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SERVICE-ORIENTED ANALYSIS OF REORGANIZATIONAL CHANGES

The paper suggests using service-oriented nature of enterprise architecture to analyze reorganizational projects and to develop patterns of implementing such projects. The paper presents stepwise algorithm of service-oriented analysis of architecture solutions and adaptation of well-known models for setting service requirements for different enterprise architecture layers.
Keywords: *enterprise architecture; service-oriented; reorganizational projects.*
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СЕРВІС-ОРІЄНТОВАНИЙ АНАЛІЗ АРХІТЕКТУРНИХ ЗМІН

У статті запропоновано використовувати сервіс-орієнтовану природу архітектури підприємства для аналізу реорганізаційних проектів та розробки варіантів реалізації таких проектів. Представлено алгоритм проведення сервіс-орієнтованого аналізу архітектурних рішень, а також запропоновано варіант адаптації відомих моделей до визначення вимог до сервісів різних шарів архітектури підприємства.
Ключові слова: *архітектура підприємства; сервіс-орієнтований; реорганізаційний проект.*
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СЕРВИС-ОРИЕНТИРОВАННЫЙ АНАЛИЗ АРХИТЕКТУРНЫХ ИЗМЕНЕНИЙ

В статье предложено использовать сервис-ориентированную природу архитектуры предприятия для анализа реорганизационных проектов и разработки вариантов реализации таких проектов. Представлен алгоритм проведения сервис-ориентированного анализа архитектурных решений, а также предложен вариант адаптации известных моделей к определению требований к сервисам различных слоёв архитектуры предприятия.
Ключевые слова: *архитектура предприятия; сервис-ориентированный; реорганизационный проект.*

Introduction. Competitive ability of a company highly depends on the quality of goods and services it provides to customers. Quality traditionally means fitness for a purpose and meeting customer requirements. If services meet customer's expectations they are considered to be of required quality, same applies to the company running its business. As customer is the source of requirements to services, he/she is the one, who estimates market competitive ability of a company. Thus, services can be used for estimating different aspects of company's internal organization, the quality of structure and relationship and also quality of the management system overall.

Service concept in enterprise management views company's product as a service for its customers. The set of services, provided to external customers, defines the core business processes of a company. These processes should be carefully defined, analyzed, formalized and managed properly in order to reach the required quality of the final result. The same idea is used for description of collaboration between business services and their IT support within a company or between IT processes and IT infra-

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structure enabling the functionality of IT systems. The enterprise model designed on the service basis is called service-oriented architecture (SOA) (Lankhorst, 2013).

Nowadays companies establish different reorganizational projects in order to implement certain changes to some aspect of their business (business process optimization, organizational hierarchy restructuring, IT solutions implementation, designing new services, upgrading data warehouses and OLTP systems etc.) (Iliashenko abd Shirokova, 2014) or to shift to a completely new business model (Glukhov et al., 2015). Service-oriented approach can be successfully used both for requirements setting and project estimation tool and as the way of selecting projects for a strategic portfolio.

This paper investigates the applicability of service-oriented approach for the analysis of complex enterprise architecture solutions, and also develops an algorithm of service-oriented analysis, proposes appropriate methods and models of service requirement setting for different enterprise architecture layers and describes an actual reorganizational project in which service-oriented analysis was used.

Literature review. SOA originates from IT disciplines but currently has broadened its meaning and content and now defines a management approach to designing the entire enterprise architecture. Nevertheless, service-oriented analysis is still used mostly in the field of information systems and software engineering.

"Enterprise architecture" traditionally refers to a series of different components of a management system and the relationship between them, different definitions can be found in: (MIT Center for Information Systems Research, 2016; Gartner, 2016; Kondratiev, 2007).

