

# Development of an information system for organizing and managing the educational process based on smart technologies

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**Abstract.** This article discusses the concept of business processes that are widely used in the educational process - the structure of the learning process management system (SMART LMS) and the implementation of part of the system in SMART LMS. When developing an LMS information system, it is necessary to formulate the concepts and principles of the learning process management system. The LMS concept demonstrates the strategic solutions that need to be addressed in higher education. Through the principles of LMS, the concept of LMS is defined using modern educational technologies. Through SMART LMS, all business processes in higher education activities are carried out transparently and SMART LMS has become a decision-making tool. A single management system is formed through the principle of mutual integration of LMS integrated systems. According to this principle, additional and other management systems of the university information environment should be integrated with existing systems and mutual information exchange should be organized.

## 1 Introduction

It is a well-known fact that, nowadays, colossal attention is paid to the development of information systems for the management of the educational process in order to make extensive use of databases and communication networks. In a number of countries, including the United Kingdom, the United States, South Korea, Denmark, Sweden, Iceland, and Uzbekistan, the introduction of e-government has led to a systematic reform of public authorities, the business sector, especially the provision of various public services to citizens.

Around the world research on education management information systems, modeling, database design, and algorithm development are constantly being conducted. One of the important tasks, in this regard, is to create higher education institution management process information system Business Process Model and Notation (BPMN) methodology and

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Relational Algebra-based Entity-Relationship Diagrams (ERD) models, algorithms, and software based on SMART (Social, Mobile, Access, Regulated, Technology) technologies. At the same time, it is necessary to optimize the logical and physical models of data on the basis of E.Codd's theory, where 1,2,3-normal forms and to develop data description formats and information retrieval algorithms in distributed information resources.

In our country, special attention is paid to the formation of databases based on management information systems, corporate information systems and the creation of national content. The Action Strategy for the further development of the Republic of Uzbekistan for 2017-2021 sets the tasks "... the introduction and use of advanced information and communication technologies; the creation of effective mechanisms for the implementation of scientific and innovative achievements". Implementation of these tasks, creation of business process models of Learning Management Systems (LMS), formation of architecture, creation of textual and physical models of data in the form of ERD schemes based on IDEF methodology, classroom and object diagrams in distributed information systems and learning process management Development of information systems based on SMART technologies is one of the important issues.

This dissertation research to some extent contributes to the implementation of the tasks set out the implementation of the numerous laws and decrees including Laws of the Republic of Uzbekistan "On Digitalization" (2003), "On Electronic Document Management" (2004), "On Electronic Government" (2015), Decree of President of the Republic of Uzbekistan 2017 No. PF-4947 of February 7, 2017 "On the Action Strategy for the further development of the Republic of Uzbekistan", Decree No PF-5099 of 30 June, 2017 "On measures to radically improve the conditions for the development of information technology in the Republic", the Resolution No PP-2909 April 20, 2017 "On measures for further development of the higher education system" and other regulations related to this activity.

## **2 Materials and mehods**

I.A.Smolnikova, V.V.Leonteva, D.S.Kuznetsova conducted research on the creation and development of a model of integrated information systems of higher education through modern trends in the design of information systems. The theme of evaluation of information systems to optimize information flows in accordance with user requests to ensure the efficiency of the information system has also been explored in the theoretical research of such scientists as V.N.Burkov, D.A.Novikov, A.M.Anokhina and V.A.Glotova. Meanwhile, V.V.Aleskovskiy, A.V.Nesterov, N.V.Komleva, G.A.Pollak, S.L.Yeremina, P.N.Melnikov, S.V.Golovkova, A.V.Zavrajin, A.M.Karmanov, V.P.Tixomirov, N.V.Tixomirova, A.V.Shiryay, Yu.F.Telnov and A.A.Aletdinova have contributed into development of the SMART education. N.V.Dneprovskaya, E.A.Yankovskaya, and I.V.Shevtsova conducted research on such elements as smart-education, smart-university, smart-textbook, which are included in the concept of SMART education and SMART technologies in the learning process. Scientists such as Uskov, V.L., Bakken, J.P., Howlett, R.J., Jain, L.C., Vytautas Stuikeys, Burlea, A.S, Burdescu, D.D, Gerval, J.P. Yann Le Ru have developed the concept and technology of smart university. T. Bekmuradov, H. Igamberdiev, M. Aripov, R. Aloyev, D. Mukhamadiev, S. Gaynazarov, A.Nishanov, A.Saidov, M.Narzullaev have conducted scientific research on the development and implementation of models and algorithms of information systems in the country, data retrieval, and security.

Meanwhile, the research process based on the architecture of the information system management of the educational process of higher education, the creation of a relational model of the database and the development of software based on modern programming technologies is not sufficiently studied.

