Journal of Engineering and Applied Sciences 12 (18): 4702-4714, 2017
ISSN: 1816-949X

Design and Development of Automation System of Business Processes in Educational Activity

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Abstract: This study sets the creation of effective electronic document flow model and its introduction into an educational institution as its main objectives. Modern computing tools and document flow automation according to the rational organization of work are being used in the process. Methods of system, structural and functional analysis, comparison, analysis and synthesis, modeling and design were all used as the main methods. It is expected to develop a database to work with the proposed system in this study and organize the protection of personal data. To this purpose, we will use methods of relational algebra and block chain technology.

Key words: System analysis, functional analysis, comparison analysis, synthesis, modeling of business processes, electronic

INTRODUCTION

In the conditions of rapid progress of the market relations and competitive economy the timely and correct solution of strategic and tactical tasks determines viability of firm, organization. Documentary information constitutes as a basis of management; its efficiency substantially is based on production and consumption of information. In modern society information became a full-fledged resource of production an important element of social and political life of society. Quality of information determines the quality of management. In modern conditions paying sufficient attention to enhancement of work with documents is necessary as management decision is always based on information the carrier of which is the document on various bases.

Management of business processes is the essential task of the modern organization and solution of it reduces internal costs, improves quality of work and allows taking control of objective accomplishment processes to use the innovative capacity of the organization and to raise its competitiveness.

Business processes automation of handling documents guarantees efficiency in making strategic and tactical managerial decisions, provides improvement in service quality that significantly improves efficiency of organization activity (Booch *et al*., 2007). The subject chosen by us is of great current interest as it is known that the organization of work with documents influences not only on the quality the organization and the standard of work of managerial personnel but also on the culture of rendering services. Success of management activity in general is dependent on how documentation is professionally maintained. According to modern researches, 85% of organization's staff working hours are spent on preparation, maintenance, filling, copying and document transfer. According to ISO (International Standards Organization), management and work with documents becomes one of the main factors of competitiveness of any entity (Osterlund and Boland, 2009). It means special work with documents and data: coordination of creation processes, changes, distribution. Correctly organized administration reduces time necessary for search, increases the accuracy and timeliness of information and eliminates its redundancy. Growth of volumes of information and respectively documents has demanded introduction of new information technologies for timely processing of documents.

The main objective of this work is the creation of efficient model of electronic document flow and its implementation in educational institutions.

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Solution of the following tasks is crucial in achieving the objective of the research:

- Research of a concept of information technologies, types, specifics and methods of their implementation for the purpose of enhancement of university's document workflow
- Consideration of structure of the market of software products in the field of electronic documentation control
- Classification, comparison and characteristic of these products
- Development of the main criteria of the choice of an effective automated control of documentation system
- The problem resolution of educational institution, that is in demand of centralized work with documents by means of implementation of corporate electronic document flow
- Implementation of corporate system of electronic documentation control (corporate electronic document flow) within this educational institution

Object of work is the model of an educational institution within which process of implementation of electronic document flow is implemented. A subject of this work are the processes, work performed during the choice of an effective automated control of documentation system, development of model of educational institution and implementation in it this system. As the main methods, methods of the system and structurally functional analysis, comparison, the analysis and synthesis, modeling, design were applied.

Scientific novelty of work is in development of criteria of the choice of an effective automated system on the basis of generalization of the existing theoretical and practical materials. Taking into account practical activities within specific educational institution, the model of the electronic document flow which allows optimization of work with documents and respectively a management activity of educational institution are offered.

The most important elements of electronic document flow are its safety, archival storage of documents and the organization of work with the digital signature which provide effective functioning of corporate system of electronic document flow in educational institution (Gontarev *et al*., 2009).

The novelty of this study is that the developed model used first time to automate business processes in the field of education. The study (Abishov *et al*., 2014) considered the system of automation of the educational process but the business process is not formalized. This study attempts to summarize and detail-formals call of processes in educational activities.

The novelty of this study in the developed model, that was used for the first time to automate business processes in the field of education. In the study (Abishov *et al*., 2014), the researches consider the system of automation of the educational process but the business process is not formalized. Our study is an attempt to generalize and formalize the bussiness processes in the educational activity in detail.

MATERIALS AND METHODS

Problem definition: The task of development of new client server system to register students and undergraduates for courses instead of old system is set for the head of information system of university. The new system shall allow students and undergraduates to register on courses and to view of the progress from the personal computers connected to a local area network of university. Professors shall have access to on-line system to specify courses which they will give and to put down grades for courses to load materials for a study. The university isn't able to replace directly all existing system. For this reason, the database containing all information on courses (the directory of courses), students and undergraduates and teachers is used in the previous form. This database is supported by relational DBMS. The new system will work from the existing DB in an access mode without updating (Senchenko, 2011).

At the beginning of each semester students and undergraduates can request the catalog of courses containing the list of the courses offered in this semester. Information on each course has to include a name of professor, the name of department and the requirement to preliminary level of training (the taken courses). The new system has to allow students to choose the necessary quantity of courses in the forthcoming semester. In addition, each student can specify alternative courses if any of the courses chosen by him will turn out to be already filled or cancelled. No more than 15 and not < 7 students can sign up for each course (if <7 then the course is cancelled (conditionally)).

