

DOI  
UDC 004.78

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### Development of information system using relevant search

The method of developing an information system of scientific activity in universities using relevant search is proposed. The current state of development of information systems is studied. The factors determining the implementation of information systems are analyzed. The concept of relevance is substantiated as a measure of the correspondence of the search results to the task set in the search query, determined by the search system. The analysis of information systems, which are considered as management systems, combining systems of saving and issuing information, and systems that provide information exchange in the management process, has been carried out. The areas of automation of information management activities in organizational structures, scientific institutions, institutions of higher education are considered. The key characteristics of the information system under development are defined. The analysis of the existing information systems of the departments was carried out and their features and shortcomings were determined. Taking into account modern problems, the tasks and criteria for creating an information system were formed. Analysis of modern web technologies, web framework was performed and the most effective of them were selected based on the results of the conducted research.

*Keywords:* information technologies, information system, relevant search, software product, Web technologies.

At the current level of information technology development, the use of a computer to save any type of information becomes the only means that provides wide opportunities for information management. An important role in the pro-

cess of obtaining information is played by the active use of information systems. The global Internet is the world's most developed information system, which is used to communicate between millions of users. The Internet provides access to more than five million information systems. From the very beginning of the development of the Internet, and especially with the advent of Web technologies, the network has been focused on providing information to its users.

Web technology has completely overturned modern ideas about working with information and computers in general. It turned out that the traditional parameters of the development of computer technology — performance, bandwidth, capacity of memory devices — did not take into account the main one — the interface with a person. The outdated mechanism of human interaction with the information system restrained the introduction of new technologies and reduced the benefit from their use. And only when the technology of communication by the means of information technologies between a person and a computer was simplified to the naturalness of perception, there was an unprecedented explosion of interest in the possibilities of active use of computer technology.

Nowadays, almost every organization has its own website. In the conditions of the use of modern information technologies, this is a necessary factor of existence, which allows to expand the field of advertising activity and thereby attract additional customers. The purpose of the work is to investigate the existing information systems that allow analyzing the scientific activity of institutions of higher education, and to illuminate the possibilities of their improvement through the use of relevant search. The relevance of the work lies in the development of an information system with a search component, the main task of which is to ensure the accuracy of search information.

**Research results.** When searching for information on the Internet, there are two important components: completeness and accuracy. This is usually called relevance, that is, the relevance of the answer to the query. At the same time, the user enters a query in the search engine and in the list of sites after ranking, pages dedicated to the search results are displayed. This indicates the high relevance of the response to the query. If the user sees a list of pages with results that do not match the given query, this indicates very low relevance. However, such a situation does not occur often.

Relevance is a measure of correspondence of the search results to the task set in the search query determined by the search engine. The rapid and uncontrolled growth of the popularity of the World Wide Web automatically led search engines to one of the most important roles in the virtual world. For any site, search engines are actually a window into the virtual world, a universal and most effective advertising platform. Working on their main task, — the

accuracy of search results — search engines were forced to develop and improve relevance criteria. The basis was the so-called «internal» criteria — the density of keywords on the page, the amount of content, the text of the headings and much more [1—5].

In the modern world, the Internet has long been used as a broad reference tool. In recent years, it has become an environment for processing and storing scientific, business and other types of information. But the main features of the Internet are the dynamics of information, its constant updating and distribution throughout the Internet [1, 3]. Search engines have long become an integral part of the Internet. Thanks to them, users of the World Wide Web try to find the necessary information. Searching for information is mainly reduced to finding the page on which this information is located, and there may be several such pages on the Internet. To obtain results that will allow you to compare information on the same type of web resources, you need to create thematic search engines [1, 6, 7].

The information system, as a management system, is closely related both to the systems of storing and issuing information, and on the other hand - to the systems that ensure the exchange of information in the management process. It covers a set of means and methods that allow the user to collect, store, transmit and process selected information. Information systems have existed since the beginning of society, as there is a need for management at each stage of its development. The mission of the information system is the production of information necessary for the effective management of all resources of the organization, the creation of an information and technical environment for managing its activities.

Noting that one of the main tasks is the development of an information system of scientific activity in universities using relevant search, the task was set to design and develop an information system of scientific activity in universities using relevant search. In any management information system, three types of problems are solved:

- 1) situation assessments (sometimes they are called pattern recognition tasks);
- 2) transformation of the description of the situation (calculation problems, modeling problems);
- 3) decision-making (including optimization ones) [8, 9].