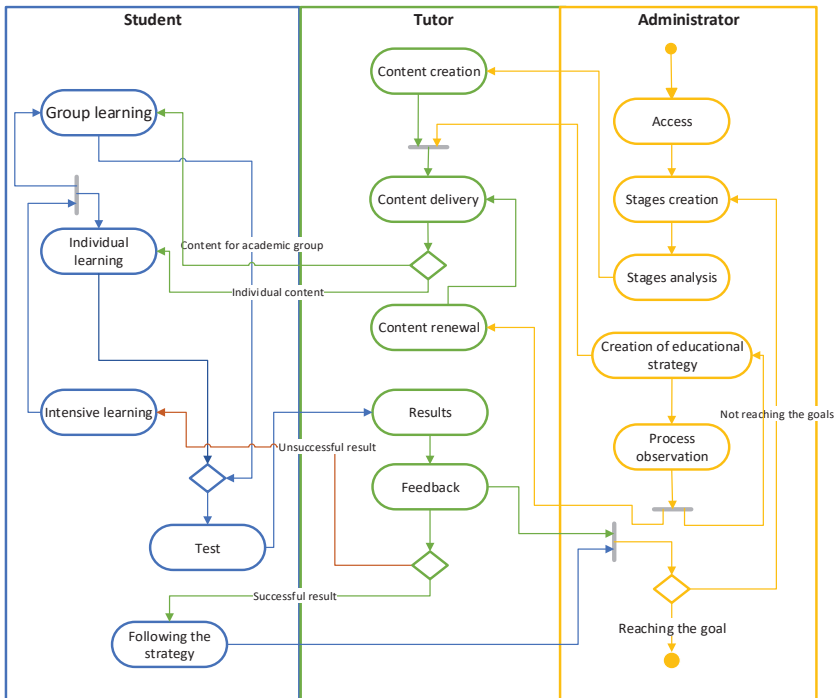
SMART LMS. Therefore, the analysis, design, modeling, development of algorithms and development of software based on MVC technologies of educational process management system based on SMART technologies are of great importance today. In order to develop an information system for the management of the educational process in higher education, it is necessary to perform the following tasks:

- development of functional business processes information system BPMN models and relational database model of information systems of higher education institutions;
- creation of ERD schemes of IDEF models based on the relational model of the information system database of higher education institutions;
- Development of appropriate tables, views, triggers, transactions, roles, users, functions in the SQL SERVER 2019 R2 database management system based on ERD schemes;
- C# in VS 2019 environment and creation of information system based on ASP.NET MVC 6.0 web technology;
- development of a security model of the role of the information system of higher education institutions in the database;
- development of the architecture of the information system of higher education institutions.

The results of the SMART LMS educational system organization and management information system models, algorithms and software packages developed by the authors have been introduced in a number of universities:

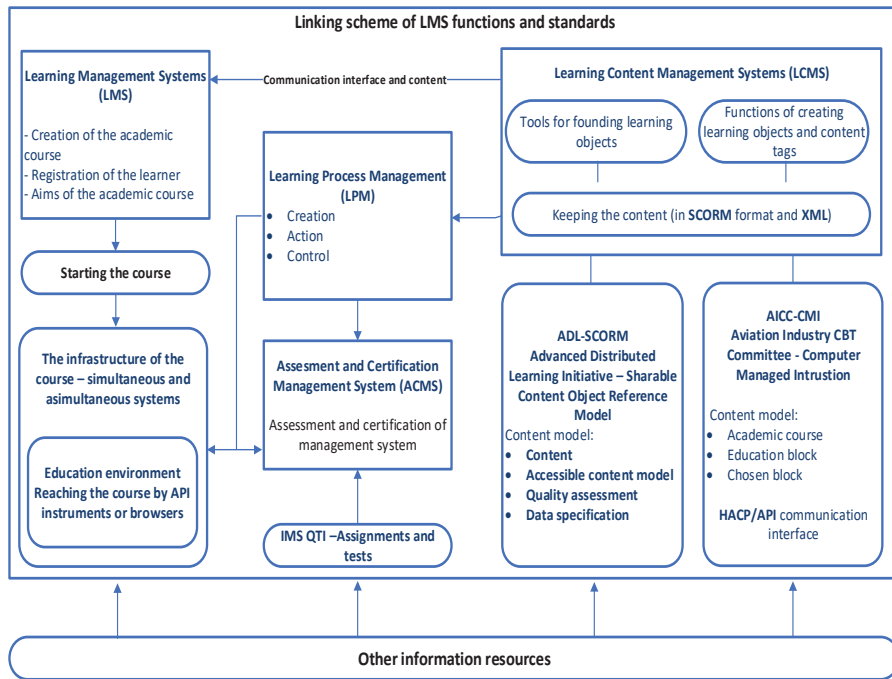
1. BPMN models of business processes in information systems, ERD schemes based on IDEF data methodology, tables, views, transactions, triggers, roles and user functions in SQL Server 2019 R2 database management system introduced in TAD INDUSTRIIS, Techno-soft LLC. Application of the results of scientific research allowed to increase the processing speed of queries in the database by 7%, the relational model of the information system and the method of business process modeling to increase the processing speed of transactions in the database by 10%;
2. Methods of protection of confidential data in the information system, the role of the information system in the database security model ALP CRYPTO, SMART SOFTWARE LLC application of research results development of database relational model and ERD schemes based on BPMN models the model allowed to ensure the security of the database and increase the processing speed of queries in the database by 7%;
3. SMART LMS information system, methods of protection of information in e-government databases Application of the results of scientific research applied to SUE "UNICON.UZ" Achieving high efficiency through the use and implementation of the information system "Education" in e-government as well as ensuring the confidentiality and integrity of data and increasing the speed of processing of transactions in the database by 10%;
4. Relational ERD model of educational process in academic lyceums and professional colleges was used in the development of business process models of e-learning environment in the practical project KA5-001 "Creation of e-learning environment in academic lyceums and vocational colleges". As a result of scientific research, the e-learning environment in academic lyceums and professional colleges has allowed to develop information systems and increase the speed of processing queries in the database by 7%.