In each semester there is time period when students and undergraduates can change the individual curricula. At this time, students have to have access to system in order to add or remove the chosen courses. After process of registration of a student or an undergraduate is complete the system of registration sends information to settlement system so that the student could pay tuition fee for semester and form the individual plan of work for the current semester. If the course is filled during registration the student has to be informed on it before final formation of his personal curriculum. At the end of a semester students have to have access to system to view

of the electronic sheets of progress. Upon termination of training of students and undergraduates there must be an opportunity to form a transcript. As this information is confidential, system has to provide its protection against unauthorized access.

Professors have to have access to on-line system to specify courses which they will teach and to check the list of the students who have signed up for their courses. Besides, professors have to have an opportunity to put down grades for courses and to form sheets.

To ensure effective activities of modern organizations system of electronic control with documents shall meet the following requirements:

Scalability: The system shall support various number of users and its capability to increase capacity shall be determined only by capacity of the hardware on which it is established.

Distribution: The architecture shall support systems interaction of territorially distributed structural divisions of the organization. At the same time various communication channels can be used as means of communication.

Modularity: The EDFS system shall consist of the separate modules integrated among themselves that provides a possibility of step-by-step implementation of system.

Openness: The open architecture of system, first of all, allows expanding platform of management of documents in response to emergence of new business objectives quickly. Secondly, it helps to integrate system with other application programs which are used in the organization. Thirdly, it gives opportunity to integrate control of documents with wider strategic initiatives such as control of knowledge. The system shall have public interfaces for possible finishing and integration.

Reliability: The system shall possess technical and the software tooling to ensure reliable and smooth functioning of system in case of different types of failures.

Security: Control flexibility of access to all range of documents from e-Mail to debatable databases from video clips to formalized documents of all types.

Accessibility: Possibilities to support the access to documents through web browsers, desktop applications and other generally available types of clients. Support of different categories of users (local, remote, mobile).

Support of standards: Support of standards at different stages of life cycle of the electronic document. Complex functionality (support of complete lifecycle of work with documents).

Automatic support of the distributed management of various information materials (documents) for all their lifecycle from creation before reviewing, statement, distribution and an archiving. Providing complete lifecycle of work with documents includes automation of work with images of documents, management of records and flows of works, content management and so on (Krivenko *et al*., 2008).

Thus, now most of the organizations try to implement such program systems which provide not only means of forming of electronic affairs and control of versions but also have a wide range of possibilities on distribution of documents and information within all the organization. Control tools and knowledge based on web technologies provide support of the document of the oriented business processes.

The companies which as a technological basis use or relational databases (Oracle, MS SQL-"Case" and Lan Docs), either the MS Exchange folders (Optima Workflow) or storage of information of own development ("1C: Document flow") have problems in ensuring joint operation over documents in territorially distributed corporate environment.

Classes of business processes management systems: If all the information systems that provide automation and management of business processes are divided into three classes the following picture will be obtained:

- Document management systems-automate the movement of documentation
- Resource management systems-automate resource management
- CASE-tools-automate the modeling and creation of processes

The interaction of three classes of business process management systems is shown in Fig. 1. The business process management system is take place at the junction of these three classes of enterprise software. ECM includes two key tools needed to build an information system:

- BPM-business process management
- IDM-integrated document management

In order to understand what kind of tasks these systems solve, let's see what modules they consist of the main modules of the business process management system are.

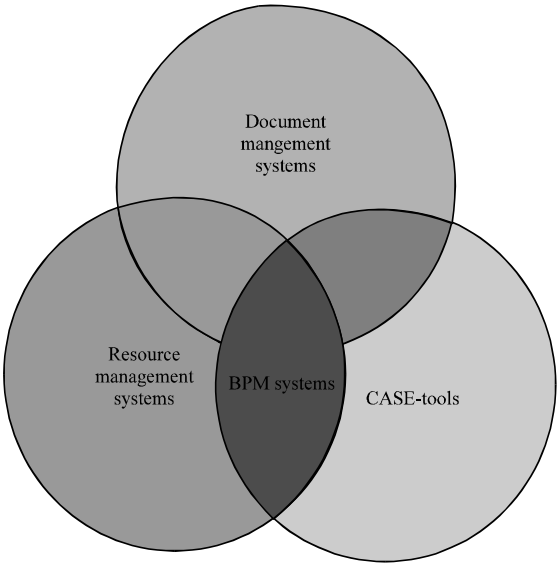


Fig. 1: Three classes of business process management systems

Module of graphic modeling: The module allows the analyst to present the process in terms of workflow, business rules and information flow.

Dynamic modeling module: The module allows you to understand the problem areas in the modeling process.

Application development module: The module provides the developer with the necessary tools for creating a user interface, various dialog forms and integration with business applications and information systems (Bobovic, 2013).

Process interface module: This module helps to view the tasks and perform them.

BPM system management module: The module allows you to configure the software, assign access rights and control hardware. Modern ECM as a rule includes the following modules: module for managing documents or records. The module provides storage of documents, document cards, versioning, delineation of access rights, keeping the history of work with the document.

