**ТЕХНІКА ТА МЕТОДИ ЕКСПЕРИМЕНТУ**
**ENGINEERING AND METHODS OF EXPERIMENT**

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## BELARUSIAN SOFTWARE FOR NUCLEAR KNOWLEDGE MANAGEMENT

A review of Belarusian software developed for nuclear knowledge management is presented. It includes the system eLab-Control that is an information system for monitoring the nuclear and radiation safety of the national nuclear regulatory body as well as content management system eLab-Science and the Belarusian educational portal of nuclear knowledge BelNET developed on its base. All the software is based on free software: Debian GNU/Linux, Web-server Apache, the Firebird database server, PHP application server. The system runs under Windows and Linux. The work is carried out through the Internet in multiplayer mode, with the division of access rights by way of widespread browsers. Portal of nuclear knowledge BelNET https://belnet.bsu.by/ is considered from the point of nuclear knowledge management.

*Keywords*: nuclear knowledge management, information system, content management system, the portal of nuclear knowledge.

### 1. Introduction

The need to preserve, transfer and popularize scientific knowledge obtained as a result of scientific research in various fields led in the early 90s of the 20th century to the creation and development of a new interdisciplinary branch in the system of scientific knowledge. It is called knowledge management, which is the process of creating, sharing, using, and managing knowledge and information [1].

The International Atomic Energy Agency (IAEA) has been paying close attention to nuclear knowledge management since the early 2000s. The IAEA emphasizes that the creation, collection, transfer, exchange, preservation, maintenance, and use of knowledge are essential for the development and retention of the necessary technical knowledge and experience, required for nuclear power programs and nuclear technologies [2 - 4]. Nowadays national nuclear knowledge portals have been developed in many countries. European, Asian, African, and other nuclear education networks are under constant growth. So, one can see the birth of the single information space in this field.

The IAEA notes, that each country forming its nuclear industry must independently develop and maintain a national nuclear knowledge portal, integrated into the global nuclear knowledge management system.

There is a wealth of information available on the internet today on nuclear topics, but most of this information is in English.

The construction of the Belarusian nuclear power plant (NPP) means the formation of the nuclear industry in Belarus and poses some problems in training specialists in physics, technology, chemistry,

biology, as well as the development of nuclear science and technology, nuclear medicine, etc. This requires a targeted national policy in the management of corresponding information resources and nuclear knowledge. The aim is to preserve and develop them at the level that ensures safe, sustainable, and effective development of the nuclear industry. The Belarusian specific character here is a long overcoming the consequences of the Chernobyl accident and the country's great scientific potential in the field of nuclear knowledge since the middle of the past century.

An Internet search for "nuclear knowledge portal" provides links to corporate sites of national regulators in the field of nuclear and radiation safety or sites created by big corporations or international portals created under the IAEA auspices. For example, the National Nuclear Regulatory Portal (NNRP) is here: https://gnssn.iaea.org/regnet/Pages/NNRP.aspx. Principles of the development of such portals are proposed and advanced [5 - 7].

Also, a search for the query "nuclear knowledge portal" gives in the first lines a link to the electronic nuclear knowledge portal BelNET https://belnet.bsu.by/ developed during the last five years by scientists and lecturers at Belarusian State University.

### 2. Belarusian information system as an instrument of monitoring nuclear and radiation safety

The Department for Nuclear and Radiation Safety of the Ministry for Emergency Situations the Republic of Belarus (Gosatomnadzor) implements functions of a nuclear regulatory body in Belarus

and realizes the big importance of nuclear knowledge management in its activities.

On the initiative of Gosatomnadzor in 2016 a project of the Belarusian State Scientific and Technical Program "Intellectual Information Systems" devoted to the development of the Intellectual information system of Gosatomnadzor employee for monitoring (supervision) in the field of nuclear and radiation safety started. Its developers are researchers of the Institute for Nuclear Problems of Belarusian State University. The software is called eLab-Control. It is based on the framework eLab [8, 9].