An automated information system is an interconnected set of data, equipment, software, personnel, standard procedures designed to collect, process, distribute, store, and present information in accordance with the requirements determined by the organization's goals. Currently, in the age of information, almost every information system uses computer technologies, and therefore in the future under information systems we will mean automated ones.

Information systems include: technical means of data processing, software and relevant personnel. Four components form the internal information base:

- 1 — means of recording and collecting information;
- 2 — means of transmission of relevant data and messages;
- 3 — means of saving information;
- 4 — means of analysis, processing and presentation of information [10—12].

The variety of information systems is growing every year. Depending on the functional purpose, the following systems can be distinguished: control systems, design systems, scientific search systems, expert systems, diagnostic systems, modeling systems, decision-making preparation systems; and depending on the field of use — administrative, economic, industrial, medical, educational, environmental, forensic, military and others.

The main factors affecting the implementation of information systems are the needs of organizations and users, as well as the availability of appropriate means for their formation. The reasons that motivate organizations to implement information systems are, on the one hand, determined by the desire to increase the productivity of daily work or eliminate their repetition, and on the other hand, by the desire to increase the effectiveness of managing the organization's activities by making optimal and rational management decisions. The first reason is quite transparent and for its implementation it is enough to implement standardized information processing systems. The successful functioning of the organization, scientific institutions, and universities largely depends on successful management, which is based on the justification of perspective development concepts according to timely, reliable and complete information that can be supplied by the relevant information system. The main task of the information management system is to subordinate all internal processes to the main goals of the organization. For this, it is necessary to coordinate the processes related to the organization's activities in such a way that they maximally ensure the fulfillment of the set tasks in a single information field. Therefore, the organization's information armament begins to directly affect the effectiveness of its activities [8, 13].

The main directions of automation of information management activities in organizational structures are as follows:

- automation of document processing through the implementation of text processing systems;
- automation of information exchange through various types of communications;
- automation of the activities of managers on the basis of computer systems of complex information systems that provide assistance in decision-making, and electronic secretaries, which allows to raise the level of work organization of managers to a qualitatively higher level.

The implementation of information systems allows the manager to get operational access to arbitrary accumulated information in order to use it effectively in the future to solve the tasks. Modern conditions are characterized by the use of highly effective internal company information systems based on the use of the latest information technologies, in particular a single local computer network. Management internal information system is a set of information processes to meet information needs at different levels of decision-making. The information system includes information processing components, internal and external transmission channels. Information, especially its automated processing, remains an important factor in increasing the efficiency of any organization. An important role in the use of information is played by the methods of its registration, processing, accumulation and transmission; systematic storage of information and its issuance in the required form; production of new numerical, graphic and other information [7, 14].

In modern conditions, highly effective internal corporate information systems are usually used using the latest information technologies, in particular, a single local computer network. Management internal information system is a set of information processes to meet information needs at different levels of decision-making. The information system includes information processing components, internal and external transmission channels. Information, especially its automated processing, remains an important factor in increasing the efficiency of any organization. An important role in the use of information is played by the methods of its registration, processing, accumulation and transmission; systematic storage of information and its issuance in the required form; production of new numerical, graphic and other information [7, 14].

Increasing the efficiency of information systems is achieved through the use of an end-to-end structure and compatibility of information systems, which allows for the elimination of duplication and ensures multiple use of information. At the same time, defined integration links are established, the number of indicators is limited, the volume of information flows is reduced, and the level of information use is increased. The information system should support such functions as providing information (for example, needed by users to solve scientific and industrial problems) and creating the most convenient conditions for its dissemination (for example, carrying out administrative-organizational, research and production activities that ensure its effective dissemination) [8, 15].

A modern information system in a given field of activity of the organization allows to ensure the solution of the following tasks:

- direct timely access to the information product (exact information about the progress of the production process in space and time);

- effective coordination of internal activities and prompt distribution of various messages;
- effective interaction with peers along technological routes using more informed and visual means of display and transmission-reception of messages;
- allocating the necessary and continuous time for managers of all levels for such highly effective activities as analysis and decision-making due to the reduction of time spent on low-productivity activities;
- use of qualitatively better technology of system analysis and operational management design at the lower and middle levels of production management.