Flow control module: The module provides partial management of business processes, allows you to transfer documents and other content through pre-designed routes, assign work tasks and create workflow progress logs.

Web content management module: The module provides the most current information, a single working environment, access to information and a common security policy.

Module for managing media content: The module operates with data in electronic form as assets in order to extract the maximum profit from them.

Module of managing the collective interaction: The module allows to establish interaction between users in the preparation and use of documents. After getting acquainted with the BPM and ECM-systems modules, it may feel that the business process management system is only a component of the ECM-system but it is not. About 20% of the data in the organization are structured while the remaining 80% has an unstructured content.

In order to manage the content of the organization, it is necessary to manage processes smoothly which in turn is impossible without content. As a rule in organizations that have chosen ECM as the basis, serious processes cannot be performed without the formation of documents.

In practice, the interaction of electronic document management systems and business process management is often not equivalent, one of the systems is dominant and plays a primary role and the other is secondary. This is because the customer has different requirements for automation and wants to achieve different goals as a result (Jeston and Nelis, 2008).

In the same case, if an organization needs to manage a whole network of end-to-end business processes, first of all it will be expedient to implement a business process management system, the functionality of which will be able to simulate, automate, monitor, analyze and improve the business processes of the enterprise. Within the framework of the BPM-system, business processes will be defined and implemented within these business a work flow will be formed a stream of documents will be generated in parallel which is convenient to manage in the ECM-system.

The real benefits from the implementation of the ECM-system will be only when it will be possible to build its interaction with the main processes of the organizations, i.e., integrate unstructured information into processes. And BPM is the link between the ECM system and other corporate information systems of organizations. BPM is what allows the document management system to become a management system for information resources and to write them into the business processes of the organization.

RESULTS

Mathematical model of the system: According to the analysis, the mathematical model of EDFS (Electronic document flow system) was built and were developed its assessment methods according to various criteria.

Determination 1: Electronic document d_i is called the pair: $d_i = <C_i+M>_i$ where C is $_i$a document structure in accordance with the selected data pattern; M_i document content.

Determination 2: Collection is the multiplicity of electronic documents with a dedicated fixed structure the content of which has the same the matic focus.

To unify the operations of electronic documents let us consider EDFS as a set of collections. We distinguish two types of metadata: descriptive (semantic content) and structural (structure and properties of documents by which carried out their processing). Determination of structure of the electronic document gives the first prerequisites to the construction of the EDFS architecture (Fig. 2).

To optimize the architecture of the EDFS we have solved the problem of optimizing the document flow of the EDFS. When selecting composite criteria the four variants of solutions were considered:

- Maximizing the total speed of EDFS
- Minimizing the cost of transfer of documents between the structural elements via the communication channels of the system
- Minimizing the costs of adjustment and upgrade of electronic document
- Minimization of the documents volume stored in the EDFS

While setting objectives to optimize document flow, the analysis of the possible optimization criteria was conducted, this showed that the document flow optimization can only be achieved by selecting a complex criterion:

$$P_{opt} = P_{xp} + P_{ninf} + P_n \quad (1)$$

Where:

P_{xp} = Cost of data storage
P_{ninf} = Cost for obtaining data from external systems
P_{npol} = Cost for obtaining data from EDFS storage

The following optimization objects have been identified to set the optimization problem:

- Time spend to obtain the required electronic document
- The cost of transmission of electronic documents between users, EDEFS storages, other information system
- Volumes of the electronic documents stored in EDFS

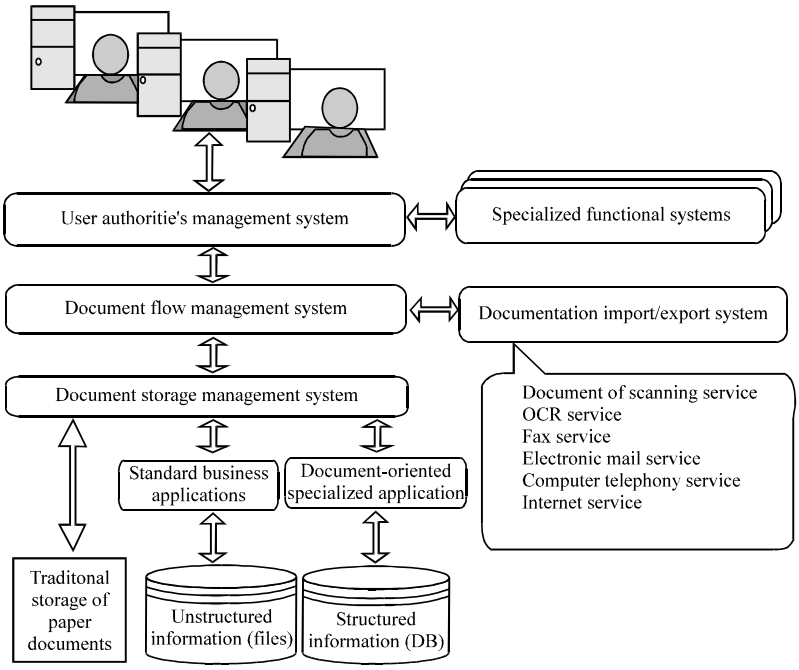


Fig. 2: EDFS architecture

- Cost for update the electronic document

Consideration of these objects helped to formulate the optimization problem as follows:

$$\sum_{i=1}^{N}\sum_{j=1}^{ni} p_i^{xp} x_{ij}\left(\sum_{k=1}^{n'_{ij}} met_{ijk} v'_{ijk} + \sum_{k=1}^{n''_{ij}} con_{ijk} v''_{ijk}\right) + \sum_{i=1}^{N}\frac{1}{Q_i}\sum_{j=1}^{n_i} p_i^{nxp} t_{ij}\eta_{ij}x_{ij} + \frac{1}{Q'_i}\sum_{a=1}^{N}\left(\sum_{j=1}^{m_i} p_i^{npol} t_{ij}\eta'_{ij} y_{ij}(1-x_{aj})\right) \rightarrow \min \quad (2)$$

$$\sum_{i=1}^{N}\sum_{j=1}^{n_i} x_{ij}\left(\sum_{k=1}^{n'_{ij}} met_{ijk} v'_{ijk} + \sum_{k=1}^{n''_{ij}} con_{ijk} v''_{ijk}\right) \quad (3)$$

$$\frac{1}{Q_i}\sum_{j=1}^{n_i} t_{ij}\eta_{ij}x_{ij} \le T_i \quad (4)$$

$$\frac{1}{Q'_i}\sum_{j=1}^{m_i} \tau_{ij}\eta'_{ij}x_{ij} \le T'_i \quad (5)$$

$$\sum_{i=1}^{N} x_{ij} = r_j \quad (6)$$

Where:

H_i = ith storage of SEDF
I_i = ith information system
p_i^{xp} = W^{xp}_i/V^{xp}_i cost of the information units storage in H_i
W^{xp}_i = Cost of H_i
V^{xp}_i = Volume of H_i
P^{nxp}_i = Cost of the transmission of an information unit from H_i
P^{ninf}_i = Cost of receiving of an information unit from I_i
X = $\{x_{ij}; i = 1, n; j = 1, n_N\}$
Y = $\{y_{ij}; i = 1, m; j = 1, m_M\}$
n_i = Number of electronic documents in H_i
N = Number of EDFS storages

$$x_{ij} = \begin{cases} 1, d_j \in H_i \\ 0, d_j \notin H_i \end{cases} \qquad y_{ij} = \begin{cases} 1, d_j \in I_i \\ 0, d_j \notin I_i \end{cases}$$

$$con_{ijk} = \begin{cases} 1, C_j^k \in H_i \\ 0, C_j^k \notin H_i \end{cases} \quad met_{ijk} = \begin{cases} 1, M_j^k \in H_i \\ 0, M_j^k \notin H_i \end{cases}$$

Where:

O_i = The amount of memory available for placement the electronic documents in H_i
M_j^k = kth metadata of d_j
C^k_j = kth content of d_j
v'_{ijk} = Volume of M_j^k electronic document d_j in H_i
v''_{ijk} = Volume of C_j^k electronic document d_j in H_i
n'_{ij} = Number of metadata d_j in H_i
n''_{ij} = Number of collection components which represent the contents d_j in H_i
n_{ij} = Addressing frequency to d_j in H_i per unit of time
R_i = Bandwidth of communication channel
m_i = Total number of documents in I_i
M = Number of information systems
T'_i = The maximum admissible waiting time of electronic document from I_i
Q'_i = Request frequency to I_i
η'_{ij} = Addressing frequency to d_j in I_i per unit of time
τ_{ij} = v_{ij}/R'_i time demanded on transfer of d_j from I_i
R'_i = Average bandwidth capacity of a compound communication channel on which d_j transferred from I_i

As a set of the variables of the task we choose: matrixes $X = \{x_{ij}; I = 1, n; j = 1, n_N\}$ and $Y = \{y_{ij}; i = 1, m; j = 1, m_M\}$ together with the electronic documents volumes v_i determined by elements of these matrixes also R_i bandwidth of transmission channels between the user and the data storages of SDEF or information systems where the selected documents contain.

To solve the optimization problem it is necessary to find such coefficients of the Eq. 2 at which value of $f(x_{ij}, y_{ij}, R_i)$ becomes minimum for this set of values of matrixes of X and Y at restrictions of memory size and receiving time of electronic documents, set by expressions Eq. 3-6. One of key components of the receiving cost of electronic documents from EDFS is the cost of storage or search of the information.

Database of the system: Corporate Database (DB) is created, maintained and operated under the control of the database server Microsoft SQL Server.

In this study we will look at the development and management of a database using Microsoft SQL Server. Will discuss the strategy of access and retrieval of data, changing data with the instructions; table types and declarative data integrity; complex queries, programming in Microsoft SQL Server in a language T-SQL custom stored procedures, functions, triggers and views; methods to improve query performance, expansion of Microsoft SQL Server functionality. The main database objects are: tables, indexes, views, stored procedures and functions, triggers, etc. During the creation of database, examples of data manipulation statements with database triggers, stored procedures, etc. will be described.

In the study (Duysebekova *et al*., 2016), there were used an algorithm of accessing the data using developed algorithm (Fig. 3a and b). After that "Atmosphere Monitoring" software was created. The program opens by running the executable file IZA.exe.