SMART LMS BUSINESS PROCESSES, FUNCTIONS AND STANDARDS. Analyze existing LMSs and support generalized data exchange standards imposed on them; the ability to import e-learning resources of any content, complexity and size; availability of mechanisms to control the student's knowledge; availability of a single database for all teaching materials; the possibility of forming an individual lesson schedule and individual curriculum, which will be recorded in the calendar of educational activities; the ability to integrate into an external mail server or the availability of internal email; availability of general and relevant electronic forums; support for the rapid exchange of text messages; the existence of an adjusted mechanism of analytical reporting; the ability to control and monitor the learning process by the staff and professors who organize the learning process; requirements such as the ability to generate reports in the learning process [1,2].



**Fig. 1.** Business processes implemented in LMS

Support of electronic document management system in the learning process as a result of comparative analysis of LMS; use of user-generated training courses based on the international standard SCORM; control over student fees; to provide a number of services to ensure communication between tutors and students in the learning process (e-mail, forum, chat, virtual classroom board (in order to allow tutors and students to use different graphics schemes in the traditional learning process)); monitoring the activities of students and staff in the system through an electronic journal; ensuring a high level of security of the system (encryption of passwords and necessary information); providing a secure communication channel between users and the system; It should be noted that the university and its branches and departments have such achievements as the formation of a single information environment.



**Fig. 2.** Linking scheme of LMS functions and standards

Creating an LMS system is done in four stages. In the first stage of the analysis – a structural analysis of the organization is created. In this case, a functional and informative analysis of how the management system of the university is organized will be explored. It also identifies existing and potential needs for data. As a result of the analysis, in the first stage, a generalized logical model of the subject area of the LMS system is formed. The functional model is documented in the form of ‘As Is’.

In the second phase of the analysis, officials are involved by the HEI, and the deficiencies identified in the ‘how-to’ model created in the first phase are eliminated and node points are identified.

In the third stage of the analysis, an improved generalized logical model is created; a reorganized form of the existing subject area and its parts is created. As a result of this step, the “As to Be” model is created.

In the final fourth stage of the analysis, an “automation map” is created.

The LMS model presented may differ slightly from existing processes in some respects. The issue of creating a blend learning model based on educational technologies in the world's leading educational institutions, while maintaining the priorities of national education on the basis of the LMS system, will be considered.

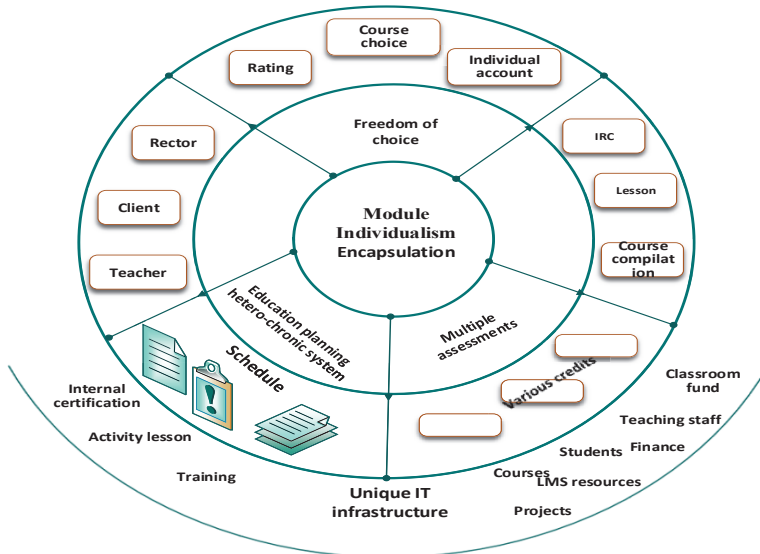
Also, the focus in the activities of the higher education institution is the educational process, so a model of information exchange with financial, scientific, economic business processes, other organizations and institutions associated with this process has been developed.