When studying the concept of relevance, it should be noted that relevance is a measure of the correspondence of the obtained result to the desired one. Search relevance is a subjective concept, as search results that are suitable for one user may not be suitable for another [14]. The main method for assessing relevance is the TF-IDF method, which is used in most search engines (both in Internet search engines and in reference systems (MSDN). Its meaning boils down to the fact that the greater the local frequency of a term (query) in documents (TF) and the greater the "rarity" (that is, the rarer it occurs in other documents) of a term in the collection (IDF), the higher the weight of this document relative to the term - that is, the document will appear earlier in the search results for this term. When a query is entered on the page of the search engine or in the search bar of the browser, events hidden from ordinary users begin to occur. The word itself comes from the Latin "relevo" and is translated into Ukrainian as "raise" or "relieve". The English equivalent of the term is "relevance", and "relevance" and "relevant" have the same definition, which consists in the correspondence of the received information to the information request made by the user.

This national standard contains other useful standardized terms and definitions related to the field of information retrieval and dissemination using automated information systems. The document helps to understand the meaning of many words in information, publishing or library activities, and not only such a unit of language as "relevance". The terms "pertinence" and "pertinent" should be interpreted as the correspondence of the received information data to the information need. Most often, this concept is confused with relevance, which is fundamentally wrong, because in one case we are talking about the relevance of a request, and in the other — about the relevance of a need.

The search engine uses standalone programs that visit websites and store information about them. These programs find new sites and then go to the main page and view its content. They study the pages related to the home (in the browser, it is loaded first) internal links. Also, bots look at links that point to other sites, that is, external links. Keeping this information, they go through them, discover new sites and find out how web resources are related to each other.

The higher the relevance of the text, the more likely it will enter the first positions of search results. This indicator has a quantitative assessment, but the algorithms for its implementation in different search engines differ and are unknown to users, and they also change over time, since search engines, trying to rise in the rankings, try to provide relevant information, reducing the time to search for it. Highly relevant pages are considered to be pages where the occurrence of a keyword that matches the query can be in the range from 3 to 7%. But this is not the only criterion for document relevance. These include a number of internal and external indicators. Internal indicators (in addition to the density of keywords) are their position in the text (inclusion in the title, their proximity to the title and to each other, with the formation of probable search phrases), as well as the presence of synonyms, which confirms the relevance of the content of the query text.

To determine the key characteristics of the information system under development, an analysis of the existing information systems of the departments was carried out and their features and shortcomings were determined. The structure and set of functional modules of most of the researched information systems are arranged in such a way that the website visitor can fully obtain the necessary information. On the main page there is a feed of news and events, where you can browse an interesting topic. The color range is pleasing to the eye, easy to perceive. The accumulation of elements on the page prevents the user from concentrating on the content of the site.

Based on the results of the analysis, the research task was set and the basic requirements for the site were formulated, the tasks and criteria for the creation of the information system were formed. The main task during the implementation of the project is to provide the following functions:

- relevant search for information using keywords;
- search filtering by keywords;
- restriction of access rights to information;
- functioning of the administrator section for editing the content of the information system, displaying analytical information, managing units;
- two-way interaction and communication support with the administration.

It should be noted that the technology of creating websites is quite formalized. Website development is a controlled process, the result of which is predictable in advance. The process of creating a site consists of a certain sequence of stages [4], the main of which are the following:

- 1 — statement of the problem;
- 2 — development and approval of the site design;
- 3 — integration of site design with the management system;
- 4 — is the procedure for publishing a site on the Internet;
- 5 — the process of filling the site with the necessary information;
- 6 — its further support.

To create software that meets the customer's requirements, it is necessary to use the following technologies:

PHP script is a script programming language created for generating HTML pages on a web server and working with databases (DB), currently it is supported by almost all hosting representatives, it is included in the "standard" set for creating sites;

JavaScript, known as a scripting language for web pages but also used in other software products, JavaScript is based on ECMAScript, all modern browsers support ECMAScript 8;

HTML (Hyper Text Markup Language) - hypertext markup language;

DBMS and MySQL.SQL (Structured Query Language) — a structured query language — created to work with relational databases, allows users to interact with the database (view, search, add, manipulate data): MySQL is a multi-user, multi-threaded SQL database server [5, 10,11].