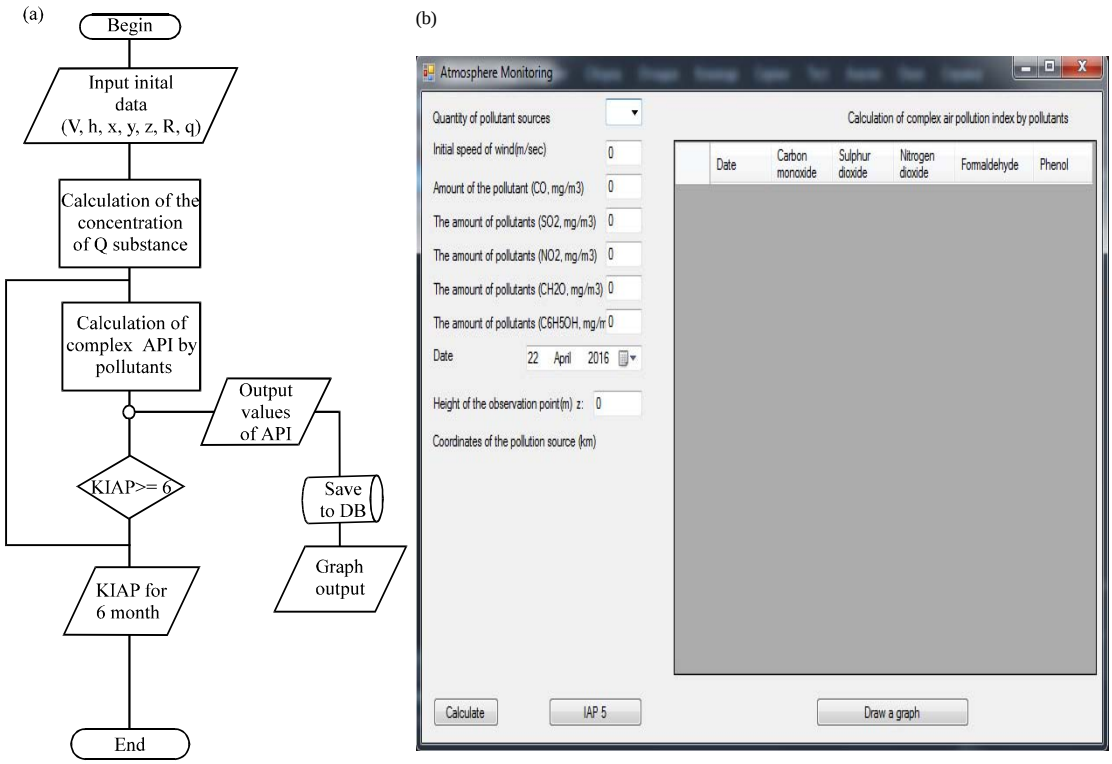


Fig. 3: a) The algorithm of the system and b) Main window of the program

The necessary initial data will be added after the program launched: the amount of pollution sources, the initial wind speed, date, measurements of pollutants, the coordinates of the source of pollution, the height of the observation point. After that one can calculate the air pollution index for each type of pollutant and see a graph of that calculation.

Based on algorithm the "Atmosphere monitoring" has been implemented as a software to develop this program we used C Sharp (C#) programming language on visual studio-windows form application for the database we took SQL Server.

The corporate database for this study also based on SQL Server. Also it is supposed that the we will use the OLAP for processing large amount of data and for optimal formation of aggregated indicators we will use the methods presented in study (Uskenbayeva *et al*., 2014, 2013).

Practical implementation on the basis of "detrix" EDFS: To solve the given tasks, the "Detrix" EDFS was chosen by means of a comparative analysis. "Detrix" is a web-based application that allows you to automate the workflow of any company in a short period of time. Fast automation of workflow is possible due to the unique capability of the system the design of any types of documents. EDFS "Detrix" is the first Kazakhstan system which is distributed completely free of charge with open source codes.

The electronic document management system for graduates, built on the basis of Detrix is a typical solution to automate the creation and processing of documentation. The work of all users of the system is carried out through a web browser. Access to the system is provided only to authorized users with different access rights. The users of the system are all employees and graduates participating in the processes of working with documents in accordance with the role assigned to them in the business process (researcher of the document, coordinator, reviewer, supervisor, administrator). When working with different documents or passing through different processes, users can be assigned different roles. All users in the system can be grouped according to a customized organizational structure. The structure in the "Detrix" EDFS is shown in Fig. 4.

Authentication and registration: The system does not have its own user registration to prevent unauthorized access. The login page is shown in Fig. 5. Registration of users is quite complicated due to the input of user data into 4 directories.

Fig. 4: Structure

Fig. 5: Login page

System directories: In addition to the available directories in the "Detrix" system there are other directories:

- Basic disciplines (compulsory)
- Basic disciplines (component of choice)
- Profiling disciplines (component of choice)

- Profiling disciplines (compulsory)
- Chairs
- Specialties

An example of the created directory is shown in Fig. 6.