When developing an LMS information system, it is necessary to formulate the concepts and principles of the learning process management system. The LMS concept demonstrates

the strategic solutions that need to be addressed in higher education. Through the principles of LMS, the concept of LMS is defined using modern educational technologies.

### 3 Results

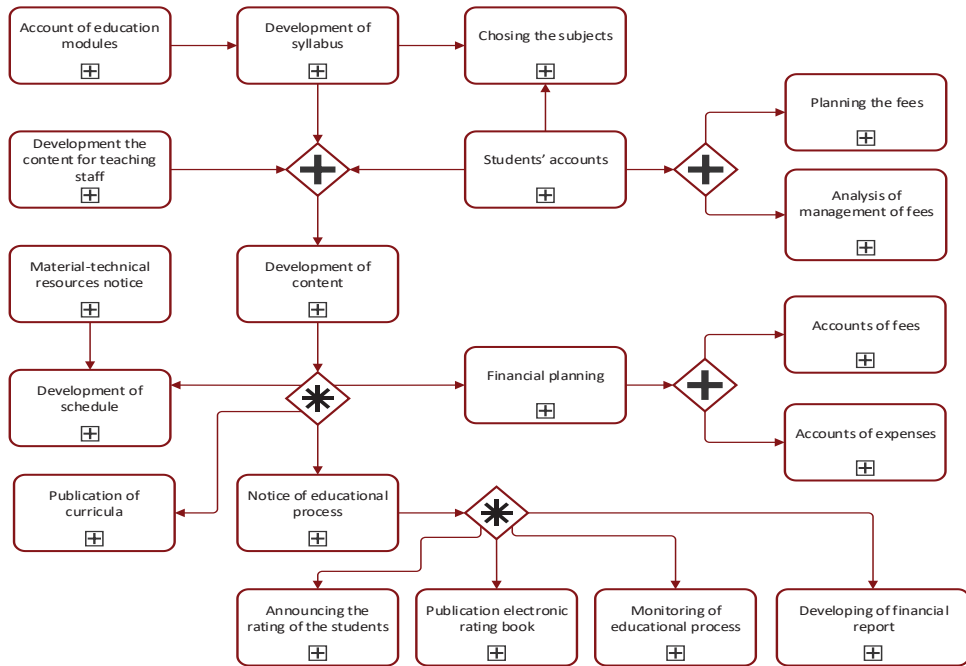
The organization of the learning process through LMS is based on three concepts: modularity, individuality, encapsulation (Figure 3)



**Fig. 3.** The concept of LMS

The next step is to analyze the SMART LMS architecture and business processes, present the SMART LMS architecture, explore the components of SMART LMS and its business processes, form BPM-schemes based on the BPMN methodology and list the functions, in the meantime, SMART LMS subsystems and their connection schemes are formed [3].

Through SMART LMS, all business processes in higher education activities are carried out transparently and SMART LMS has become a decision-making tool.



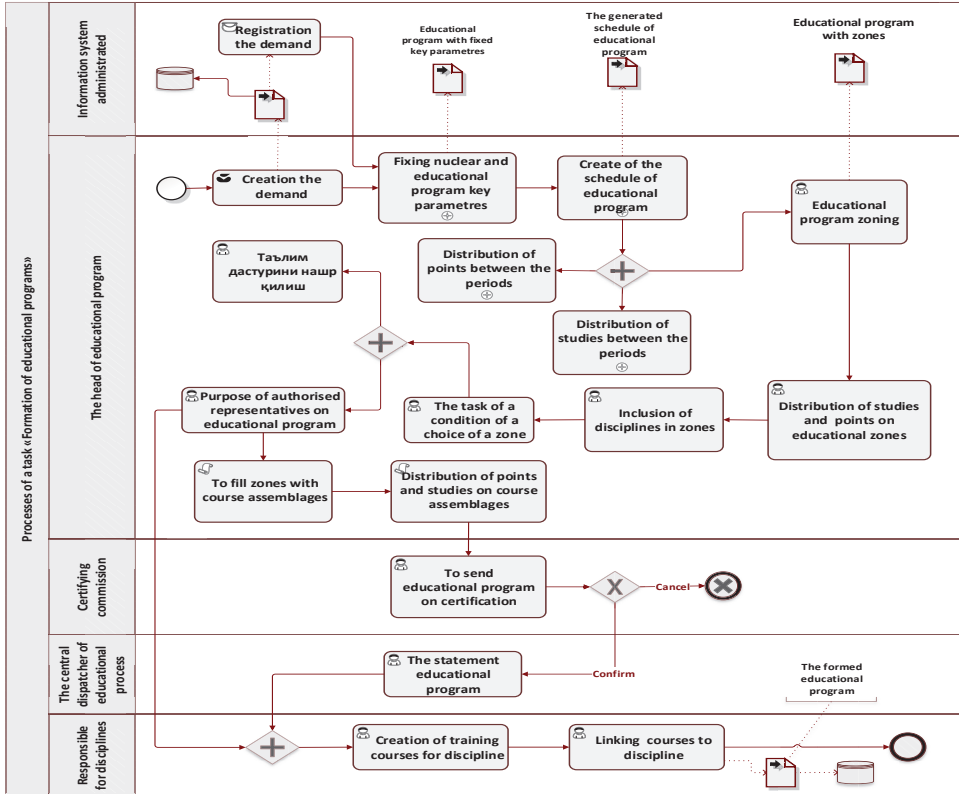
**Fig. 4.** Parts system structure in SMART LMS