According to (Lankhorst, 2013), enterprise architecture is a coherent whole of principles, methods, and models used in design and realization of an enterprise's organizational structure, business processes, information systems, and infrastructure. Traditionally, enterprise architecture is depicted as a layered-structure: business layer, IT layer (application layer), infrastructure layer (technology layer) (The Open Group, 2009). Enterprise architecture has been originally developed as an answer to the problem of the alignment between business requirements and IT infrastructure (Kalyanov, 2011; Lankhorst, 2013). Nowadays it is considered as a mainstream systemc approach to enterprise management. Well-structured business is crucially important for success, especially in a volatile environment (Anisimov et al., 2009).

Service-oriented architecture (SOA) represents a set of design principles enabling units of functionality to be provided and consumed as services (Lankhorst, 2013). The same author reasonably states that the service concept applies equally well to business as it does to software applications. The number of emerged research, concerning service-orientation of different business fields, justifies this opinion (Goldstein et al., 2002; Fitzsimmons and Fitzsimmons, 2000; Illeris, 1997) etc. The importance of service-orientation at the business level of enterprise architecture is highlighted in (Op't Land et al., 2009).

In order to find information on service-oriented enterprise architecture analysis the following databases were searched: Google scholar, IEEE Explore, ScienceDirect, Wiley InterScience, Springer. In addition, the manually conducted search was carried out. The terms "service-oriented architecture", "service-oriented analysis", "architecture solution analysis" were used as a search string. The extraordi-

nary majority of the sources found were devoted to information systems and IT architecture design, software engineering and IT service management. In spite of generally accepted concept of service-orientation of enterprise architecture, methods and approaches of service-oriented enterprise architecture analysis are poorly researched so far.

Problem statement and research objective. Enterprise architecture is a backbone of a company. The model of enterprise architecture is defined from business perspective: business goals, which company intends to achieve, set primary requirements to enterprise architecture. The latter should be stable enough, but at the same time possess a certain level of flexibility and adaptibility to changing business environment and fast developing technologies. The more complicated the enterprise is, the more difficult is the process of implementing changes into its management structure and the more components of this structure should be involved (Ilyin and Levina, 2015). As a result, whatever fundamental architecture elements are, each is more or less temporary (The Open Group, 2009). Such an in-build ability of enterprise architecture to undergo changes is supposed to provide future success to company.

An important feature of enterprise architecture is that it is a coherent whole: individual components can be optimized locally, but that does not mean that a system consisting of them is optimal. Often communications between different areas of one company are not arranged properly, the decision-making system is not coordinated throughout the enterprise. So, despite the growing popularity of the architectural approach, currently there is a certain lack of common language and unharmonized communications between business and IT professionals. This puts serious obstacles to design, simulation, implementation and realization of balanced architectural solutions. In this regard, an important component of organizational efficiency of today's companies is the so-called alignment of various architectural components, in particular – business and IT components. Alignment in this context means ensuring compliance with mutual requirements of various components to each other. Aligned components (architecture layers or particular elements within the same layer) predetermine the creation of a balanced enterprise architecture (Ilyin and Levina, 2013), which ensures effective functioning of company not only in present, but also paving the way to future sustainable development (Ilyin and Levina, 2015). Efficiency in this case cannot be achieved through local optimization – it is required to implement an integrated approach, which takes into account the interconnection and interdependence of business and IT components.

The research objective of this paper is to develop an algorithm for service-oriented analysis of architecture solutions. The latter means a solution of the problem domain that addresses all the involved enterprise architecture layers and elements. In addition, it is necessary to find methods, models or approaches that could be used for service identification for different service layers.

Key research findings. The model of layered enterprise architecture with services as the main link between various layers (Figure 1) has been developed in (Lankhorst, 2013): layers of services are realized by the lower layers and provide some functionality to upper layers. Each layer can have internal services for the same layer components, such as internal application services that are used by applications to provide services to end users. The authors suggest to use service-oriented approach

not only in the analysis of IT projects, but also in the analysis of complex architectural solutions in order to provide the compliance with company's development strategy.