Formation of the individual plan of master student: To automate the process of approving an individual plan of Master student a new type of document has been developed. The process of creating an individual plan in the Detrix system is shown in Fig. 7 and 8. Further, the movement of the created individual plan passes, according to the described business process. After the completion of the business process, you will be able to send the document for printing. The result of the business process is shown in Fig. 9-10 and Table 1.

Fig. 6: Directory-basic disciplines (compulsory)

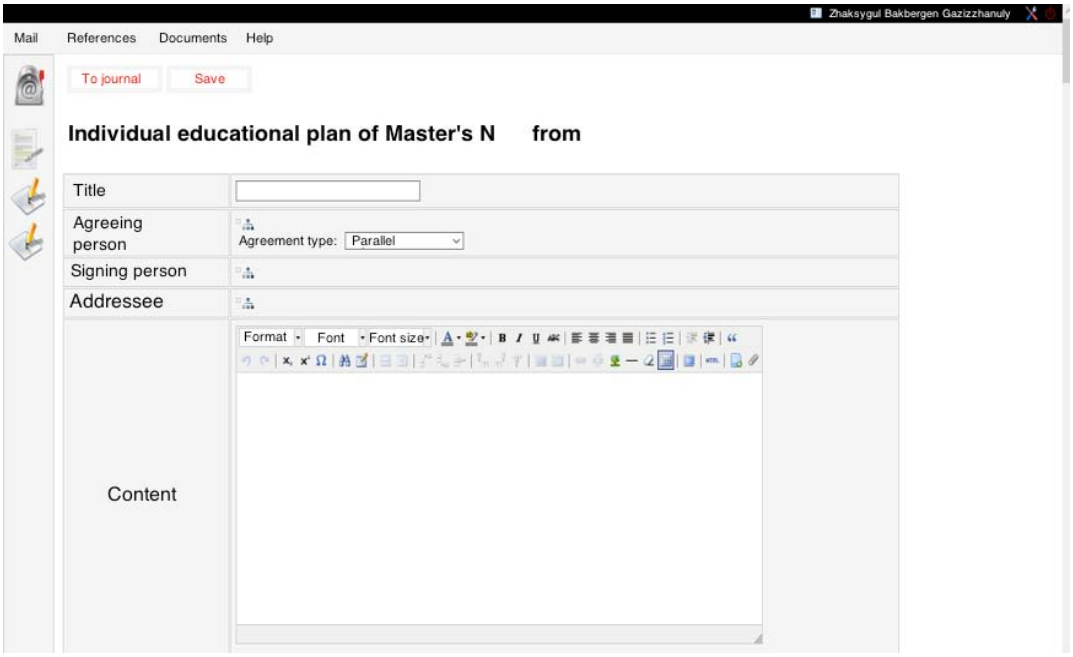
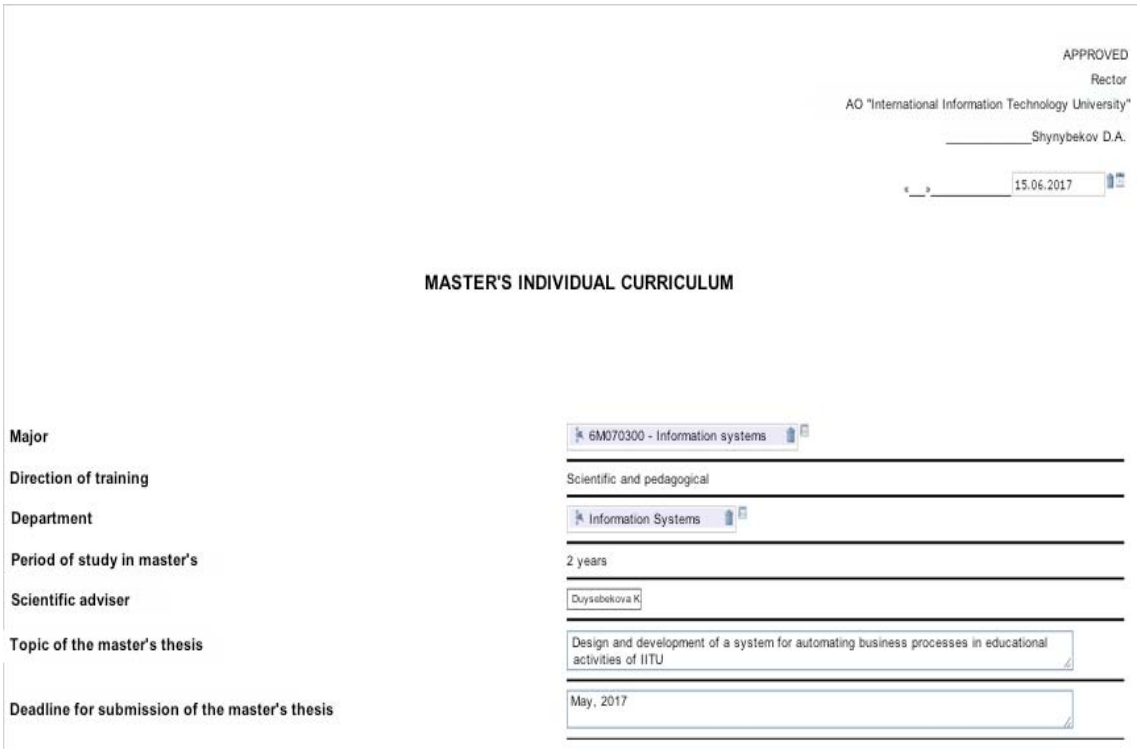


