Scientific Services Consolidation Methods

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Abstract—The article discusses methods of consolidating scientific services of a digital platform for integrating a set of scientific services for various fields of science for conducting interdisciplinary research. Solutions for creating consolidated services can be widely used for multilevel, multiscale modeling in the field of materials science, which provides complex modeling at several levels of the hierarchy. Currently, this problem is being solved by creating multicomponent hierarchical software systems on corporate computing systems. With the advent of high-performance cloud computing platforms, it will be possible to order services for solving particular modeling problems as a scientific service. In this case, the tasks of complex hierarchical modeling will be solved by a consolidated service—a service providing sequential-parallel execution of complex modeling components in the form of specialized scientific services. The description of the processes for the provision of scientific services is based on the research methodology and is a research plan (the work process mapping), which describes a set of operations related to time and includes a list of necessary resources for their implementation. In modern conditions of the development of a microservice approach to the creation of computing systems and the evolution of the Service Oriented Architecture and of the Enterprise Service Bus integration, special attention is paid to the problems of efficient integration of platform services. The paper proposes to supplement the existing description of a scientific service with the possibility of ordering a third-party service based on agile integration. This approach will allow at the present stage of development of service architectures to overcome the shortcomings of centralized systems such as Enterprise Service Bus and take advantage of the elasticity of cloud computing and a microservice approach to creating information and computing systems.

Keywords: consolidated service, multiscale modeling, multilevel modeling, digital platform, cloud computing, scientific service, service integration

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INTRODUCTION

The concept of multiscale modeling, which integrates multilevel methods for modeling the behavior of materials, is widely used in materials science and technology of new materials [1]. The need for complex modeling at several levels of the hierarchy requires the creation of multicomponent hierarchical software systems to solve the problems of multiscale computer modeling of the structural properties of various materials. Such systems use various software tools that provide effective modeling of the properties of materials at a certain level. An important task in these systems is the development of software tool binding technologies and a comprehensive interpretation of modeling results [2].

Along with the process of creating hierarchical software systems for multiscale modeling, digital platform technologies that offer services, including in the field of mathematical modeling of material properties are being improved.

One of the ways to integrate multiscale modeling tools is to use the properties of a digital platform in a cloud computing environment. A platform approach for integrating a set of scientific services aimed at a comprehensive solution to a scientific problem using a series of tools is to combine scientific services within one consolidated service.

In general, insufficient attention is paid to the problems of integrating resources for scientific research and services within the digital platform, including the presentation of linked set of scientific research processes set for cloud-based digital plat-
form. Most providers offer unrelated simulation tools using SAAS (software-as-a-service) technology to solve one simulation problem. In this paper, we propose methods for representing consolidated services in a cloud computing environment based on the theoretical and practical development of a digital process model for representing multiscale modeling processes as a scientific service of a digital platform. An agile integration [3] is proposed as the main tool for consolidation of modeling services, which allows us to overcome the shortcomings of the Enterprise Service Bus and take full advantage of cloud computing [4] under the current conditions of the evolution of the Service Oriented Architecture for software components integration.

CONSOLIDATED SCIENCE SERVICE

A digital platform’s scientific service is understood as a combination of processes and resources for carrying out research work by providing consumers with equipment, supplies, information and communication and providing resources, products of intellectual scientific activity, human resources, the result of which is research [5].

To describe the processes associated with the implementation of the scientific service, the platform provides a tool for creation of a research process mapping (research plan). The research plan lists the operations necessary for the execution of the service, their duration, sequence of execution and consumed resources, as well as information forms for filling out an application for the execution of a scientific service and its order. In the simplest case, the research process is described by a Gantt chart (or its analogue) with an indication of the schedule of operations and the resources necessary for their implementation — equipment, materials and labor. Currently, many digital platforms do just that. However, it is obvious that a complex research uses the results of several research teams. These results can be formatted as separate scientific services and integrated into a consolidated service. To this end, it is proposed to provide for the inclusion of references to the used scientific services in the research plan.