Each developer uses technologies for creating sites that he considers most suitable for himself. However, most specialists choose a technology in accordance with the tasks that arise before them during the development process, and which they must solve as efficiently as possible.

The database helps to systematize and store information from a certain subject area, facilitates access to data, search and provision of necessary information. Before creating tables, you need to create a database structure, which is the basis for creating an adequate and efficient database. The database design process itself is a complex design process, mapping the description of the subject area into the scheme of the internal data model. In fig. 1 shows the designed ER-diagram, which was used in the development of this system.

**Waterfall model.** For the successful implementation of the project, it is not enough to choose effective technologies and development tools, provide the necessary budget and find qualified developers. In practice, business process design standards are used, which can be formulated in the form of generally accepted concepts. The most relevant is the waterfall model, or the sequential development of the waterfall model (Waterfall Model). The basic idea is that the development process is divided into clearly defined phases that are performed in strict sequence. The name "waterfall" appeared in connection with the appearance of the diagram depicting the development process [7]. Individual tasks that make up any project are, in practice, divided between several process areas. The classic waterfall model includes the following areas:

- development of requirements (requirements) — collection of business requirements of the customer and their transformation into functional requirements for the software product;
- analysis and design — development of domain model, design of database scheme, object model, user interface;

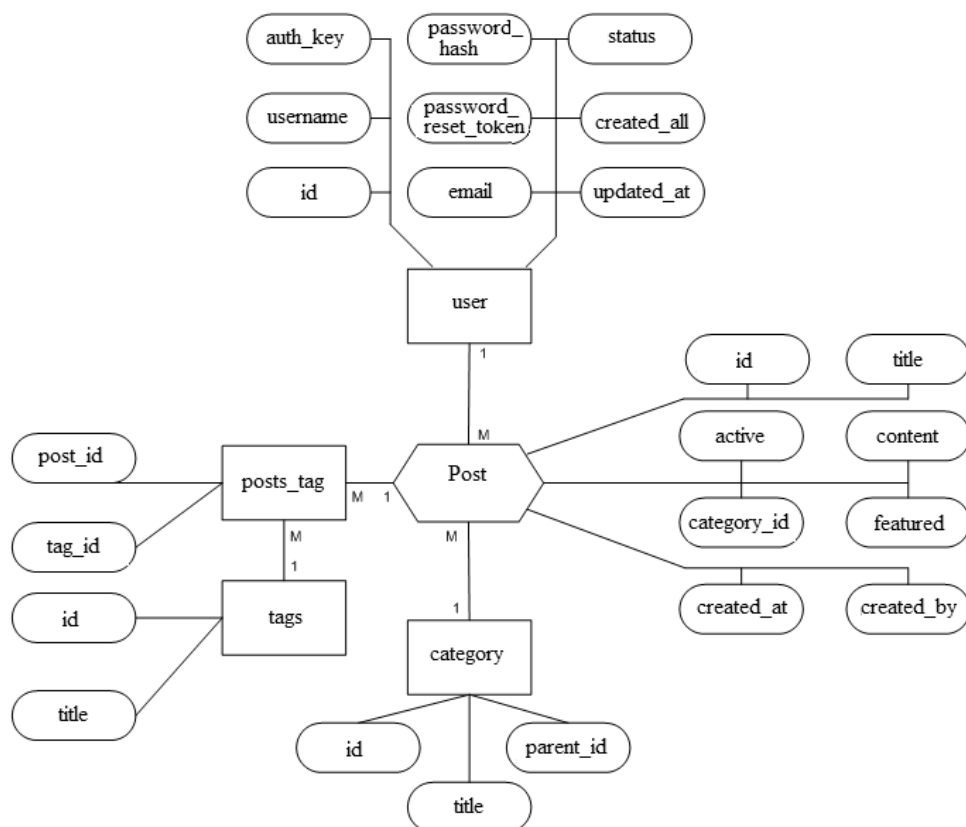


Fig. 1. ER - diagram of the designed information system

- implementation — creation of a product according to the specifications developed at the previous stage;
- testing — includes verification of compliance of the functionality of the software product with the needs of users (validation), as well as the search for defects in the implementation;
- deployment — user training, system installation, transfer to industrial operation.