Fig. 7: Step 1 (Detrix system)



APPROVED
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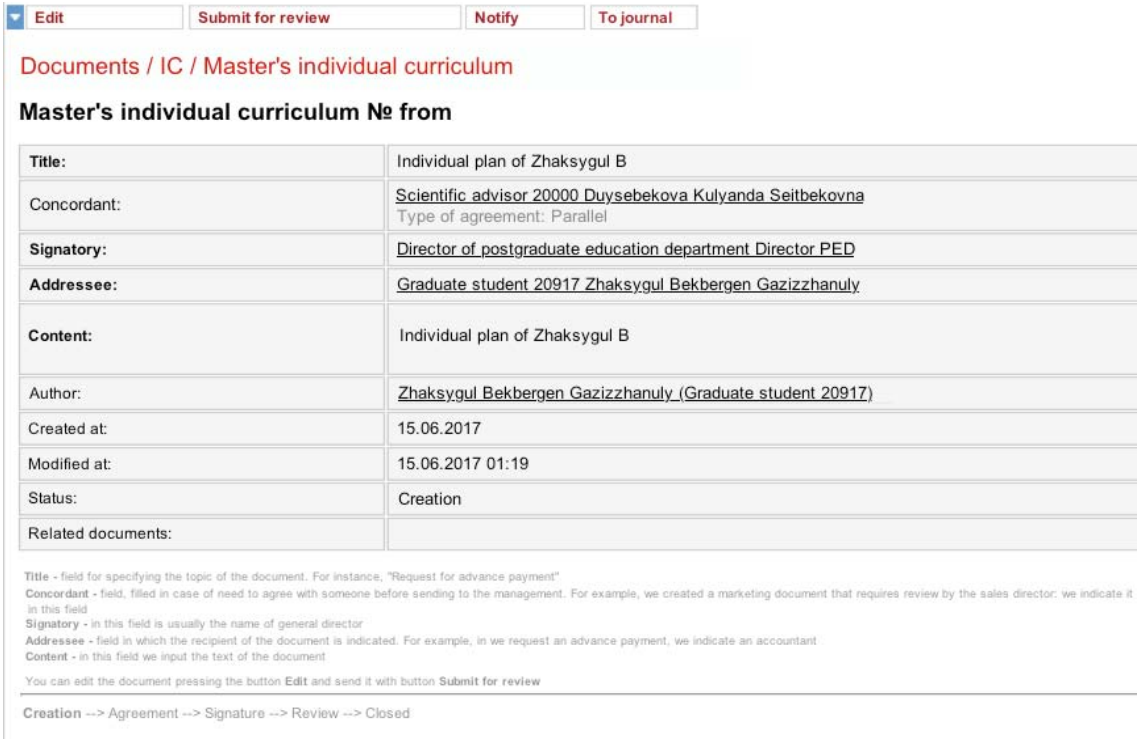
«__»_____ 15.06.2017

MASTER'S INDIVIDUAL CURRICULUM

Major	6M070300 - Information systems
Direction of training	Scientific and pedagogical
Department	Information Systems
Period of study in master's	2 years
Scientific adviser	Duysebekova K
Topic of the master's thesis	Design and development of a system for automating business processes in educational activities of IITU
Deadline for submission of the master's thesis	May, 2017

Fig. 8: Step 2 (Detrix system)



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Documents / IC / Master's individual curriculum

Master's individual curriculum № from

Title:	Individual plan of Zhaksygul B
Concordant:	Scientific advisor 20000 Duysebekova Kulyanda Seitbekovna Type of agreement: Parallel
Signatory:	Director of postgraduate education department Director PED
Addressee:	Graduate student 20917 Zhaksygul Bekbergen Gazizzhanuly
Content:	Individual plan of Zhaksygul B
Author:	Zhaksygul Bekbergen Gazizzhanuly (Graduate student 20917)
Created at:	15.06.2017
Modified at:	15.06.2017 01:19
Status:	Creation
Related documents:	

Title - field for specifying the topic of the document. For instance, "Request for advance payment"
Concordant - field, filled in case of need to agree with someone before sending to the management. For example, we created a marketing document that requires review by the sales director: we indicate it in this field
Signatory - in this field is usually the name of general director
Addressee - field in which the recipient of the document is indicated. For example, in we request an advance payment, we indicate an accountant
Content - in this field we input the text of the document

You can edit the document pressing the button **Edit** and send it with button **Submit for review**

Creation --> Agreement --> Signature --> Review --> Closed

Fig. 9: Step 3 (Results of business process)

Table 1: Step 3 continue individual curriculum

Course codes	Course name	Semester	Total credits	Classroom h	MIWT h	MIW h	Final room control
Basic Courses (BC)-total credits							
Mandatory component							
IFN 5201	History of philosophy of science	1	2	30	30	90	Exam
PED 5204	Pedagogy	1	2	30	30	90	Exam
PSI 5203	Psychology	1	2	30	30	90	Exam
IYA 5202	Foreign language	1	2	30	30	90	Exam
Elective							
IYA 5208	Foreign language	2	2	30	30	90	Exam
MLF 5303	Fundamentals of machine learning methods	1	3	45	45	135	Exam
SRO 5210	Organization of scientific researchers	2	2	30	30	90	Exam
ADA 5205	Models and methods of data organization	1	2	30	30	90	Exam
AMS 5206	Application of Mathematices and statistics to IT	1	3	45	45	135	Exam
Profiling courses (BC)-total credits							
Mandatory component							