With the development of information system architectures from monolithic systems to microservice [6, 7], solutions for integrating cloud services and problems of describing the consolidation of services in an information system are receiving increased attention. In modern conditions, the success of modeling (and research in general) depends on the ability of an information system to process large flows of information of an evolving structure efficiently and in a given time. Models extract information from a variety of sources, integrating it for the necessary subject processing and obtaining the desired result. Along with the evolution of a service-oriented architecture model [8], tools for integrating information systems are developing. Currently, there is a gradual transition from the concept of a centralized Enterprise Service Bus [9] to the concept of agile integration [10].

The basis of the concept of agile integration is the decentralization of ESB, the use of modern service integration tools based on program interfaces (APIs), implemented in microservice systems (REST, gRPC, etc.) [11]. Integration runtime is created in accordance with advanced container technologies for virtualization and cloud computing infrastructure management. The main properties of agile integration are:

—container integration environment—each application integration takes advantage of the multi-layer architecture of microservices, is performed by separate containers with its own runtime environment configured for this integration;
—decentralized integration—integration containers operate independently of each other, which increases the reliability of the integrated integration system;
—fine-grained integration—the integration container interacts with a series of microservices, which increases the flexibility and scalability of the information system.

Using the properties of agile integration, a cloud-based digital platform should provide integrated network forms for organizing scientific, technical and innovative activities. A digital platform, in this case, is a set of automated processes of interaction between participants in a scientific and technical process based on the use of scientific services and methods of their consolidation, which increase the effectiveness of scientific research through the use of digital technologies and the provision of a common information space.

SERVICE CONSOLIDATION SYSTEM IN A DIGITAL PLATFORM

Based on the results of the analysis of multiscale modeling processes, the following methodology can be proposed for organizing the work on creating a consolidated scientific service.

Step 1. Development of a target function for a consumer of a consolidated scientific service, which contains a description of what is required of a scientific service from the point of view of its consumer. At this stage it is necessary:

—identify the main goals of consumer modeling (and research in general);
—specify the tasks requiring solutions;
—formulate proposals for the consolidation of existing cloud services.

Step 2. Development of a model of the organization of work to obtain a result including the structure of resource consumption and costs. The model should contain decisions on the use of basic resources—personnel, used technologies, equipment, information
resources, channels of interaction with partners and consumers, etc. In addition, solutions should be presented in the model for key research organization processes, aimed at ensuring that the scientific service can be constantly offered in the required volume in accordance with a certain system of functional indicators, rules and norms for organizing processes.

Step 3. Analysis of the developed model of the functioning of the consolidated scientific service, comparison with the existing model of research. The rationale for the decision that a scientific service can be provided in the existing organizational structure of a digital platform, or a well-developed alternative to the formation of a new structure in a digital platform to provide a consolidated scientific service.

Under conditions of complex processing of large flows of information within the framework of a digital cloud computing platform, there are two possible ways of linking one or more services into one consolidated scientific service.

In the first case, the application process for the provision of a consolidated service is carried out on behalf of its consumer for all scientific services that are part of the consolidated scientific service. The consumer fills out the order form and agrees the research plan with each of the service providers independently.

The second way to provide a consolidated service involves the development of a generalized order form for it. The process of coordination of the components of scientific services is conducted on behalf of the supplier of the consolidated service as part of the coordination of the research plan between the consumer and the supplier.

The first way to consolidate scientific services does not involve major changes in the algorithms for ordering, tracking processes for providing services and obtaining research results. However, this method of ensuring the implementation of the consolidated service requires the consumer to have competencies to order all the scientific services that make up the consolidated service and link their results to a single study. In this way, it is quite simple to solve the problems of organizing research and the distribution of responsibility between suppliers and consumers of consolidated services. One consumer of a consolidated service has organizational relations with all suppliers of scientific services that are part of a consolidated service.

In the second method of organizing the provision of a consolidated service, a service consumer interacts only with the provider of this service. The suppliers of scientific services that are part of the consolidated service interact with the supplier of the consolidated service, which must have the competencies necessary to order these scientific services. This method of organizing a consolidated scientific service involves a greater degree of linking the consolidated service with the services that are part of it in terms of analyzing the results of the provision of these services and generating the initial data for their order.

