Engineering and Computing Portal to Solve Environmental Problems

A M Gudov a, S Y Zavozkin b, I Y Sotnikov c
Kemerovo State University, Kemerovo, Russia

E-mail: a good@kemsu.ru, b shade@kemsu.ru, c mxtonlife@mail.ru

Abstract. This paper describes architecture and services of the Engineering and Computing Portal, which is considered to be a complex solution that provides access to high-performance computing resources, enables to carry out computational experiments, teach parallel technologies and solve computing tasks, including technogenic safety ones.

1. Introduction

Human-made technogenic environment is known for a lot of potential and real threats that are dangerous for both the environment and human beings themselves. The role and impact of man-made factors on habitat and human beings are necessary to be studied in order to get the system overview.

Coal mining companies can be vivid examples of man-made entities that negatively affect the environment. The development of coal industry enterprises causes the increase in water consumption that is associated with both production and subsequent coal enrichment. As a result, significant increasing of the amount of wastewater is detected, that is considered to be one of the major factors of water pollution. Quite a lot of wastewater components can accumulate in water reservoirs and inside aquatic organisms, causing irreversible effects. Particularly, implementation of highly mechanized complexes with complex hydraulic systems at mines causes large consumption of oil products in the context of mining operations, some of them remain in mine water and further pollute it. Therefore, the development of wastewater treatment methods is currently of great value. To assess the effectiveness of such methods, software tools are needed that provide an opportunity for mathematical modeling of the wastewater treatment process, since field experiments are very labor-intensive. As a result of this modeling, it is determined that one of the most cost-effective methods is wastewater treatment in spent mining workings of flooded coal mines.

Based on the information above, the important tasks are as follows: assessment of a current level of facility technogenic safety, possible threats forecasting and efficiency evaluation of their elimination methods. Specialized software and hardware are usually used to solve such problems. Often you have to deal with a variety of programs, different ways of interacting with them, various formats of input and output data at the same time. Such kind of software is not always open source and publicly available. Commercial products are known for a high license cost to use them. Moreover, computational experiments require high-performance computing resources and technologies.

Cloud computing model can be used in order to reduce the cost of computing experiments, so the payment is required only in case of software renting and computing resources usage. Taking into consideration this model, the Engineering and Computing Portal has been developed at Kemerovo State University, which provides a set of services for solving science-intensive tasks, including those related to technogenic safety [14]. Access to the following services is currently available:

– The "Onlide" service [15,16] for the development of own serial and parallel programs. Here are the main system functions: design of multi-file program projects; available initial code uploading and downloading the one created by using the system; compilation and launching on the proposed computing resources, including high-performance resources; saving program results to a user's workstation. It also has a debugging service for parallel programs, based on the automated control of
the correctness approach. Users have the opportunity to independently determine the situations in the MPI program that are supposed to be detected by the system.

- Service for managing a user's file storage. Calculation results, user program outputs as well as software projects are stored in a dedicated storage for each user.

- Service for solving the problem of mine flooding that uses a multiparameter mathematical model that allows studying the processes of flow, distribution and settling of non-dissolved impurities, taking into consideration the possibility of changing the mine working form due to sediment accumulation [13]. The service enables to carry out numerical experiments with possible environmental consequences caused by using flooded underground mine workings as treatment facilities, as well as visualize the results obtained.

- The "Virtual Laboratory Practice" service [15,16], providing teaching materials devoted to the theory and technology of high-performance computing, as well as virtual laboratory workshops on parallel programming.

2. Architecture

The portal is based on the service-oriented architecture (SOA), used to build distributed systems that provide services for other systems or other services [4]. SOA simplifies the integration of new components to enhance the portal's capabilities. The SOA uses Web services technology [9] based on such standards as: WSDL [11,12] - used to describe the Web service, SOAP [5,6] - represents message format for interacting with the Web service and BPEL [10] - used to describe business processes (orchestration). Business process is a high-level Web service that combines capabilities of the existing ones.

Figure 1 shows the portal architecture. Components such as Liferay Portlet, Apache Axis2, Apache ODE, and LDAP Server will be discussed in more detail in the next section. For the other components, a brief description is given below:

- Client System is any external client system that interacts with Web services / business processes of the portal and / or with the LDAP directory.