DISCUSSION

We have developed an automation model of business processes in the educational activities but this model is universal. It can be used in other areas, like robotics (Kuandykov *et al*., 2013; Uskenbayeva *et al*., 2014; Cho *et al*., 2014) with only a change in the input data, stored in the data warehouse without adding changes to the model itself. Also for the first time to protect the personal data there will be used blokchain technology (Collins, 2016).

CONCLUSION

The architecture of a common corporate system of electronic control of documents includes:

- System kernel
- Set of the functional subsystems

During implementation by services the architecture of all decision acquired the following structure: at the bottom level there are general-system data: information on users of all systems (LDAP, Lightweight Directory Access Protocol), MS (AD and other), also at this level happens authorization and authentication of users and access to the general reference manuals of an information system is also organized; over the general data there are applications creating business logic. These applications work independently from each other as general information is stored at the bottom level available to all applications; interfaces of all systems come down in the common portal and are represented in the common interface of the user; the user gets access to all systems through a web browser that provides uniform authorization and habitualness of interfaces.

We chose such method because the similar architecture of an information system allows us to increase services in a short time to use different systems without concern of problems of incompatibility to carry out the small stages closing private tasks. Benefits, certainly were obvious: in case of addition of new service there was no need to change the business processes which are already realized in the software as addition of set of services is implemented in the form of the sequence of small stages as a result we receive the finished decision. Thanks to it if we had a need to postpone work for later period or to refuse further work, the system remained with the same set of functionality which allowed to solve specific objectives; during implementation and in subsequent we used the web interface which allowed to envelop all organization without performing works on setup of client places.

The opportunities provided by modern electronic document management systems were studied as a result of the work. Was developed the EDFS for the post-graduate education department taking into account the requirements that were set to the system. EDFS consists of two parts: the general and the user which are implemented as applications in the MS Access Database. From the general part, you can create a user part of the EDFS and edit the general data. Using the user part of the EDFS, you can receive documents from other users and send your own, through the connection to the common part.

During the research we examined what constitutes collective methods of recognition as well as the approaches that are used in the formation of collectives. Algorithms of recognition of handwritten text (letter patterns) as well as algorithms for learning neural networks for pattern recognition were considered. A program was developed in Visual Studio in C# which uses three different algorithms for recognizing letters:

- Comparison with the standard
- MLP Neural Network
- Ensemble of neural networks

As a result of testing, it was found that the best way to recognize handwritten letters is a comparison algorithm with a standard using a combination of two or more methods:

- Distance to the center (the normalized distance)
- Number of points in the sector (density of points)
- Proportion
- Number of loops

In addition for the test case, the best result was obtained using a grating passing through the center of the letter. The algorithm of using ensembles of neural networks was completely incapable of recognizing handwritten letters or a correct approach to using this algorithm was not found.

The algorithm of the neural network MLP showed a very good result in the process of recognition of handwritten letters. In this case, the algorithm is affected by the number of characters in the learning as well as the similarity of the training set and the test sample.

By results of testing we see that when recognizing handwritten letters using collective methods it is possible to achieve very good results but it is necessary to further test the system on different models of handwriting as well as with different types of documents.

At the moment, the field of research tasks related to the methods of combining classifiers is interesting for researchers and there are quite a lot of convincing results in it. In this field in recent years, many different strategies and methods have emerged to combine classifier solutions and ensemble building.

Since, the idea of combining the solutions of several classifiers has been proposed, fundamental results have been obtained. The main one is that "instead of searching for the best feature space and the best classifier, the task is to search for the best ensemble of classifiers and then search for the most optimal method of integration.

One can make the assumption that in the future the problem of finding the best set of methods of association and the optimal way of their joint use will become urgent. Indeed, while for the traditional classification problem it is most important to search for the best individual classifier, i.e., the one that has the greatest accuracy and satisfies the requirements for errors of the 1st and 2nd kind (i.e., the requirements for the probabilities of signal skipping and false alarms), the property of the accuracy of individual classifiers is not so important in the framework of the task of combining the solutions of classifiers. The most important are the meta-properties of the ensemble of classifiers. An example of such meta-properties is the combined coverage factor, indirectly reflected in terms of the requirements for the diversity property of the selected ensemble of classifiers. The result of this requirement is that in the tasks of combining solutions, individual classifiers can be "not so good" but working in an ensemble as a single algorithm, they have quite good accuracy and low requests to computational resources.

Thus, the rules for the integration of private decisions of independent experts are considered. Combining solutions is a special problem in the field of pattern recognition which does not reduce to the usual classification problem (with one classifier). It is subject to a subsequent more in-depth study and its practical use can lead to qualitatively better properties of recognition systems that use the paradigm of sharing the set of classifiers that form a collective solution.

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