In the waterfall model, each of the process areas represents a separate phase of the project. The phases are performed strictly sequentially, that is, analysis and design begin after the completion of requirements development, before the start of the implementation of the completion of the design [7]. This approach works well in projects where requirements can be clearly defined and recorded. In these cases, the waterfall model allows you to ensure a given level of quality (which can be quite high) and adhere to budget and time constraints.

The information system, as a management system, is closely related to the systems of storing and issuing information, as well as to the systems that ensure the exchange of information in the management process. Covers a set of means and methods that allow the user to collect, store, transmit and process selected information. An automated information system is an interconnected set of data, equipment, software, personnel, standard procedures that are designed to collect, process, distribute, store, and present information in accordance with the requirements arising from the goals of the organization. The information system should include the following components:

- database containing data on: administrators, content and content in the system;
- a content management system that helps the administrator quickly adjust the structure and content (formatted text, photos, videos, tables, forms, etc.), the possibility of creating new administrators;
- the authentication and registration module allows you to register a new administrator, after which he will be able to log in to the system using his name and password, there is also an option to configure confirmation of registration by the administrator;
- feedback, gives the user the opportunity to contact the administration, to solve certain questions or consult;
- relevant search, which will allow the user to find the necessary information as accurately as possible;
- sorting information by keywords.

The implementation of an automated information system allows you to get immediate access to information for further use in the process of solving the tasks.

The conducted analysis of modern web technologies allows us to note that currently there is no language for web programming that would dominate other languages. Programmers prefer one or another language only based on the context of the given task. But it is necessary to understand the difference between a web programming language and a framework. A programming language contains a basic syntax, often has a standard library. The framework provides various libraries to the developer. Some languages and frameworks are a single entity, such as JSP or ASP.NET. Other languages are used without a framework - PHP or Perl. Web programming languages and frameworks are classified into:

client-side — used to write programs on the client side, they include such languages and frameworks as JavaScript, SilverLight, AdobeFlash;

server — used for writing programs on the server; the most popular among them are PHP, JSP (Java), ASP.NET, Perl, Ruby.

Among the Windows platforms, ASP.NET technology, developed by Microsoft, dominates. The advantage of this technology is the ability to create sites of any complexity and passability, from the simplest to resources that can handle several million requests per day.

On the Unix platform, the most popular web programming language is undoubtedly PHP. The main advantages of this language are highlighted: high speed, simple syntax, support by most hostings. The Perl language is also known on the Unix platform. Unlike PHP, Perl has a very complicated syntax. Experienced programmers do not use it to create sites. The Ruby language and its Ruby on Rails framework are gaining great popularity among web developers, because with its help you can quickly create an adequately functioning site. However, this language has low performance. JSP (Java Server Pages) — the technology of creating a site using the Java language has a lot in common with ASP.NET. Developers who choose JSP are mostly guided by their own subjective preferences rather than the advantages or disadvantages of these two technologies [2, 3, 9, 10, 11].

The PHP language is built-in and has exceptional flexibility in relation to the needs of the developer. There are no browser dependencies because PHP scripts are fully compiled server-side before being sent to the client. PHP scripts can be delivered to any device with a browser, including mobile phones, electronic notebooks, pagers and laptops, not to mention traditional PCs. Programmers who develop auxiliary utilities can execute PHP code in command line mode.

Since PHP does not contain code oriented to a specific Web — server, users are not limited to certain servers (perhaps unfamiliar to them). Apache, Microsoft IIS, Netscape Enterprise Server, Stronghold and Zeus — PHP works on all the listed servers. Because these servers run on different platforms, PHP is generally a platform-independent language and exists on platforms such as UNIX, Solaris, FreeBSD, and Windows. The strategy of OpenSource, and the distribution of the source texts of programs in the masses, undoubtedly had a positive impact on many projects, first of all — Linux, although the success of the Apache project strongly strengthened the position of OpenSource supporters. This also applies to the history of the creation of the PHP, since the support of users from all over the world turned out to be a very important factor in the development of the PHP project [2, 3, 9, 10, 11].

For the set goals, the PHP language is the most successful, because the adoption of the Open Source strategy and the free distribution of the initial PHP texts provided convenience to users, and also reduced the cost of the software product. In addition, a large number of open documentation, as well as popular electronic conferences, make it possible to find answers to even the most difficult questions.