- User Client Workstation is a user's workstation. For example, a personal computer.

- Web-browser is a web browser installed on a client's workstation; it is used to deal with the portal web-interface.

- Portal Server is a server computer that hosts the portal.

- Nginx is used as a proxy server, passing requests to other components (Apache Tomcat 7, Tornado and PHP-FPM). Static file (images, JavaScript files, etc.) requests are considered to be exceptions, because Nginx is optimized for this type of query.

- Tornado is a Web server that is used as a platform for the “Onlide” program online development service performance.

- PHP-FPM is a FastCGI process manager used to generate dynamic PHP content for the “Virtual Laboratory Practice” service, because Nginx does not have native support for generating such kind of content.

- Apache Tomcat 7 is a Web application server that provides support for servlet specifications. Here Liferay, Axis2 and ODE are deployed.

- AppGenPortlet is a portlet for generating Web interface of the portal services.

- HPCAdminPortlet is an administrative portlet for managing access to computing resources and resources accounting.

- AuthHandler is responsible for verifying user access to Web services and business processes.

- Artifact HPCWebService is a Web service for interacting with high-performance computing resources.

- StorageWebService is a Web service for interacting with a user's file storage.

- MineFloodingWebService is a Web service for interaction with the program that solves the problem of mine flooding.

- VTKUtilsWebService is a Web service for dealing with VTK format files.
Figure 1. Portal architecture as a UML deployment diagram

3. Solutions used

Information concerning portal users, Web services, business processes, computing resources is stored in the LDAP directory [8]. OpenLDAP open solution is chosen as an implementation.

To integrate the Web-based service approach, Apache Axis2 [1,7] and Apache ODE solutions are used. Apache Axis2 represents the system of integration and management of the life cycle of Web services. The main features of this system are as follows:

- SOAP versions 1.1 and 1.2 support. This feature of Axis2 can be useful in case the client system does not support the latest version of the SOAP protocol;
- WSDL versions 1.1 and 2.0 support;
- A modular structure that provides extensibility by integrating new modules and handlers. Apache ODE is the BPEL business process execution system.

Liferay Portal is a configurable integrated solution for building Internet portals. Liferay enables to integrate existing users from LDAP directories.
All pages of the portal are built by using portlet technology. A portlet is a Web application developed in accordance with the JSR-168 or JSR-286 specification [2,3]. They generate fragments of HTML content that are embedded in a Web page. Such kind of a page can consist of many portlets.

Liferay provides the ability to create personal pages for each user. This feature is used to create a personal user workspace. When registered, a user can be associated with a certain user group. Liferay enables to set personal site templates for each group, which are added to the user's desktop as soon as the user is added to the corresponding group. Moreover, Liferay provides roles that allow to limit user’s access to portlets or ban to perform certain actions on the portal.

4. Services
The descriptions of the already implemented services are presented below.

1) Service for managing the storage of user files.

Each registered user is considered to have his own directory for storing files (results, initial programming codes, images, etc.). There is the service implemented that is used by users to interact with their storages via the portal web-interface. Fig.3 presents its interface.

![Figure 2. Service for user interaction with data storage](image)

2) Service for solving the problem of mine flooding.

The corresponding portal service is implemented for the multiparameter model [13] to solve the problem of mine flooding. This service authoring involves the following stages:
1. Create a new project or open a previously created one;
2. Create a new task or select an existing one;
3. Configure the model parameters (Figure 3), start the task and wait for it to be completed;
4. Start image generation according to the results achieved and wait for it to be completed;
5. Result visualization (Figure 4).
A user can finish the work with the portal and use the service later when starting a task and visualizing results. The solution results can be downloaded from the server by using the service itself, or via the previously presented service for interaction with the storage.

3) «Onlide» service.

This service is used for remote designing of parallel and sequential programs. Here is a list of available functions:

1. Designing of software projects, which can consist of many source files:
   - Projects can be of different types;
   - Various settings can be customized for different types of projects, such as compiler, compilation keys, plug-in libraries, etc.;
   - Templates with already defined type, settings, files, etc can be used to design projects;
   - Projects can be saved on a remote computing resource or client workstation, downloaded from them.

