The Method of Engineering Tasks Composition on Knowledge Portals

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***Abstract*—The paper presents an approach to engineering tasks composition on engineering knowledge portals. The specific features of engineering tasks are highlighted, their analysis makes the basis for partial engineering tasks integration. The method of engineering tasks composition is developed that allows to integrate partial calculation tasks into general calculation tasks on engineering portals, performed on user request demand. The real world scenario "Calculation of the strength for the power components of magnetic systems" is represented, approving the applicability and efficiency of proposed approach.**

Keywords—engineering task, knowledge portals, composition, parameters.

I. Introduction

Nowadays one of the major trends in the development of content management is moving from simple structure web-sites to large integrated portals of corporate knowledge. These portals contain a description of the different scientific, engineering or industrial tasks, information about methods of solving or providing services to implement them. Knowledge portal is an integrated portal designed to provide meaningful access to structured data and portal knowledge. Knowledge portals can be devoted to different subject domains. The knowledge portals that represent information on engineering subject domain (radio engineering, chemical industry, strength of materials, aerospace industry, materiology, casting manufacturing, etc.) are called engineering knowledge portals. The environment of such portals allocates great amount of different engineering tasks (ETs). This allow portal users to carry out real-time calculations related to the portal subject domain.

The main problem is the lack of a method of engineering tasks composition that will set the sequence of engineering tasks that should be included in complex engineering task on users demand. The use of such method for the engineering knowledge portals designing will ensure the efficiency of engineering tasks performance and improve the automation level of their composition.

This paper describes a novel method of knowledge portals engineering tasks composition, allowing to reduce the time of their performance as well as to automate the process of their interaction.

The paper is structured as follows: Section 2 provides the analyses of existing approaches to Web-services composition used for the performance of engineering tasks. Section 3 contains the description of engineering tasks characteristic features. Section 4 describes new method of engineering tasks composition. Section 5 highlights evaluation results, the evaluation has been applied using a real-world scenario within subject domain "Strength of materials". Section 6 concludes the work with a summary and outlook on future work.

II. Background and related works

Since the environment of engineering knowledge portal concentrates a large amount of information and software resources, the portal development platform should provide the ability to display these resources in different formats and the ability to integrate the applications for displaying of information resources using the means of workflow formation. Portal's workflow can be considered as means to automate the execution of tasks sequence related to the engineering tasks implementation.

Web Service Composition is a method to connect different web services that are used for creating high level business architecture by compiling of web services in order to provide functionalities that are not available during design [1]. Consequently, there is a possibility to develop a new functionality by simply reusing of components that are already available but unable to complete a task successfully on their own.

Various authors classify different WSC approaches:

- Static and Dynamic Composition ;
- Model Driven Service Composition;
- Declarative Service Composition;
- Automated and Manual Composition;
- Context-based Service Discovery and Composition.

The ability to select and compose heterogeneous Web services over the Web efficiently and effectively at runtime is an important step towards the development of the Web service applications [2]. By utilizing Web services end user is able to create composite services to fulfil the requirement when single service unable to do it.

Most of the approaches related to the Web service composition [3, 4, 5, 6] realized the fact that the prerequisite tasks to generate the composition solution are the service discovery and service selection of the candidate Web services stored in the service repository.

Semantic web services [7,8,9,10] provide an open, extensible, semantic framework for describing and publishing semantic content, improved interoperability, automated service composition, discovery and invocation, access to knowledge on the Internet [11].

Automatic Web service composition consists of four phases: Discovery, Planning, Selection, and Execution [12]. The first phase involves creating a plan, i.e., sequence of services in desired composition. The plan creation could be manual, semi-automatic, or automatic. The second phase embodies service discovery due to the plan. Planning and discovery are often combined into one step. After discovery of suitable services, the selection phase starts. It embodies a selection of the optimal composition from the available combinations of web services judging on nonfunctional properties like QoS properties. The final phase involves executing the services due to the plan. If some service is not available, another one takes it place. Concerning ET performance on engineering knowledge portals the most time-consuming is the phase of Discovery. As it is in need to choose from ETs variety only those that are to be composed for complex engineering calculation performance [13].

III. The characteristic features of engineering tasks

This section offers the detailed description of engineering tasks, their peculiarities and types. All engineering tasks can be divided into 2 types: complex and partial. Complex engineering tasks consist of partial and allow to perform complex engineering calculations. Partial engineering tasks allow only to determine certain feature or parameter and they do not show overall picture of how to perform engineering calculations [13]. In the process of complex ET formation the composition of partial ETs is held. Thus, to improve the efficiency of ETs performance on the engineering knowledge portals it is necessary to reduce the time of partial ETs composition as well as to automate the process of their composition.

Let us describe characteristic features of ETs that influence on their effective execution on the engineering knowledge portals:

- the decomposition of complex ET into partial ET;
- hierarchical subordination of ET;
- usage of the same partial ET in different complex ET;
- dependents of the ET execution order from their topic, parameters and characteristics;
- different directivity of ET.