At present the Intellectual information system consists of four modules: Module 1 for monitoring (supervision) the safety during the construction and commissioning of the Belarusian NPP, Module 2 for monitoring (supervision) over radiation safety of ionizing radiation sources, Module 3 for accounting and control of nuclear material, spent nuclear material and radioactive waste, Module 4 with general information and auxiliary tools. All employees can work in the system with appropriate access rights in a single user interface. Remote access from regions is realized via VPN. The system facilitates access and provides the preservation of different types of data [10]. eLab-Control as well as other eLab products provide increased security including access via HTTPS – HyperText Transfer Protocol Secure. The system is installed on the virtual machine of server VMWare ESX. Module 3 is installed also on a separate computer.

eLab-Control provides some tools to search for information: simple search within the central working area of the window, complicated queries with compound Boolean logic operators, special search inside the tool "Tree of enterprises" and full-text search of documents. The last search allows us to find information on the query in natural language. It should be noted that existing search engines such as Google and Yandex have very sophisticated search algorithms. A query submitted in a natural language for such a system will produce a very relevant set of results. But there are specific practical situations when the use of popular search engines is impossible. For example, when the developed information system does not have access to the Internet. The principles of functioning of the software search tool assume the next different modes of operation: indexing of documents, document search mode, ranking the results by relevance. Now the processing of the following types of documents is realized: PDF, DOC, DOCX, RTF.

Module 3 provides nuclear material accounting for all Belarusian Material Balance Areas and can be tuned for the level of location outside facilities (LOF) and facilities. The module allows to import or to calculate at the basis of introduced information about batches and to export all necessary accounting reports in the required format according to Fixed Code 10 and Labeled Code 10 introduced by the IAEA [11]. There are Inventory Change Reports (ICR), Physical Inventory Listings (PIL), Material Balance Reports (MBR), General Ledger, Concise Notes (CN), Textual Reports (TR). Original algorithms were proposed for these reports' calculations. The module provides all necessary features in nuclear material accounting including automatic accounting of corrections etc.

Verification and validation of Module 3 occurred through real data of Belarusian Reports submitted in the IAEA in 2013 - 2019.

Currently, at the level of the regulatory body, the system eLab-Control is used for all accounting of sources of ionizing radiation, accounting of nuclear material with reporting to the IAEA, supervision of the construction of the Belarusian NPP.

Software eLab-Control, as well as framework eLab, have a client-server architecture based on free software: Debian GNU/Linux, Web-server Apache, the Firebird database server, PHP application server. The system runs under Windows and Linux. The work is carried out through the Internet in multiplayer mode, with the division of access rights by way of widespread browsers: Mozilla Firefox, Google Chrome, Chromium, etc.

eLab features are the next. It is open to modifications by users, includes a standard set of log forms, and is easily adjusted to customer specifics. It runs on a secure server. No additional software installation is required on the client computer. It is sufficient for a standard browser. eLab can operate both on a local Intranet or global Internet, allows in the frame of a single installed copy of the product at the same time to maintain the workflow of many laboratories and organizations, with different profiles. The system is easily configured for the needs of the project.

Framework eLab history is the following. Originally it was an electronic document management system of a testing laboratory. In 2010 the first version of eLab was implemented in the educational process of Belarusian State University, Belarusian State Technological University, Belarusian National Technical University, in the Chemical-toxicological laboratory of the Minsk Drug Treatment Clinic. In 2012 it was the commissioning of eLab-Fuel in the 202 Chemmotology Center of Fuel for quality monitoring and management of specimens, measurements, and passports of fuels and lubricants of the Belarusian Armed Forces. It is estimated that over the past time more than 60,000 custom tests of fuel quality were carried out and documented using the system eLab-Fuel. Then there was the commissioning of

eLab-Fuel in the Belarusian branch of Russian Company GazPromNeft in 2013.

### 3. Content management system eLab-Science

In 2015 an original content management system (CMS) eLab-Science was developed based based on framework eLab. Then the Belarusian educational portal of nuclear knowledge BelNET (Belarusian Nuclear Education and Training) was developed https://belnet.bsu.by (see Fig. 1).

