An Open Service Provider Concept for Enterprise Complex Automation

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Abstract. The paper introduces a solution for IT services representation and management in the integrated information space of distributed enterprises. It is proposed to develop an Open Service Provider as a software platform for interaction between IT services providers and their users. Implementation of the proposed concept and approach is illustrated by an after-sales customer support system for a large manufacturing corporation delivered by SEC “Open Code”.

1. Introduction

Intensive application of modern information technologies (IT) at production enterprises with a distributed architecture and complex supply chains motivates to look for new opportunities to increase the efficiency of IT infrastructure organization and management. A traditional approach of IT management is based on the integration of various software and hardware solutions with different functionality, being used to solve concrete problems and implement popular use cases. These solutions can be delivered by different providers, or represent specialized components of a complex platform, supported by one of reputable system integrators. Anyway, the lifecycle of these solutions is usually long and thorny; IT departments need to spend much time and efforts to collect the requirements; choose the best provider; adapt, deploy and integrate the solution; train the users and instantiate appropriate service desks.

At the same time, a significant trend in user’s experience paradigm shift from architectural perception to service-oriented vision can be identified, which is predominantly influenced by using experience of working with the Internet and mobile devices. Users like to get new software features as soon as they become available and get used to permanent changes of a user interface (UI). Therewith, software developers have enough technical opportunities to better understand the dynamics of user requirements change and respectively adapt and modernise IT solutions making early updates.

Consequently, the strategy of IT infrastructure organization and management should be revised. The enterprise integrated information space should become a kind of a virtual environment for evolving software solutions where they meet their users on a competitive basis. Being instantiated in the form of services instead of systems or working places, they better fit the requirements and adaptively react to user behavior changes. To solve this problem, an Open Service Provider (OSP) solution is proposed below, which is inspired by the modern Internet, knowledge driven and multi-agent technologies. The
results are illustrated by the enterprise management situational center delivered by SEC “Open code” that implements the OSP concept.

2. Theoretical background overview

Basic challenges of internal information processes management at modern enterprises and supply chains are concerned with a necessity to support a horizontal interaction between a number of departments with various goals and tasks. In order to consider this factor, matrix organizational architectures are introduced [1]. The use of matrix models is also determined by the big number of projects as this organizational structure is considered the best to support project management activities and share resources between functional structures. A number of theories are studying the control over network organizational structures, for example the theory of hierarchical management describes the problems of decision making under the circumstances of unpredictability [2, 3]. Self-organization in networks applicable for enterprise management is investigated using a Bio-inspired approach [4, 5].

Peer-to-peer (P2P) networks [6, 7] are used in practice to simulate the work inside matrix organizational structures. P2P models are frequently used to describe and simulate interaction processes in organizations with the network structure and autonomous decision makers. Actors, representing employees in the integrated information space, are the peers of the network as they are autonomous enough to make decisions and to use their own resources for project execution.

Despite the role of self-organization, autonomy and an active horizontal interaction of employees at modern distributed enterprises and supply chains, IT departments continue to function according to traditional waterfall workflow. Considering the challenge to integrate various software solutions and data resources into a solid information space, each new idea of business automation is examined giving much attention to detailed analysis of business requirements, implementation features and options, economical efficiency and possible providers qualification. All this work takes much time. So in order to build the IT-infrastructure, the corresponding department collects and registers the applications, purchases information resources, software, soft solutions, deployment, implementation and provides users’ support.

This process has several features. Firstly, the procedure of collecting and recording applications is rather complicated because users do not have full information about the properties and capabilities of existing IT-systems on the market. IT departments must visit the companies, gather information about the possibilities of their systems, and then visit different forums, exhibitions and provide collected information about contemporary soft solutions to users. On this basis, the users create their own vision of the system, and then it can be implemented. Secondly, the described software lifecycle has a limited period of service. It is necessary to provide recycling terms, integration with other software solutions (exchange of data, software interfaces).