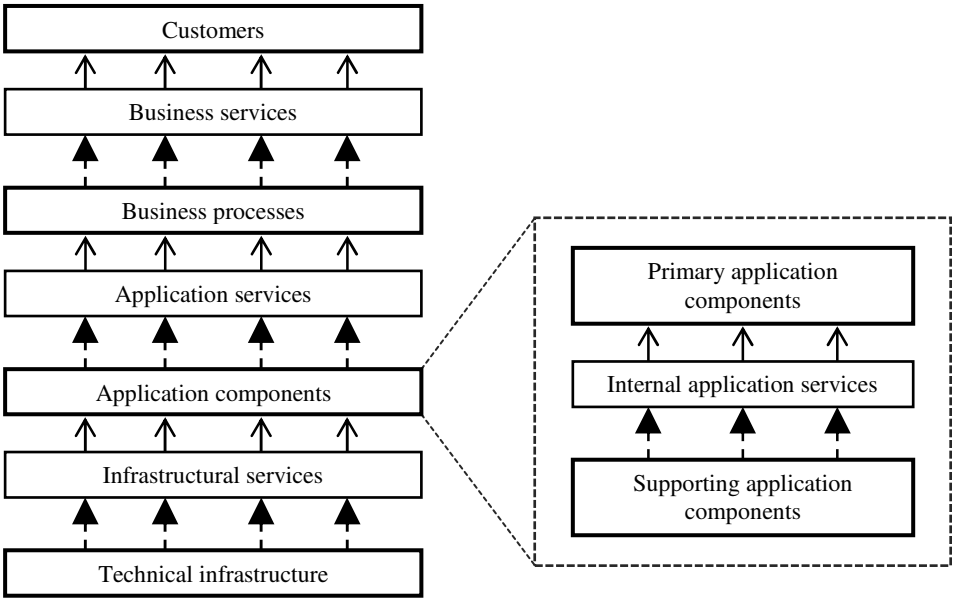

Figure 1. **Model of service-oriented enterprise architecture** (Lankhorst, 2013)

Alignment of various layers in enterprise architecture can be performed by means of reengineering of services provided by layers to one another. Service reengineering involves relevant service requirements setting and providing compliance of services to these requirements. Requirement management is a well-established discipline within IT area (Barmin, 2011). But the common approach to setting service requirements for all enterprise architecture layers do not currently exist. There are separate, widely spread in its domain models and approaches that can be used as a source of service requirements to different layers of enterprise architecture. Application of these models can be an effective tool of architectural layers alignment by service reengineering.

The stepwise algorithm of the service-oriented analysis of architectural solutions can be as follows:

1. Develop an "as is" model of the architecture of the problem domain (in accordance with the model of service-oriented architecture in Figure 1).
2. Analyze the reasons behind the need for a reorganization project within the problem domain; determine which layer of enterprise architecture and/or services of the layer causes this.
3. Develop proposals on solving the problem in a selected layer.
4. Track the impact of the proposals by means of setting new service requirements for all layers of architectural model and develop proposals on reorganization of layers to ensure the provision of new services.
5. Develop a "to be" model of the architecture of the problem domain.

For setting service requirements for different layers the following well-known models can be used. The models, mentioned further, are traditionally used for the problem domain analysis, but the authors of this paper suppose that they perfectly fit for service identification purpose too.

Requirements to business layer services. The main idea of each business can be formalized in a business model – a presentation of how (by means of what) a company intends to make money. One of the most common business model presentations nowadays is those developed by (Osterwalder and Pigneur, 2010). This model can be applied to description and analysis of any business and is widely used by the world-famous companies (IBM, Ericsson, Deloitte etc.). Basing on this business model, company strategy is built and the ways of its implementation are identified.