The following user groups are distinguished on the portal:

an anonymous user (not authorized on the portal) who can read materials that are in the public domain;

a registered user who can perform laboratory work on the portal and read materials with the appropriate access level;

an authorized user who can read materials with an authorized user access level and edit information on the portal;

the portal administrator responsible for the portal content;

system administrator of the portal.



Fig. 1. Screenshot of portal BelNET.

Within eLab-Science, all the necessary scientific and educational portal functions are implemented, including the ability to edit remotely the portal structure and to enter documents. Also, there are various tools of sorting and filtering, several levels of access to documents depending on user rights. The system allows us to develop scientific materials containing complicated formulas and pictures, laboratory works, tests, etc.

Principles of organizing access for BelNET portal users are the same as for eLab-Control: multiplayer mode, data entry by filling out web forms in online mode, separation of access rights of different categories of users to data and user interface, work through a Web interface using widely used browsers.

Let us note that one of the main principles of the framework eLab developing is a system process approach [12]. Applied to computer automation of the business process of an organization, it involves understanding and managing interrelated processes in an organization to increase its effectiveness.

This approach represented at the database level for eLab-Control was given in [9]. There are four main components of the business process in the field of nuclear and radiation safety: user management, organization management, registration and accounting of radioactive materials, and related equipment, as well as the supervision process.

The corresponding diagram for eLab-Science is given in Fig. 2. Here one can see the other four main components: management of users, taxonomy, content, access to content.
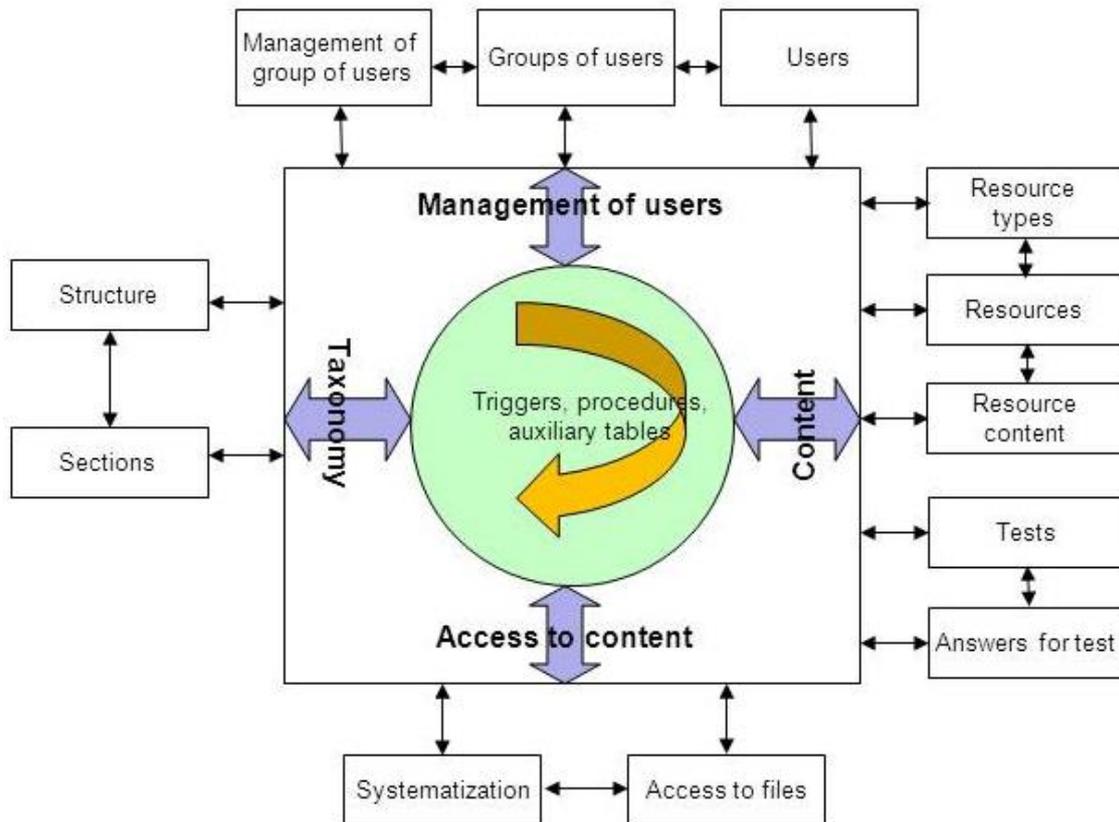
Fig. 2. Diagram of process system approach in eLab-Science.