A single management system is formed through the principle of mutual integration of LMS integrated systems. According to this principle, additional and other management systems of the university information environment should be integrated with existing systems and mutual information exchange should be organized.

The integrity of the unified information system of the university must not be compromised; copies of objects and processes must not be used. It is advisable to integrate the existing information systems in the university with LMS.

The university is divided into several independent tasks (part systems) that are integrated with each other to implement business processes in the LMS (Figure 4).

The LMS section “Curriculum Development” is modeled on the business processes in the system based on the BPMN methodology in the order shown in Figure 5 below:



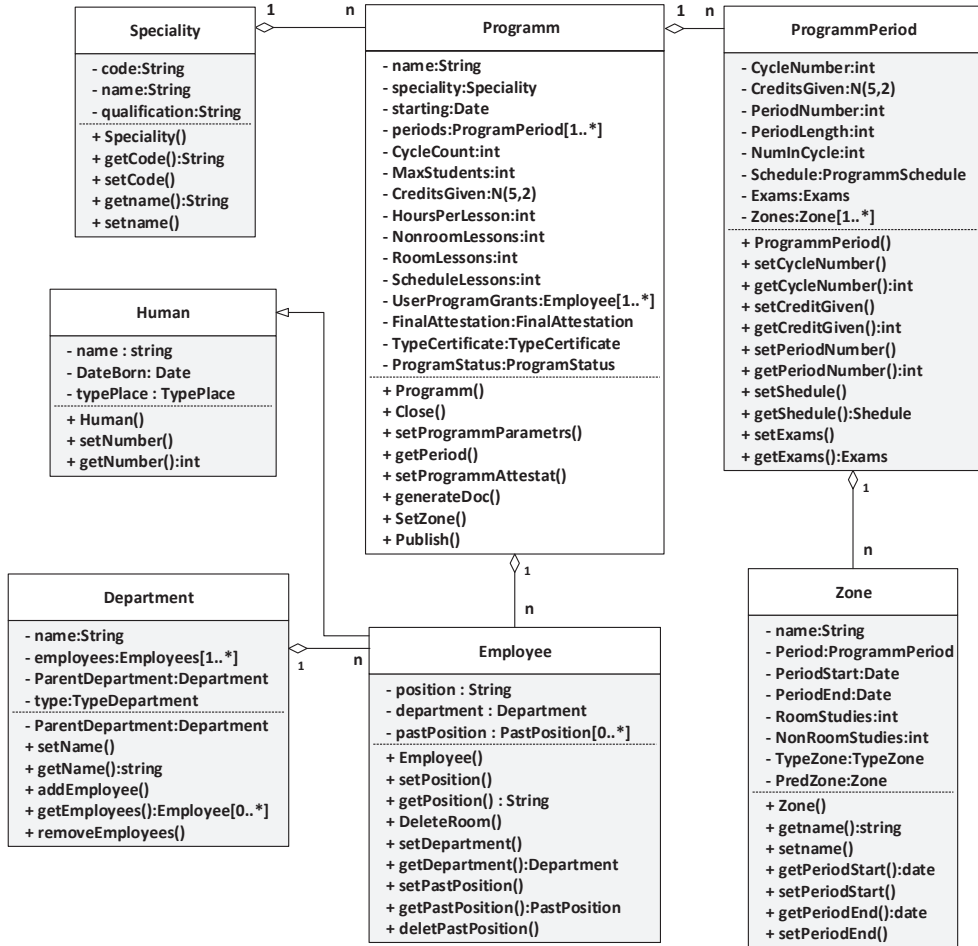
**Fig. 5.** Business processes of the “Curriculum Development” system

LMS objects are described by breaking them into logical blocks. A brief description and details of the objects in each logical block are provided. The UML methodology was used. The objects of the system are divided into the following logical blocks: “Curricula”, “Users”, “Training Courses”, “Clerical”, “Administrative Curriculum”, “Finance”, “Sciences”, “Students”, “Clients”, “Professors”, “Classes”, “Assignments”, “Virtual Folder”, “Chat”, and “Forum” [5].