At the same time, the modern software provides a high level of autonomy and adaptability, which makes it complicated to maintain. Consequently, IT-specialists spend a lot of time on identification and elimination of various faults and issues. To solve the above mentioned problems, IT departments usually prefer to rely on a single software vendor, that in terms of new opportunities can be behind the new but risky startups. At the same time, startups have some difficulties in entering the market and creating their own customer base.

In order to solve this problem, there is a proposition of a new model of Open Service Provider based on the technologies of business processes automation and self-organization support. The idea and principles are similar and inspired by the intelligent solutions in transportation logistics, the Internet and multifunctional centers [8, 9]. An OSP concept is similar to the idea of «One Internet» governance [10]. The common trend in these areas is virtualization: a web aggregator that collects information about applications from potential buyers and the information about service providers and then links them on the basis of P2P principles is introduced. This web aggregator provides the best options for implementation of services for both sides: buyers (future users) and software providers.
3. A conceptual model and problem statement

Let us consider the parts of the integrated information space built as a result of enterprise complex automation as a list of functional features (IT services) $s_j$, where $j = 1..N_s$ is a number of service.

Each service has corresponding problem domain $d_i$, $i = 1..N_d$: e.g. customers management, product lifecycle management, counting, HR management, etc.

In this sphere, each service requirement can be described by a Boolean variable:

$$r_{i,j,l} = r_{i,j,l}(d_i, s_j, t_i) \in \{0, 1\},$$

where $t_i, l = 1..N_r$ is the $s_j$-order submission time.

The fact of each service delivery is defined by:

$$v_{i,j,l,k} = v_{i,j,l,k}(r_{i,j,l}, g_k, c_{i,j,l,k}, \Delta t_{i,j,l,k}) \in \{0, 1\},$$

where $g_k$ represents a possible service provider (IT company), $k = 1..N_g$, $c_{i,j,l,k}$ – the costs of the service to be delivered, $\Delta t_{i,j,l,k}$ – the period of time required by the service to be delivered, including implementation, integration, testing and QA.

In this model, we assume that multiple providers can implement and deploy one service, which is significant for a business with high competitiveness. The number of options $v_{i,j,l,k}$ generated for each demand is limited by the current service provider capabilities and their core competence.

Options $v_{i,j,l,k}$ are related to each other in resources: the same providers $g_k$ can be used for different services allocation. For two service options $v_{i,j_1,l,k}, v_{i,j_2,l,k}$, $j_1 \neq j_2$, we can also define the relations of:

- sequence $\phi(v_{i,j_1,l,k}, v_{i,j_2,l,k})$, one service requires for its start one or several preceding services to be completed, and
- combination $\psi(v_{i,j_1,l,k}, v_{i,j_2,l,k})$, the services are implemented simultaneously.

Therefore, there is a generated virtual network of services, combined with a network of options $v_{i,j,l,k}$ with transitions of the sequence and relation to one demand or resource.

The proposed model allows formalizing the following challenges of OSP. Firstly, it is necessary to minimize the services delivery costs, which makes the platform attractive for users:

$$C(d_i) = \sum_{j=1}^{N_s} \sum_{l=1}^{N_r} \sum_{k=1}^{N_g} v_{i,j,l,k} \cdot c_{i,j,l,k} \rightarrow \min.$$  

(3)

Next, the operational efficiency and performance of services should be high:

$$T(d_i) = \sum_{j=1}^{N_s} \sum_{l=1}^{N_r} \sum_{k=1}^{N_g} v_{i,j,l,k} \cdot (t_{i,j,l,k}^{fin} - t_{i,j,l,k}^{sm}) \rightarrow \min,$$

where $t_{i,j,l,k}^{sm}$ is a $d_i$ delivery time.

Finally, the individual earnings of each real service provider should also be high, which comes to a certain contradiction with the goal (3):

$$\forall g_k: \sum_{j=1}^{N_s} \sum_{l=1}^{N_r} \sum_{k=1}^{N_g} v_{i,j,l,k} \cdot c_{i,j,l,k} \rightarrow \max.$$  

(5)

The solution of the introduced problem is specified as a set of non-zero values of Boolean variables

$$\mu(d_i) = \{v_{i,j,l,k}(r_{i,j,l}, g_k, c_{i,j,l,k}, \Delta t_{i,j,l,k}) = 1\},$$

(6)

that can be referred to as an IT strategy with cost $C(d_i)$.