One of the main problem with ET representation on knowledge portals is the description of their parameters (basic loading, winding radius, critical length, maximal diameter, etc.) that form the basis for partial ET integration.

Partial ET structure is similar to the complex ET structure and includes ET name and parameters. Search of the partial ET, to be included into the complex ET may be based on comparing of ET parameters, as complex ET includes only those partial ETs that have common parameters or parameter ranges of values overlapped. The formal description of partial and complex ETs sets is given below.

Let the set of complex ET to be:

$$ET^c \ni ET_k^c, ET_k^c = \left\langle T_k^{cET}, p_{gk}^{cET} \right\rangle \quad (1)$$

where

ET^c–complex ETs set,

ET_k^c–k-th ET from complex ETs set,

T_k^{cET}–title of k-th ET from complex ETs set,

p_{gk}^{cET}–q-th parameter of k-th ET from complex ETs set.

Partial ETs set is:

$$ET^p \ni ET_l^p, ET_l^p = \left\langle T_l^{pET}, p_{tl}^{pET} \right\rangle \quad (2)$$

where

ET^p–partial ETs set,

ET_l^p–l-th ET from partial ETs set,

T_l^{pET}–title of l-th ET from partial ETs set,

p_{tl}^{pET}–t-th parameter of l-th ET from partial ETs set.

As discussed approach deals with engineering tasks of knowledge portal, assume that each ET is uniquely identified by set of its parameters. It means that two ET with the same parameters could not have a different semantic in what they do and meanings of partial and complex ETs parameters could be used for partial ET integration into the complex one. Using such formal description, specific method can be used to automate ET composition.

IV. The method of engineering tasks composition

Proposed in section 3 allows to develop the method of ETs composition, allowing correctly and dynamically generate a sequence of partial ETs that are in need to be included into the complex ET when the portal is functioning.

ETs composition using proposed method can be presented as an ordered tree. Whereas the ordered tree is a tree with a root, which defines the order of child nodes, the usage of ordered tree for representation of complex ET composition process will specify the sequence of partial ETs included in a complex one execution.

The stages of proposed method are represented on Fig.1.

Stage 1. Comparing ET parameters.

At the first stage it is in need to discard from the set ET^p those ETs, for which p_{tl}^{pET} is not equal to p_{qk}^{cET}. It is in need to compare and select those partial ETs which parameters match the complex ET parameters. It is necessary to analyze the partial ETs set and choose from it those ETs, which parameters match the complex ET parameters according to the rule:

$$p_d^{cET} = \cup_i^m p_i^{pET} \quad (3)$$

whereby possible the fulfilment:

$$p_i^{pET} \cap p_j^{pET} \quad (4)$$

where $i, j = \overline{1, m}$

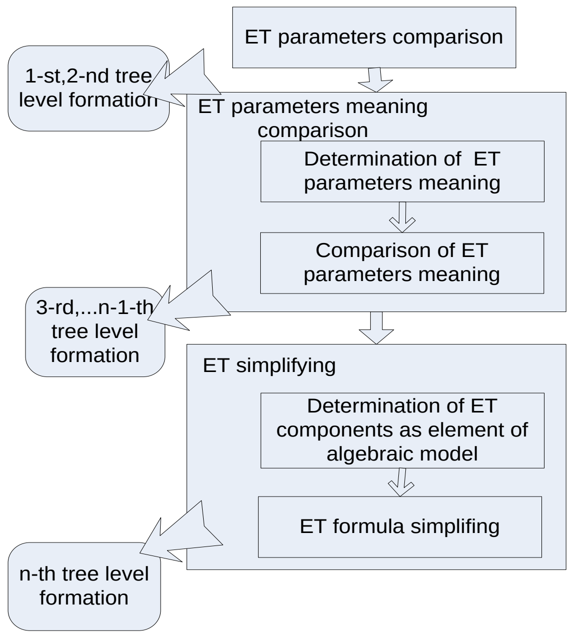

Figure 1. Stages of ETs composition method

The result is a subset of partial ET set satisfying the rule (3) and complex ET tree with second level tops, which are elements of this subset.

Stage 2. Checking ETs parameters values.

It is necessary to compare meanings of p_{tl}^{ET} to cut the subset of partial ETs, that has common parameters but their meanings are not equal. The comparison is done based on the occurrences or equality of these parameters meaning range of values.

Thus, on the second stage ETs parameters values from partial ETs set, formed on the first stage, are compared to complex ET corresponding parameters. The comparison is held due to the rule:

$$M\left(p_{il}^{ET}\right) <> M\left(p_{jr}^{pET}\right) \quad (5)$$

under the condition that $p_{il}^{ET} = p_{jr}^{pET}$

Stage 3. Simplifying ET formula.

The third stage operates with specific rules and operations to represent the formula of ET (described using specific algebraic model) in minimized form. Such simplifications rules are based on properties of operations [14, 15].

The resulting complex ET tree can be saved in the knowledge base as a pattern for further use with the possibility of its modification. It can be modified using standard operations on trees.