The business model according to (Osterwalder and Pigneur, 2010) consists of 9 building blocks, which describe 4 main areas of business: customer, value proposition, infrastructure and financial component. The building blocks of the model are (according to the sequence of filling cells of the model): customer segments, value proposition, sales channels, customer relationships, revenue streams, key resources, key activities, key partners, cost structure. The content of each block is defined basing on the content of the previous one. Customer segments are defined first, and then value propositions for each segment are detailed. The latter determines which activities the company needs to perform in order to produce what customers want. Thus, this chain of blocks defines the key business services that company provides to its customers and, as a consequence, core business processes intended to perform these services. Using the business model canvas for setting business service requirements allows aligning market requirements and core business processes through which the company's strategy is implement.

Requirements to application layer services. Aligning of business strategy and IT strategy and corresponding aligning of business and application layers is one of the central problems in enterprise management nowadays. The strategic goal of information technology is to support both the achievement of long-term goals and operational business challenges by means of: information systems implementation; high-quality information support of business processes; improving the IT department organization in terms of efficiency, performance and cost optimization (Osipov, 2008).

IBM approach – the so-called Component Business Model (CBM) – is often used for development of IT strategy and IT service management. CBM represents IT activities as a set of core competencies and components. The set of these components is determined basing on best international practices for IT departments and companies providing IT services (IBM, 2009). Components form a clearly defined group of closely related kinds of business activities. Each component has a mutually exclusive set of activities to achieve its business purpose. Similar to a standalone business, each business component provides and receives business services (IBM Business Consulting Services, 2005). Thus, the defining attribute of a component is the service it provides, rather than the position it occupies or the fixed sequence of steps.

CBM provides a framework for organizing components by competency and accountability level. By employing this framework, executives can begin to envision how current business activities might function as an interlocking set of modules (IBM

Business Consulting Services, 2005). CBM framework is a matrix: columns reflect business competencies, defined as major subject areas with special features and necessary skills; lines correspond to the accountability levels that characterize boundaries and objectives of actions and decision-making. Business competencies are different for each company, accountability levels are prescribed by model developers. IBM CBM is developed and adapted according to the needs and objectives of a particular company.

Another common tool for the application layer requirements setting is an approach based on SWEBoK (Software Engineering Body of Knowledge) (Bourque and Fairley, 2014). One of the areas of expertise described in SWEBoK is an area dedicated to software requirements setting. According to (Bourque and Fairley, 2014), the requirement to software is defined as a property that must be implemented in a software product, in order to solve some real world problems. The requirements depend on a business task: it can be a local automation problem to support particular business processes, or improvement of the existing IT solutions by means of integration of the existing information systems, or elimination of the identified software drawbacks etc.

Requirements to technical infrastructure services. Enterprise information system sets the requirements to technical infrastructure. Each information system has requirements to hardware, which enables information system carry out its functions properly (Ilyin et al., 2015). Technical infrastructure requirements should include requirements on the following components (Stepanets, 2015):

- Engineering systems and structured cabling system.
- Network infrastructure.
- Automatic telephone station.
- Hardware and software.
- Server equipment.
- Systems server virtualization.
- Basic network services based on the TCP / IP protocol.
- Domain and directory service.
- File servers.
- Print servers.
- Database Management Systems (DBMS).
- Management Servers And Protection of Internet traffic.
- Mail servers.
- Unified communications.
- Terminal servers.
- Backup servers.
- Servers antivirus protection.
- User workstations.
- Peripheral appliances.
- Data processing centre (DPC).

Service-oriented analysis application. The service-oriented approach, described above, was used in the process audit project. The project was performed by the authors of this paper under the contract with the Saint Petersburg Metropolitan (hereinafter referred to as Metro), which provides underground passenger transportation in the city. The project was focused on the audit of compressed air produc-

tion and distribution process. Compressed air is an important energy source for Metro, it is produced by electro-mechanical department and is sold to operation departments. The reasons for the project were:

- change of energy efficiency requirements for companies (in accordance with the Federal Law # 261-FZ);
- the need to bring the compressed air system in accordance with the modernized rolling stock, equipment and air distributing system involved in the process of production and distribution of compressed air.

