also considered.

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