It is well known that the content of any portal is information posted on its pages. The process of filling the portal with information and filling out the knowledge base, developing special materials for the distance learning system is a time-taking process. It is obvious that the formation of the portal content is a creative process that requires a non-trivial approach at every stage of its implementation.

For the realization of the diagram from Fig. 2, CMS eLab-Science provides the following special tools for formation resources and determination of the type of access to them:

editor of sections of the portal, which allows changing its structure online;

editor of resource type allowing to add new types of resources to the existing 31 ones;

editor of resource,

editor of resources systematization, which ensures the placement of a resource in one or some sections of the portal;

editor of access to files for determining the type of access to the resource for different user groups;

editor of resource content;

editor of test questions of the lab test;

editor of answers to test questions.

The editor of the resource provides an abstract (till 4098 characters) in addition to all the necessary information about the resource. The editor of resource content allows us to create a complete, arbi-trarily long resource text using the HTML markup language, e.g. laboratory work or scientific paper.

Also, a tool for preview the edited resource is implemented as well as the mobile version of the portal within CMS eLab-Science. Joint work of authorized users in the restricted area of the portal can occur.

Let us emphasize that, in addition to eLab-Science, a small number of CMS provides the possibility of typing formulas using a special markup language. This is Moodle https://moodle.org/. It is a virtual learning environment developed based on open-source software for creating online learning sites. Moodle is the base of the IAEA's CLP4NET online learning platform http://clp4net.iaea.org/. MediaWiki is a content management system for wiki projects based on open-source software https://meta.wikimedia.org/wiki/MediaWiki.

What are portals based on the CMS eLab-Science besides BelNET? Scientific portal CoExAN https://coexan.bsu.by/ of the Project ID 644076 Call H2020-MSCA-RISE-2014 Horizon2020 "Collective Excitations in Advanced Nanostructures" was crea-ted as well as an electronic portal eLab https://elab.bsu.by/, devoted to framework eLab.

Thanks to the CMS eLab-Science, a portal for any educational and scientific profile can be created. Such a portal can be edited without leaving home, from any city in the country, from anywhere in the

world, at any time. To do this, a user needs only access to the Internet and the appropriate access rights. Moreover, within the CMS eLab-Science, a convenient tool can be easily organized for quick free publication on the Internet in an electronic archive of various kinds of scientific materials (drafts of articles, pre-publications, scientific reports, technical information, etc.). The world's best analogs of such a proposal are the next: arXiv https://arxiv.org/ – an electronic archive in the field of physics, mathematics, computer science, electronics and systems sciences under the auspices of the Los Alamos National Laboratory and the Cornell University Library (USA), bioRxiv – an online archive https://www.biorxiv.org/ for preprints in life sciences and medRxiv https://www.medrxiv.org/ under the auspices of Cold Spring Harbor Laboratory (USA).

### 4. Portal BelNET

The mission of BelNET is to create favorable information, socio-cultural, and educational environment for the sustainable development of the country's nuclear industry. The BelNET main purpose as an information system is the popularization of nuclear knowledge to attract the most capable young people in this field and create a positive image of nuclear power [8, 13].