Using the terminology of enterprise architecture, the need for process audit arose for two reasons: on the one hand, the requirements for services provided by business processes to customers have changed, on the other – there were changes in technical infrastructure and there appeared an opportunity to provide higher quality services to the upper IT application layer. To implement such a project effectively it is advisable to carry out a comprehensive analysis of the architecture of the problem domain ("as-is" model), to identify bottlenecks and to provide a comprehensive architectural model of the situation ("to-be" model). Thus, the need to make changes in the services, provided to customers, will entail the need for reengineering of the relevant business processes; new technical infrastructure capacity will require changes to IT processes. The architectural approach means these interrelated issues have to be treated as a whole and a single integrated solution based on the principle of service-oriented architecture alignment has to be developed.

As a result of document analysis and interviews with specialists of the electro-mechanical department and departments, consuming compressed air, the requirements to the business process "Provision of compressed air" were formulated:

- consumers should be provided with compressed air on demand in real time in the required quantity and according to required technical parameters;
- it must be possible to provide compressed air with different technical parameters to different consumers;
- it is necessary to provide accurate accounting of the produced, distributed and consumed compressed air quantity by each customer;
- precise planning of compressed air cost for the future should be enabled by means of correct accounting and appropriate IT support of the planning process.

During the process analysis and modelling, the authors took into account, among others, the business process modelling policy of Metro. It prescribes to classify all processes into 3 groups: primary (core value-adding), secondary (support) and management processes. The following processes and subprocesses within the process "Provision of compressed air" were identified:

1. Core process – "Technological provision of production, distribution and consumption of compressed air":
   1.1. Production of compressed air.
   1.2. Distribution of compressed air.
   1.3. Consumption of compressed air.
2. Support process – "Maintenance of compressed air provision":
   2.1. Maintenance and repair of equipment and distribution networks:
   2.1.1. Maintenance of compressors.
   2.1.2. Maintenance of additional equipment.

2.1.3. Network maintenance.
2.1.4. Operating repairs.
2.1.5. Unplanned repairs.
2.2. Waste Management.
3. Management process – "Management of compressed air provision":
3.1. Registration and accounting of production, distribution and consumption of compressed air:
3.1.1. Registration and accounting of energy resources.
3.1.2. Registration and accounting of maintenance and repairs.
3.1.3. Registration and accounting of waste.
3.1.4. Registration and accounting of compressed air production.
3.1.5. Registration and accounting of compressed air distribution.
3.1.6. Registration and accounting compressed air consumption.
3.2. Planning of production, distribution and consumption of compressed air.
3.3. Monitoring and analysis of production, distribution and consumption of compressed air.

The analysis has shown that the process of compressed air production, distribution, consumption and its technological support was performed satisfactorily, while the management process had certain problems, mostly caused by inappropriate information support of management process. Taking into account the recommendations of the company and the requirements set for the process above, the analysis of the "as is" situation resulted in the following bottlenecks' list:

- Inability to control major operational production process due to the lack of proper information exchange between primary and secondary processes on the one hand and management processes – on the other.
- Duplication of data transfer functions from primary processes to management processes.
- Functionality of information systems, intended to provide information support to "Provision of compressed air" process, are not used properly to support information exchange within the process.
- There are no services and the corresponding interfaces for correct data exchange between information systems (information concerning compressed air production, resource consumption during production, maintenance and repair of equipment, equipment failures is transferred orally or using hard copies).

In order to eliminate the identified bottlenecks and enable the provision of services according to customers' requirements, it was proposed to implement a system of operating management (real-time control) of the "Provision of compressed air" process. In particular, the following general changes to the existing process system were proposed in order to create a "to-be" process model:

- It is necessary to carry out the accounting not only of produced quantity of compressed air, but also of distributed and consumed compressed air in order to ensure monitoring and control over the actual data about the quantity along the whole resource transmission chain from producer to consumer.
- It is advisable to implement a system of operating scheduling, operating monitoring and analysis of the production process, distribution and consumption of compressed air. "Operative" here means getting correct and well-timed data from core

processes by management processes. The ability to implement operating control largely depends on the selected process automation schemes.