We are to explore only the block “Educational programs” from the blocks of system objects.

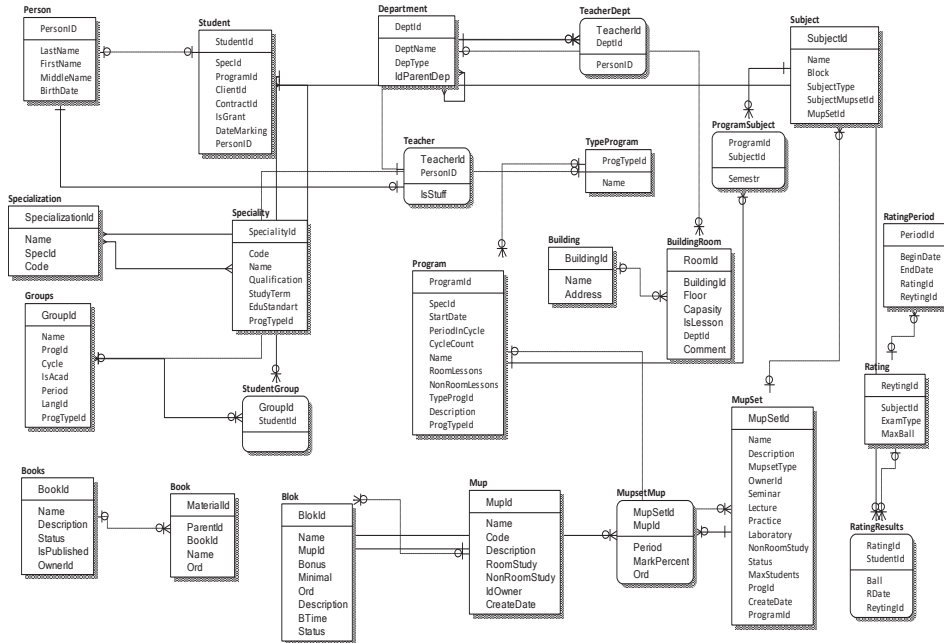
This block lists the main areas and methods of specialization, specialization, training program, training program cycles, zones, trustees, department, and employee facilities (Figure 6).





**Fig. 6.** Class diagram of the block “Educational programs”

In order to implement these business processes, the state educational standard of the educational process of higher education, curricula, areas of study and master's specialties, students, professors, academic disciplines, rating, rating schedule, the results of the rating, the diagram of the relational relationship between objects such as training materials, training modules are shown in Figure 7 below:



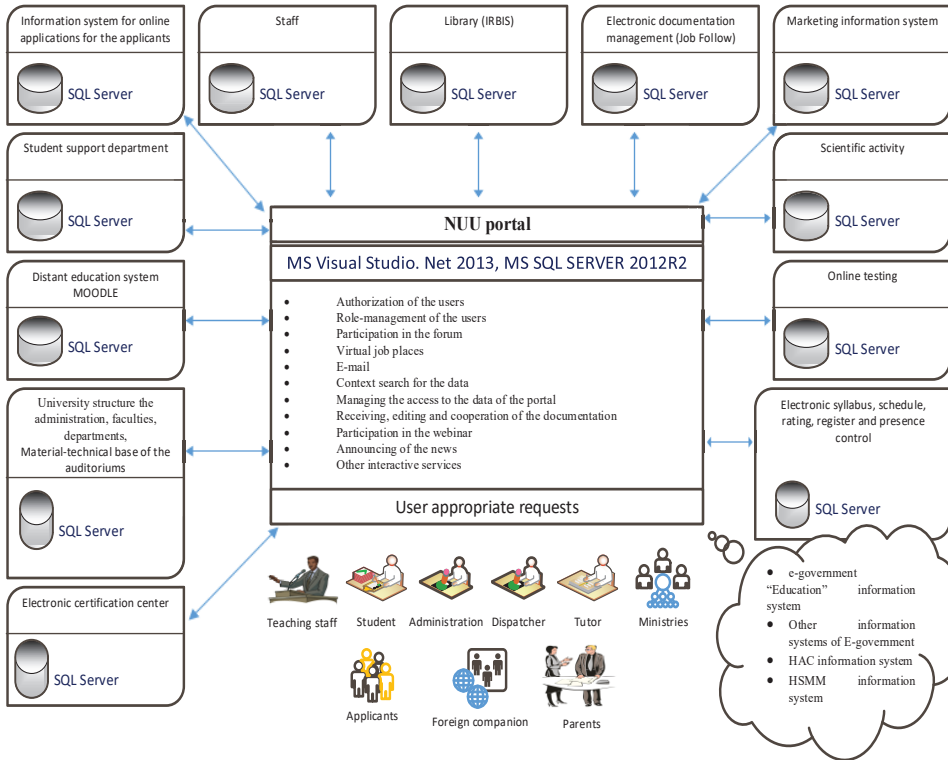
**Fig. 7.** LMS ERD scheme

This diagram, which consists of the main objects of the LMS, was created using CA Erwin Data Modeler 7.3 software in IE (Information Engineering) notation, which is one of the main methodologies for modeling information systems. The ERDs of all LMS objects are also fully developed through IE notation.

The LMS is designed as an integrated web application that allows users to access and use the institution's distributed information system to carry out their activities effectively. LMS On-line services provide educational services to citizens. These include online application for applicants, e-application, the procedure for admission to educational institutions and the provision of educational grants, online testing system for knowledge assessment, electronic lesson schedule, information for parents about their child's mastery and attendance. It also provides services such as information, student contract payment system, electronic library and electronic catalog system, course access system.

## 4 Discussion

Currently, work is underway to integrate the state portal with the university information system. That is, registered users of the Unified Identification System (ID.UZ) will be able to perform their functions at the university.



**Fig. 8.** University portal architecture

The following subsystems (services) have been developed to perform these functional tasks:

- Educational process organization services. These services create a system in which the learning process is carried out via the Internet; the preparation and publication of educational materials, communication between teacher and student, verification of knowledge acquired during the course.
- Information exchange services between users. These services provide the communication needed between students, faculty, and partners to discuss questions or issues that arise in the learning process, and to facilitate curriculum development with convenient tools.
- Centralized document storage, systematization, publication and access control services. These types of services are directed to keep the resources available to all users in a systematic and orderly manner.
- Personnel management services. Through these services, it is possible to manage the discipline of execution of orders decreed by employees. This leads to the implementation of decision monitoring, data routes, reporting in various forms, meetings (seminars, presentations) and webinars.
- Employee time planning services. These services are designed to effectively plan how to perform the assigned tasks. Users job creation and customization services. This service helps each user to create and configure simple and

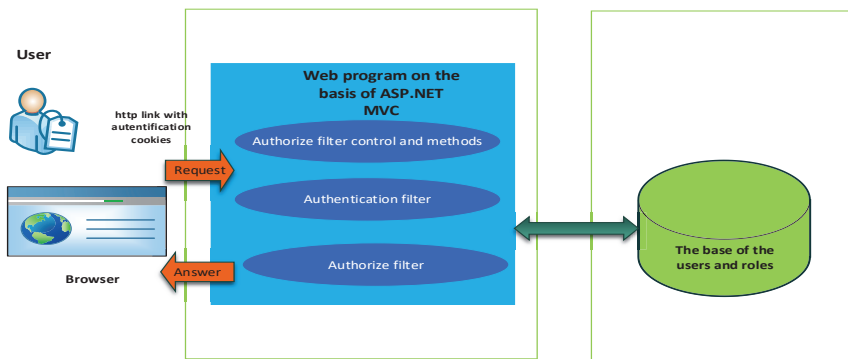
– convenient means of using only the resources of the information system that belong to them.

The university portal is formed in integration with the university LMS information system. The university portal has the above architecture.

Planning and implementation of the educational process in higher education provides users with higher education services through the LMS section system.

LMS users access the Internet or local area network using a web browser. In this case, to ensure security, it is necessary to ensure the confidentiality of traffic from the web browser to the web server, authenticate users, and ensure the authentication of the web server. SSL certificates are used to provide traffic protection and authenticate the web server. SSL certificates allow encrypted data exchange between the user's browser and the server. SSL certificates can be purchased from Registration Centers (VeriSign, Inc.; The Go Daddy Group, Inc.; Thawte...).

IDS / IPS systems use a firewall to filter incoming and outgoing traffic to detect and eliminate attacks from the Internet or other networks. The architecture for authentication, identification and authorization of LMS users is shown in Figure 9:



**Fig. 9.** Authentication, identification and authorization of LMS users

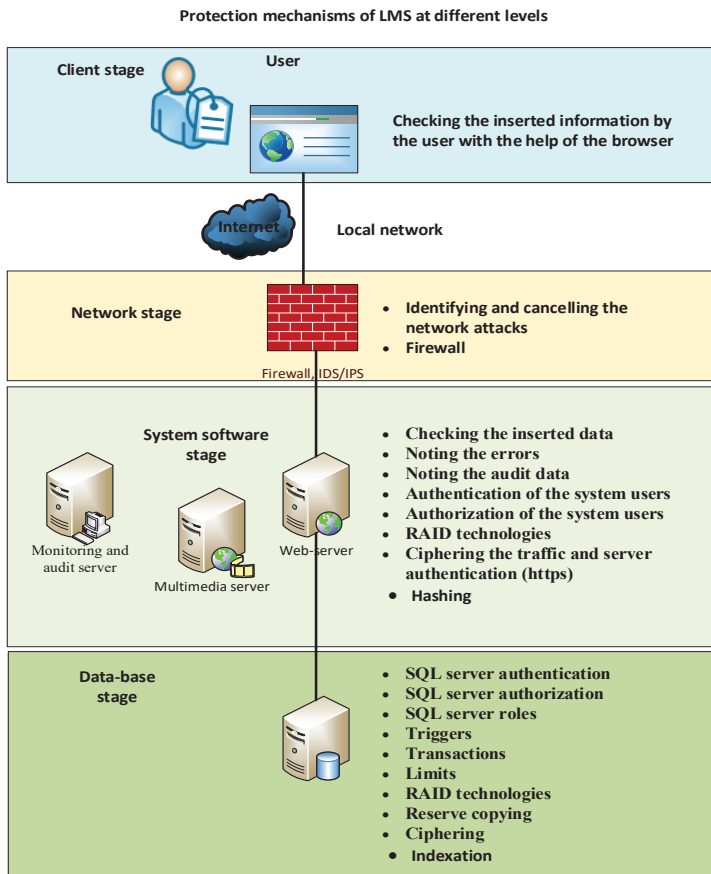
A role mechanism is used in the information system to ensure user authorization. There are a number of roles created in the program, and each role has certain rights.

**Table 1.** LMS role system

Roles/objects	Syllabus	Subject	Module	MTP	Timetable	Student	Staff	News	Users	Load
role_program_editor	o(r,w,d)	o(r,w,d)						r		
student	R	r	R	R	r			r		
department	R	r	R	o(r,w,d)	o(r,w,d)	o(r,w)		r		
Teacher	R	r	o(r,w,d)	o(r,w,d)		r		r		R
uquv	(r,w,d)	(r,w,d)	(r,w,d)	(r,w,d)	(r,w,d)	(r,w,d)	(r,w,d)	(r,w,d)		(r,w,d)
monitoring	R	r	R	R	r	r	R	r	r	R
kontingent						(r,w,		r	(r,	

						d)			w)	
role_mtr_ed itor					(r,w, d)			r		
staff							(r,w, d)	r		
role_news_ editor								(r,w, d)		
role_yukla ma								r		o(r,w, d)
role_djad_e ditor				R	(r,w, d)	r	R	r		R
role_admin								r	(r, w, d)	

Each user can be assigned multiple roles. In an information system, roles have the same rights as those listed in Table 1 in relation to system objects.



**Fig. 10.** Protection mechanisms of LMS at different levels

The protection mechanisms shown in Figure 10 above are used to ensure security in the information system web application layer [5,8].

## 5 Conclusion

The following objectives will be achieved as a result of the development and implementation of information systems for the organization and management of the educational process on the basis of SMART technologies in higher education:

1. The task of harmonizing the national education system with the educational process of developed foreign educational institutions has developed the architecture and software of the LMS information system based on SMART technologies, while preserving our national traditions.
2. Based on the description of BPMN methods and models, LMS business process models were created and optimized, and the LMS architecture was formed. The BPMN models of LMS business processes developed provide an opportunity to model other types of university activities and e-government information systems. LMS has enabled the implementation of traditional teaching methods electronically by creating online courses by providing the ability to manage the learning process.
3. Conceptual, textual and physical models of LMS structured data were developed in the form of ERD schemes based on the IDEF methodology. The structure of the LMS database was optimized on the basis of 1,2,3-normal forms of E.Codd. Based on ERD schemes, tables, views, transactions, triggers, roles, and user functions were developed in the SQL Server 2019 R2 database management system. Developed business processes and relational models allowed to increase the processing speed of queries in the database by 7%, increase the processing speed of transactions by 10%.
4. Data description formats and information retrieval algorithms have been developed in the LMS distributed information system, which makes it possible to form dynamic queries using logical expressions in data retrieval.
5. Classes and object diagrams in the LMS distributed information system, SSL certificates using role models, methods of data protection of the educational process based on data encryption and hashing have been developed. Application of the results of scientific research in UNICON.UZ SUE and SMART Software LLC allowed developing a relational model of the database and ERD schemes based on BPMN models, a model of information system protection to ensure database security.
6. SMART LMS information system in C # language in VS 2019 environment was created using SQL SERVER database and Entity Framework, MVC, HTML, JQUERY, AJAX web technologies. Based on SMART LMS module and algorithms, it allowed transferring non-confidential data to other information systems in real time in higher education.

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