The portal contains now over 1500 original scientific, training, and information materials. The content of BelNET includes a glossary, thesaurus, monographs, textbooks, scientific papers, presentations, materials of international scientific conferences, video films. There were developed original analytical reviews of terms "Physics of ionizing radiation" and "Dosimetric units", that consider a large number of regulatory documents. It was created a cycle of laboratory works for junior students at universities and schoolchildren devoted to physics of passage of ionizing radiation through matter. Content in the field of nuclear knowledge management includes original lectures in Russian and English, training modules "Nuclear Knowledge Management" and "Nuclear Power as a Factor of Sustainable Energy Development". They are developed in podcasting technology and include lectures in the form of audio and video files, laboratory works, and tests for them. The chemical sector of the portal contains original specialized materials in Russian such as lecture courses "Water-chemical regime", "Radiochemistry", "Radiometry". The materials of the Universal laboratory complex on nuclear physics for students-physicists have been posted at BelNET too.

In 2020, in the section "Science" the following new subsections were created: Leading scientific centers, Leading scientific journals, COVID-19 pandemic. At least 2 times a week, links to important world news in all the fields of nuclear knowledge are published.

The number of visits to BelNET, according to the visit counters installed on the portal, reaches five thousand during last year from many countries of the world: Russia (38 %), Belarus (18 %), Ukraine (10 %), United States (4.3 %), Germany (1.4 %), Kazakhstan (1.4 %), Moldova, Armenia, Turkey, Lithuania, Czechia, Bulgaria, and other countries.

The taxonomy (hierarchical structure) of BelNET is rather complicated [13]. The sitemap has now the following structure:

<u>Main Page</u>
About the Project
New arrival
Recommended to read
Team of developers
Sitemap
<u>Information center</u>
Legislation
Basic principles
Science
Practice
Training courses
Biographies of Belarusian scientists
<u>Collaboration</u>
News
Useful links
Forums
Resources
Contacts

Section *"Nuclear Education and Training"*, links to which are located in each section, subsection, etc. till each point of the lower level of the portal taxonomy (Fig. 3) is intended for a quick jump to necessary information and has the following top structure:

Nuclear physics
Nuclear energy
Nuclear physics methods
Nuclear and radiation safety
Registration and analysis of ionizing radiation
Nuclear materials
Nuclear and radiochemistry
Radioactive materials
Water chemical regime of NPP
Nuclear knowledge management
News
Basic principles
Science
Practice
Legislation
Training courses
Contacts
Biographies of Belarusian scientists
Forums