- Implementation of operating accounting data will provide management processes with more accurate data on the actual quantity of the produced, distributed and consumed compressed air. This will increase the accuracy of calculations and create preconditions for better planning.

- It is necessary to implement a process control mechanism to monitor the effectiveness of the process. A system of key performance indicators (KPI) can be used as such kind of a controlling mechanism.

The "to-be" process model sets new requirements to the services of information systems involved in the "Provision of compressed air" process:

- It is necessary to integrate production equipment with SCADA, and SCADA with ERP system to provide timely and effective information exchange (in accordance with the developed model of information exchange).

- It is necessary to develop services and corresponding interfaces for transmission, storage and processing of information about the process (in accordance with the developed list of services and interfaces).

The new way of process automation allows:

- efficiently manage the operational conditions of technological equipment (working on current needs rather than on the maximum capacity), which will fulfill the requirements of energy efficiency;

- quickly and automatically transmit information to the accounting information system, which enables real-time analysis and process control, as well as leads to significant reduction of paper document flow;

- get factual data on produced, distributed and consumed compressed air, rather than by indirect methods. It enables calculating more precisely quantity and cost of compressed air for each consumer.

The next step of our analysis was the identification of necessary changes to IT infrastructure level: what are hardware requirements to enable providing new IT services. The analysis revealed the need to organize additional networks to ensure the integration of separate information systems. Capacity of the existing servers will be enough to support these new services of IT systems.

In order to monitor the effectiveness of the reengineered process system and its information support, the following KPI were developed: for core process – direct cost of the compressed air production for the period (per 1 cubic meter), energy consumption for the production of 1 cubic meter of the compressed air for the period; for support process – total cost of ownership of the technological equipment unit; for management process – deviation of the planned cost of compressed air from the actual value for the period.

In summary it can be said that service-oriented architecture analysis helped create an integrated architecture solution for the "Provision of compressed air" process. Thanks to using of this approach not only the bottlenecks in the process were identified, but appropriate actions to address these bottlenecks were developed. Thus, the process audit project resulted not only in reengineering suggestions, but also in new IT support and infrastructure requirements to enable necessary process reengineering. Such a complex architectural solution is balanced from architecture alignment

point of view, that will ensure the effectiveness of its implementation. Since the project was realized in a highly specialized section of the company (only compressed air provision process was in focus), the results of this project will impact the effectiveness of activities in this area only. In the meantime, the results of the project set requirements and may reveal new bottlenecks in the interfacing departments or other processes of the company. In this context, it is more effective to implement reorganizational projects not in isolation, but as part of a larger portfolio of the related projects (Nikolova et al., 2015).

Conclusions and directions for further investigations. Enterprise architecture approach means that a company should be treated as a system – as a coherent whole of the components it consists of. Every system requires a systematic approach to changes implementation. The way to bring changes to company is a reorganizational project. Each project must be considered in the context of and in conjunction with related projects. In practice, a systemc approach to reorganization of certain activities of a company means using a service-oriented architecture project analysis. The paper describes a stepwise algorithm of service-oriented analysis of architecture solution and demonstrates its adaptation for a specific project. This kind of analysis allows tracing the influence of individual changes to the entire enterprise architecture, to take this influence into account while implementing changes, thereby ensuring the implementation of a comprehensive, balanced (in terms of architecture component alignment) architectural solutions. The approach proposed proved its efficiency in a real business case.

As reorganizational projects are usually managed as a portfolio, it is crucially important to manage them together. Mutual influence and interdependency of projects within a portfolio can be aligned by means of service requirements analysis. Service-oriented approach to managing reorganizational project portfolio can be subject for further research.

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