**Choosing a web framework.** A framework is a framework that has a number of methods and classes that allow you to create programs faster and help you write more structured code. Most frameworks implement the MVC (Model — View — Controller) model. The main goal of this approach is to divide logic into three components:

- 1) Model (Model) — works with the database.
- 2) Controller (Controller) — implements the main functionality and defines the logic of the system.
- 3) View — presentation of information to the end user.

CodeIgniter is a lightweight platform with MVC architecture. Ideal for learning how to work with frameworks. CodeIgniter is not inferior to larger platforms — Symfony and Zend. The purpose of the framework is to allow developing projects much faster, using a rich set of libraries for standard tasks, as well as a simple logic and structure for connecting them.

Symphony is a well-known and large framework with rich functionality, aimed at creating large programs, the developer of which has full control over the configuration: from the directory structure to external libraries. Symphony has a number of components that facilitate the process of testing, debugging and writing documentation. Many developers agree that Symphony is not the best tool for creating small sites due to the large size of the platform. This is primarily due to the execution of a large amount of code for each request. This framework should be chosen for large projects.

Kohana is a sophisticated PHP5 MVC framework that provides a rich set of components for building applications. This is one of the development branches of CodeIgniter. Kohana also works with MVC architecture and allows you to change the configuration easily and quickly.

Laravel is a relatively new name in web development with an expressive, sophisticated syntax. The framework provides powerful tools for the development of large, stable applications, as well as a block-by-block testing system, a migration system, etc.

Yii is a popular and highly effective PHP platform for developing WEB 2.0 applications. Yii has quite rich functionality by default: DAO/ActiveRecord, I18N/L10N, caching, authentication based on access control roles, etc. All of this can significantly reduce development time. Yii loads only those classes (functions, modules) that are necessary. Also, the framework is well adapted to work with AJAX. Security actually became one of the main advantages of the framework — data input control (validation), filtering, protection against SQL injections.

The advantage of Yii over other frameworks lies in efficiency, wide capabilities and quality documentation. From the very beginning, Yii has been de-

signed very carefully to meet all the requirements for the development of serious web applications. Yii is the result of the authors' extensive experience in developing web applications, as well as their research into the most popular web frameworks and applications. Based on the above characteristics, the Yii framework was chosen for work.

**Choosing a database management system (DBMS)** is a complex multi-parameter task, which is one of the important stages in the development of web applications. The simplest approach when choosing a DBMS is based on an assessment of the extent to which existing systems meet the basic requirements of the information system project being created. MySQL is considered the optimal solution for small and medium-sized applications. Server source code is compiled on many platforms. The full capabilities of the server are revealed in UNIX — systems that support multithreading, which increases the overall performance of the system. Advantages of MySQL server:

- ease of installation and use;
- unlimited number of users simultaneously working with the database;
- the number of rows in the tables can reach 50 million;
- high speed of execution of commands;
- availability of a simple and effective security system.

When developing a DBMS, special attention should be paid to the information structure. The information structure is a way of organizing the information materials of the system together with all the connections that allow these materials to interact with each other. The level of comfort when using the site by visitors depends on how well organized such interaction is. When developing the information structure of the system, it is taken into account that, depending on the amount of information materials that need to be placed in the system, its model can be linear, hierarchical and confusing ("cobweb"). Each of these models has its advantages.

The most effective means of preventing abuse is the separation of user rights. This allows you to establish minimal access to information. Users are granted only those rights and those data that are necessary for them to perform the information. The purpose of this principle is obvious — to reduce damages from accidental or deliberate unauthorized actions. Secondly, to mark the division of duties and powers, in which administrators will be responsible for their actions. That is why it is advisable to divide into two roles: administrator and user. The administrator has the ability to create, edit and delete, the user can only view information.

The Yii2 framework has a template that provides access sharing capabilities. There are three applications in the advanced template: frontend, backend and console. Frontend is the part of the program that ensures interaction of the system with the end user of the project. Backend is an administrative panel,