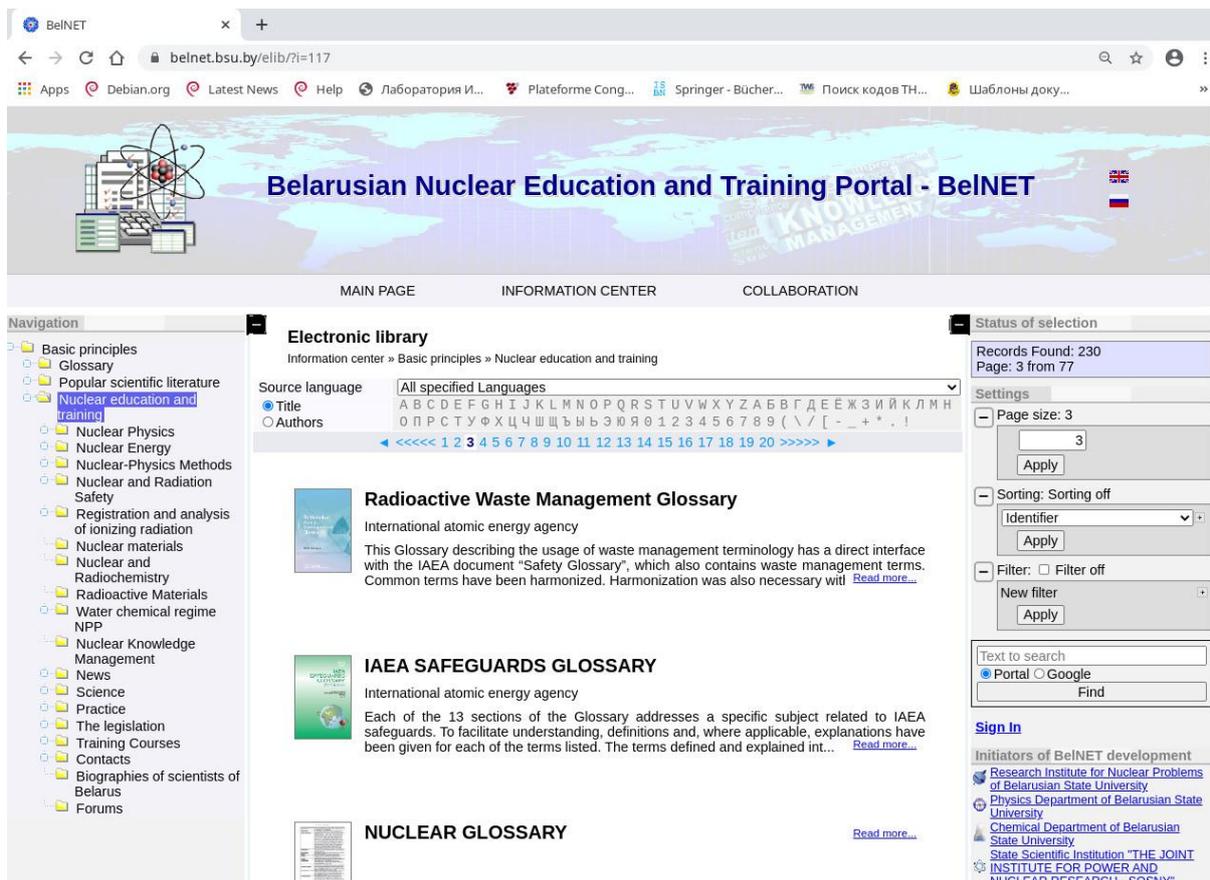Each item here has the next complicated structure.

Fig. 3. Screenshot of page "Basic principles" with the section "Nuclear Education and Training".

## 5. Conclusion

Framework eLab based on free software was used for different information systems in the field of nuclear knowledge management.

The intellectual information system of Gosatomnadzor employees for monitoring (supervision) in the field of nuclear and radiation safety eLab-Control was developed. Currently, at the level of the Belarusian regulatory body Gosatomnadzor, the system eLab-Control is used for all accounting of sources of ionizing radiation, accounting of nuclear material

with reporting to the IAEA as well as supervision of the construction of the Belarusian NPP.

The original Belarusian content management system eLab-Science has been developed to create educational and scientific portals of various profiles. On its basis, a specialized electronic portal of nuclear knowledge BelNET was developed. At present, BelNET is the only major scientific and technical information resource in the field of nuclear knowledge in the Republic of Belarus. The BelNET goals and objectives implement the IAEA's approaches to nuclear knowledge management.

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**БІЛОРУСЬКЕ ПРОГРАМНЕ ЗАБЕЗПЕЧЕННЯ ДЛЯ МЕНЕДЖМЕНТУ ЯДЕРНИХ ЗНАНЬ**

Представлено огляд білоруського програмного забезпечення для менеджменту ядерних знань. Він включає в себе систему eLab-Control – інформаційну систему моніторингу ядерної і радіаційної безпеки національного ядерного регулюючого органу, а також систему управління контентом eLab-Science і білоруський освітній портал ядерних знань BelNET, створений на її базі. Усе програмне забезпечення засноване на вільному програмному забезпеченні: Debian GNU/Linux, веб-сервер Apache, сервер бази даних Firebird, сервер додатків PHP. Система працює під операційними системами Windows i Linux. Робота ведеться через Інтернет у розрахованому на багато користувачів режимі з поділом прав доступу за допомогою широко поширених браузерів. Портал ядерних знань BelNET https://belnet.bsu.by/ розглядається з точки зору менеджменту ядерних знань.

*Ключові слова*: менеджмент ядерних знань, інформаційна система, система управління контентом, портал ядерних знань.