2. Project editing:
   - Downloading files from a user's local workstation;
   - Downloading project files to a user's local workstation;
   - Creating new files;
   - Deleting project files;
   - Viewing and editing project files. Various editors and display methods are available for different file extensions.

3. Compiling and starting a project;
4. Using and creating plug-ins for enhancing functionality of the development environment.

5. Conclusion
The engineering and computing portal is implemented at Kemerovo State University. It is used for computational experiments, teaching theory and technology for high-performance computing. This comprehensive solution is available for a wide range of engineers, students, graduate students and researchers. Portal services as well as computing resources are provided to users on a lease basis. In the future, it is planned to expand the list of computing services. The CFD Phoenics solution in the form of services is under active integration process.

References
[1] Jayasinghe D. Apache Axis2 Web Services. D. Jayasinghe, A. Azeez; Packt Publishing; 2 edition, 2011. 308 pages
[2] JSR 168: Portlet Specification 1.0. Available at: https://www.jcp.org/en/jsr/detail?id=168
[3] JSR 286: Portlet Specification 2.0. Available at: https://www.jcp.org/en/jsr/detail?id=286
[4] Patterns - Service-Oriented Architecture and Web Services. Available at: http://www.redbooks.ibm.com/redbooks/pdfs/sb246303.pdf
[5] Simple Object Access Protocol (SOAP) 1.1. Available at: https://www.w3.org/TR/2000/NOTE-SOAP-20000508/
[6] SOAP Version 1.2 Part 1: Messaging Framework (Second Edition). Available at: https://www.w3.org/TR/soap12/
[7] Tong K. Developing Web Services with Apache CXF and Axis2. Tong K. – TipTec Development, 2010. JSR 168; Portlet Specification 1.0. Available at: https://www.jcp.org/en/jsr/detail?id=168
[8] Understanding LDAP Design and Implementation. Available at: http://www.redbooks.ibm.com/redbooks/pdfs/sb244986.pdf
[9] W3C. Web Service Architecture. Available at: http://www.w3.org/TR/wsbpel
[10] Web Services Business Process Execution Language Version 2.0. Available at: http://docs.oasis-open.org/ws-bpel/2.0/WS-BPEL-V2.0-OS.html
[11] Web Services Description Language (WSDL) 1.1. Available at: https://www.w3.org/TR/wsdl
[12] Web Services Description Language (WSDL) Version 2.0 Part 1: Core Language. Available at: https://www.w3.org/TR/wsdl20/
[13] A.M. Gudov, S.Y. Zavozkin, I.V. Grigorieva, L.V. Bondareva, V.A. Perminov High Technology Software Web-Tools to Solve Environmental Problems of Coal Region. Proceedings of the XIV International Terpogov Conference "Information Technologies and Mathematical Modeling (ITMM-2015)", Tomsk: Tom., 2015. Part 2. P. 120-124
[14] Goudov, A., Perminov, V., Filatov, Y., Un, L.H., Zavozkin, S., Grigorieva, I., Sotnikov, I. High technology software web-Tools to solve environmental problems of coal region (2017) CEUR Workshop Proceedings, 1839, pp. 61-73.
[15] Sotnikov I. Y. Web-system Paralarea for e-learning and program development in high-performance computing. Proceedings of the XVI All-Russian Conference of Young Scientists in Mathematical Modeling. Krasnoyarsk, Russia. October 28-30, 2015. Novosibirsk: ICT SB RAS, 2015. P. 91-92
[16] Sotnikov I. Y. Development of the Paralarea system for studying the theory and technologies of high-performance computing and its Onlidle subsystem for program development. Collected materials of the All-Russian Scientific and Practical Conference "Information and Telecommunication Systems and Technologies", October 16-17. 2015, Kemerovo. FGBOU HPE "Kuzbass. State. Tech. Un-t them. TF Gorbachev »; Rare: Trofimov I.E. (Editor's note) [and others]. Kemerovo, 2015