Presenting the complex engineering tasks in the form of tree structure allows to process each node of the tree, which represents a different partial ET, simultaneously, avoiding tree branches, which are independent of each other, which will minimize time for complex ET composition.

V. Example of the complex engineering task composition

To confirm the efficiency of the proposed method the test group of complex ETs for problem domain "Strength of materials" was selected. Let us show the example of complex ET from the test group formation using proposed method. This ET is "Calculation of the strength for the power components of magnetic systems". At the 1-st stage the analysis of partial ETs set was done. It was in need to choose from this set only those partial ETs that satisfies condition (5). Such ETs are:
–calculation of basic parameters – ET_1^p ;
–verifying calculation – ET_2^p ;
–strength calculation – ET_3^p ;
–critical constant calculation – ET_4^p ;
–resistance calculation – ET_5^p ;
–resistance calculation – ET_5^p ;
–calculation of reducing the strength of welds – ET_7^p ;
–calculation of flanges, rings and fasteners – ET_8^p ;
–calculation of static strength – ET_9^p ;
–calculation of stability – ET_{10}^p ;
–calculation of cyclic strength – ET_{11}^p ;
–calculation of crack resistance – ET_{12}^p ;
–calculation of voltage variation – ET_{13}^p ;
–calculation of seismic impacts – ET_{14}^p ;
–calculation of the vibration strength – ET_{15}^p ;
–calculation of the limiting value of deformation– ET_{16}^p ;
–calculation of the vibration stability – ET_{17}^p .

Formed complex ET tree is shown on Fig. 2. The root node show complex ET: ET_1^c – "Calculation of the strength for the power components of magnetic systems", intermediate nodes are ETs: ET_1^p – "Calculation of basic parameters" and ET_2^p – "Verifying calculation", leaves are the rest described ETs.

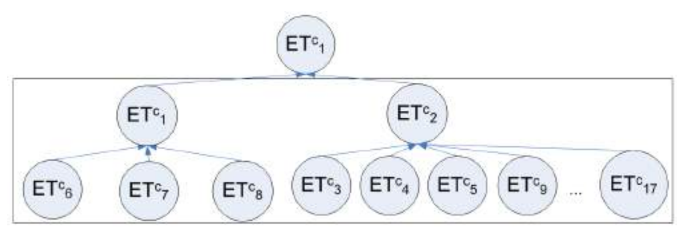

Figure 2. Complex ET tree after first stage

At 2-nd stage, the comparison of ETs parameters meanings was held according to the rule (5). Some partial ETs were discarded from the set formed on the first stage, as some of their parameters are out of range of values with values of the same parameters of general ET. The following ETs were discarded:
–critical constant calculation – ET_4^p ;
–calculation of stability – ET_{10}^p ;
–calculation of cyclic strength – ET_{11}^p ;
–calculation of voltage variation – ET_{13}^p ;
–calculation of the vibration stability – ET_{17}^p .

Complex ET tree after 2-nd stage is shown on Fig. 3. Tree includes the same nodes and leaves as tree represented on Fig. 3, but ET_4^p, ET_{10}^p, ET_{11}^p, ET_{13}^p, ET_{17}^p – were removed from the tree as the result of the 2-nd stage.

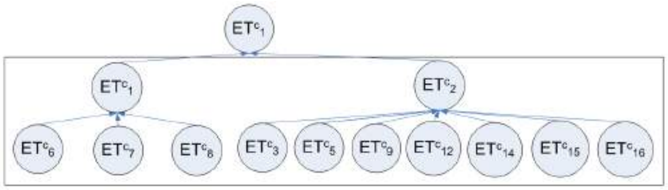

Figure 3. Complex ET tree after 2-d stage

VI. Conclusions

The paper presents method of engineering tasks composition on engineering knowledge portals. Proposed method of engineering tasks composition allows to integrate partial engineering tasks into a complex one on engineering knowledge portal, performed on user's request. It also allows to represent the process of complex engineering task composition as ordered tree that improves the efficiency of their performance through parallel processing of independent tree branches.

Future work is aimed on implementation of suggested method to different types of complex engineering calculation tasks. This will allow to approve its applicability and efficiency on real world scenarios. Developed software tool will be tested and verified on real world scenarios when engineering knowledge portals are developed. Quantitative evaluation of the proposed approach and tool efficiency will be obtained for different subject domains: the average time of engineering task composition, engineering tasks correctness and quality will be validated.

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МЕТОД КОМПОЗИЦИИ ИНЖЕНЕРНЫХ ЗАДАЧ НА ПОРТАЛАХ ЗНАНИЙ

Глоба Л.С., Новогрудская Р.Л.

В статье предложен подход к композиции инженерных задач на инженерных порталах знаний. Описаны характерные особенности инженерных задач. Разработан метод композиции инженерных задач, который позволяет интегрировать простые инженерные задачи в общий расчет на порталах инженерных знаний. Предложено описание процесса формирования общего расчета "Расчет на прочность силовых элементов магнитных систем ИТЕР который подтверждает повышение эффективность композиции простых расчетных задач при использовании предложенного метода.