There can be multiple IT strategies for problem domains $d_i$, so the basic problem of OSP is to find
and dynamically manage the interaction between IT services providers and users considering the challenges (3 – 5).

4. Solution vision
Considering the contradiction of stated problem (3 – 5), it is proposed to solve it constructively, in the form of a design of a specific IT platform that provides the users and developers of IT services with OSP functionality for interaction. The OSP solution is presented in Fig. 1. A modern enterprise contains a few departments that cooperate with each other based on the P2P principle of information exchange. The platform supports both hierarchical and matrix organizational negotiations.

![Diagram](https://via.placeholder.com/150)

**Figure 1.** An open service provider concept.

Software products and solutions can be accessible by certain services implemented in the integrated information space. In the modern Internet, realization of specific features becomes more concealed for users. When users visit different sites and portals, this process seems to them like using widgets on their dashboard. To implement this idea, it is necessary to develop a functional aggregator that provides the users with a variety of services with unified API and UI. On the other hand, to implement the functionality, it is necessary to develop a unified service aggregator that should be able to involve various service providers. This aggregator should have an open architecture, support interoperability and the set of unified intelligent software solutions for decision making support and application of the unified technology of combined security and data storage.

The proposed approach allows involving all actors into the process of decision making. The users get access to new functionality immediately and directly, software providers get the opportunity to easily access possible users on a competitive basis, and enterprise top management get a powerful analytical tool that provides a realistic picture of users interaction based on real statistics. Consequently, it becomes capable of controlling the entire IT-infrastructure of the company. An IT department in this case forms the goals and objectives for service providers and users. Due to it, the company management obtains an opportunity to monitor and influence functional aggregators, receive...
an overall picture of their work and realize the process of decision making. Service providers, in turn, are motivated to permanent changes, updates and upgrades.

5. Implementation

Implementation of the proposed concept and approach was performed by SEC “Open Code” for a number of IT solutions of complex automation of production enterprises and supply chains. A number of IT services were built on the basis of three components: knowledge base (ontology), electronic archive and intelligent directory. Open Service Provider was introduced to bring together these services. The resulting solution is presented in Fig. 2.

![Figure 2. An “Open Code” OSP solution.](image)

OSP becomes an open platform to provide different services for users based on implementation of the intermediate module of negotiation. In the process of OSP implementation, a number of technical problems were successfully solved. First of all, it was necessary to solve the problem of OSP scalable architecture development and componentization, to implement the functionality for configuring, adaptability and self-organization, to resolve issues related to the maintenance of the archives, to document management and event registration. Then, the enterprise information environment was revised so that users get convenient access to services, providers have access to the services registration and support and the management staff has been able to keep track of all these processes. Finally, enterprise business processes were reviewed and built in such way that users could understand the features of the services in the Internet instead of a software solutions with predefined fixed functionality.

We can describe an after-sales customer support system for a large manufacturing corporation as an
example of the “Open Code” OSP solution probation. The system includes a productions and support unity and is a part of the enterprise integrated information space. Producers and consumers can interact with each other in an extensive sales network. All system participants have different capabilities and needs, therefore they use different functionality of the system.

An after-sales customer support system includes an after-sales service monitoring module and a customer support service. The monitoring system is presented as a visualized menu, which contains an interactive electronic map, an indicator to determine the location of objects and their condition, and a general state of affairs for the after-sales service. Customers get a special after-sales service with information about their items. They can also use it to send the request to a company for repairing, servicing and conducting the regulated works.

6. Conclusion
The proposed concept for Open Service Provider allows large enterprises to develop an IT infrastructure on the basis of modern technologies involving users and providers of IT solutions in the process of the concurrent interaction. OSP benefits includes easy adaptation, configuration flexibility, an ability to expand, a possibility of constant updates in response to changing users’ needs and a technical capability of constant updating and being in a permanent state of efficiency. One of the important advantages is the simplicity of support after the system implementation.

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