Thus, each of the ways to integrate scientific services has its own advantages and disadvantages. For a digital research platform, it is advisable to use both methods. For both methods of forming consolidated services, the digital platform should have adequate tools for describing the consolidated service and managing the process of its provision.

The flow chart of a scientific service should allow it to include operations of providing a third-party scientific service with an indication of the consolidation method and attributes of the service order and obtaining its results, as well as the processes for using these results when performing a consolidated service.

Based on the above considerations, a digital platform consolidating scientific services should be created as a hierarchy of microservices operating in the environment of a cloud integration platform. This allows you to take advantage of cloud computing, ensuring the elasticity of the integration information system, a high degree of adaptability to changing operating conditions, to reduce the modeling time and increase its efficiency.

Given the above aspects, we define the composition of the digital multi-scale modeling platform as a combination of the following components:

- a system for describing scientific services;
- a system for publishing a scientific service;
- system of classification of scientific services;
- search system for scientific services;
- a system of ordering a scientific service;
- system of planning and accounting of resources;
- a system of recording results and expert evaluations;
- user access system;
- integration subsystem.

The system for describing scientific services is the basis of the scientific services provision system and is intended for the specification of the scientific service template that defines its following main characteristics:

- identification data;
- data of the service provider;
- service order form;
- a research plan with an indication of the resources consumed;
- procedures for ordering a service and agreeing on changes in the of research plan.

The system of publishing a scientific service within the framework of the portal gains access to the register of scientific services available for order, and ensures the systematization of “cognate” scientific services.
The system of classification of scientific services is designed to group scientific services in accordance with specified criteria (field of study, research methods, instrument base, territorial and organizational affiliation, etc.) in order to ensure quick relevant search and systematization of scientific services. Given the dynamism of scientific research, it is advisable to create a classification system with a variable list of criteria and a dynamically tunable grouping system.

The search system for scientific services is designed to find “cognate” scientific services using the classification system of scientific services and these systems for describing the scientific service, taking into account the results and expert estimates. In the system, it is advisable to design blocks for searching for “cognate” services using artificial intelligence methods with self-learning elements.

The system of ordering a scientific service is designed to formalize contractual relations for the provision of scientific services during the process of selecting and ordering scientific services in collaboration with publishing, search, description of scientific services, planning and accounting systems.

The system of planning and accounting of resources is intended for maintaining a register of resources (personnel, equipment base, consumables) and their status, as well as a calendar for loading and reserving resources.

The system of recording results and expert evaluations is designed to accumulate scientific results obtained by users of the platform, as well as to objectively calculate their performance indicators.

The user access system is designed to record, identify and authorize users.

The integration subsystem is designed to implement end-to-end business processes in the common information space of a digital platform, including the operation of consolidated services.

Integration is the basis of a digital platform that connects all its systems, as well as ensuring the functioning of a digital process model for representing a number of scientific research processes as a cloud service or a complex of services integrated into a consolidated service. The proposed mechanism for integrating scientific services provides, in particular, the needs of multiscale modeling in a high-performance computing environment of a digital platform [12, 13]. The advantage of this approach is the use of the concept of agile integration, which allows us to take full advantage of the elasticity properties of cloud computing in modern conditions of evolution of a service-oriented model of interaction of software components.

CONCLUSION

Providing a consolidated service designed to solve a scientific problem requires an integrated approach. The approach includes a description of atomic microservices; metadata describing how to obtain services and transfer results; service orchestration tools. A digital platform can be the basic foundation for creating a consolidated service. Using a single registry of services, management tools for the integration of processing and internal data exchange allows you to create a chain of services. Such chains or service networks can provide a fundamentally new service for processing data and obtaining scientific results.

In particular, in the field of mathematical multiscale modeling of material properties, the presented technology allows multilevel hierarchical calculations using specialized software tools by various teams of researchers in an individual execution environment of productive virtual computing systems.

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