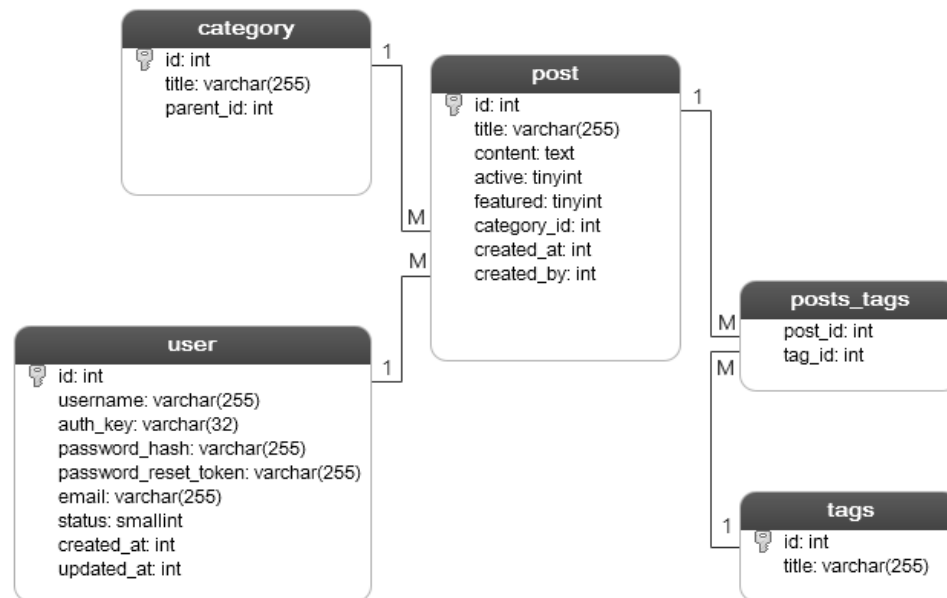


Fig. 2. The data scheme of the designed database

analytics and other similar functionality. The console is usually used to perform scheduled tasks via cron, low-level server management, system deployment, work with migrations and resources.

There is also a common directory that contains files used by more than one application. For example, the model of articles, they are necessary for the administrator to create, edit, as well as for the user to view. A controller class AdminController has been created that describes the beforeAction method for user authentication. All subsequent classes in the backend section will inherit the AdminController class to check user rights.

Database design begins with the study of the technical task for database design, which must be provided by the customer. Therefore, it is desirable that the customer has the appropriate terminology and knows, at least in general terms, the technical capabilities of the main DBMS. During the preparation of the technical task, the following are compiled: a list of input data with which the customer works; a list of initial data needed by the customer to manage the structure of his enterprise. A database schema is the structure of a database system described in a formal language that refers to the organization of data to create a plan for building a database with table distribution. Formally, a database schema is a set of formulas (rules) called integrity constraints. Integrity constraints ensure compatibility between all parts of the scheme (Fig. 2).

Currently, the site is one of the most important business tools: with its help, you can advertise your goods and services or even directly cooperate

with customers. However, the site's effectiveness as a business tool can be diminished if the site does not perform as intended. Technical analysis of the website is required to obtain information about the correctness of its operation from a technical point of view. As part of this analysis, the correctness of the operation of various scripts on the site, the availability of various site pages, and the speed of data loading can be checked. If necessary, such an analysis may include checking the software code of the site to detect errors that may interfere with the normal operation of the resource.

Thus, a website with the following functionality has been developed: when the user visits the main page, he sees a menu consisting of the unchanged "Feedback" page and other pages created by the system administrator in the "Administrator" → "Categories" section. In the same module, functions for editing, creating and deleting categories are provided. The administrator has more options than the user, he can create new articles, keywords, categories, there is also a module for changing the appearance of the main page, namely editing the slider, etc.

The popularity of using Web information has caused a significant increase in serious scientific research related to the development of search services and the development of methods for increasing the relevance (relevance to requests) of data received by users. This is explained by the appearance of a large number of thematic Web pages, which mostly contain low-quality or unverified data or simply duplicate each other, that is, they are irrelevant sources of information.

## **Conclusions**

The information system of scientific activity in universities using relevant search was developed according to the proposed parameters of the design and implementation of the information system. The relevance of the selected method of developing an information system with a search engine is based on the accuracy of search results. This project includes the development of a database for the automation of the information system, which is effectively used in practice. The implementation of this project significantly improves the preservation of data integrity, the processing of customer requests, increases the efficiency of the work of a scientific institution in modern conditions, in order to find relevant information that meets the user's criteria, it is necessary to spend a lot of time processing various sources on the topic of interest to him. Unfortunately, the situation is not significantly improved by search engines, which sometimes issue thousands of relevant results for one query, which also does not contribute to increasing search efficiency. That is why this topic is relevant and requires further thorough research.

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Received 14.02.2023

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