Big Data incorporation based on Open Services Provider for distributed enterprises

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Abstract

There is provided a new software solution for multiple data sources integration at modern enterprises with distributed organizational structure. Open Services Provider (OSP) is a platform powered by SEC "Open code" that allows developing situational centers for decision making support based on Big Data analysis and visualization. The paper describes a problem of management of modern distributed enterprises, the proposed OSP solution and results of its probation in practice. Research is supported by Big Data engineering center at Samara University.

Keywords: Big Data; Open Services Provider; Complex Automation; Integration

1. Introduction

In order to provide high competitive power and soundness most large industrial enterprises need to cooperate and share their resources. This trend enforces top management to introduce modern administration technologies that are based on interaction in matrix organizational structures, and caused by it information analysis and data flows integration and exchange. In case of high autonomy of involved parties and flexibility of cooperation the process of their integration in solid information space becomes hard. To solve this problem there is proposed an IT solution based on service-oriented software architecture capable of adaptation to new integration requirements and processing the Big Data of informational interaction between several enterprises with autonomous behavior. This vision is predominantly influenced by using experience of working with the Internet and mobile devices. This paper presents the features of Open Service Provider powered by SEC "Open code" and some benefits of its implementation in practice.

2. Theoretical background overview

Basic challenges of information processes management at modern supply chains are concerned with a necessity to support a horizontal interaction between a number of enterprises 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]. Self-organization in networks applicable for enterprise management is investigated using a Bio-inspired approach [3, 4].

Peer-to-peer (P2P) networks [5, 6] 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.

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 [7, 8]. This proposed approach is close to 5PL (Fifth Party Logistics) concept, which is based on implementation of a number of services for customers and enterprises provided by a specially designed software platform. 5PL platform is open for new transportation companies and even drivers and helps them negotiate with customers in integrated information space.

Interaction of customers and service providers powered by intermediary services [9] generate and can be characterized by a big number of events that form Big Data and require modern technologies for its analysis [10]. Business processes that support such interaction should be flexible and dependent on unique customer requirements. This makes it reasonable to implement subject-oriented approach for business processes management (S-BPM), which conceives a process as a collaboration of multiple subjects organized via structured communication [11].

An OSP concept is similar to the idea of «One Internet» governance [12]. 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 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:

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

where t_l, $l = 1..N_r$ is the s_j – order submission time.

The fact of each service delivery is defined by:

$$v_{i,j,l,k} = v_{i,j,l,k}(r_{i,j,l}, g_k, c_{i,j,l,k}, \Delta t_{i,j,l,k}) \in \{0, 1\}, \tag{2}$$

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 $v_{i,j,k}$ 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:

$$C(d_i) = \sum_{j=1}^{N_s} \sum_{l=1}^{N_e} \sum_{k=1}^{N_g} v_{i,j,l,k} \cdot c_{i,j,l,k} \to \min . \tag{3}$$

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

$$T(d_i) = \sum_{j=1}^{N_s} \sum_{l=1}^{N_e} \sum_{k=1}^{N_g} v_{i,j,l,k} \cdot \left(t_{i,l_{\min}}^{fin} - t_{i,l_{\min}}\right) \to \min , \tag{4}$$

where $t_{i,l_{\min}}^{fin}$ 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):

$$\forall g_k : \sum_{i=1}^{N_d} \sum_{j=1}^{N_s} \sum_{l=1}^{N_e} v_{i,j,l,k} \cdot c_{i,j,l,k} \to \max . \tag{5}$$

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

$$\mu(d_i) = \{v_{i,j,l,k}(r_{i,j,l}, g_k, c_{i,j,l,k}, \Delta t_{i,j,l,k}) = 1\}, \tag{6}$$

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.

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.

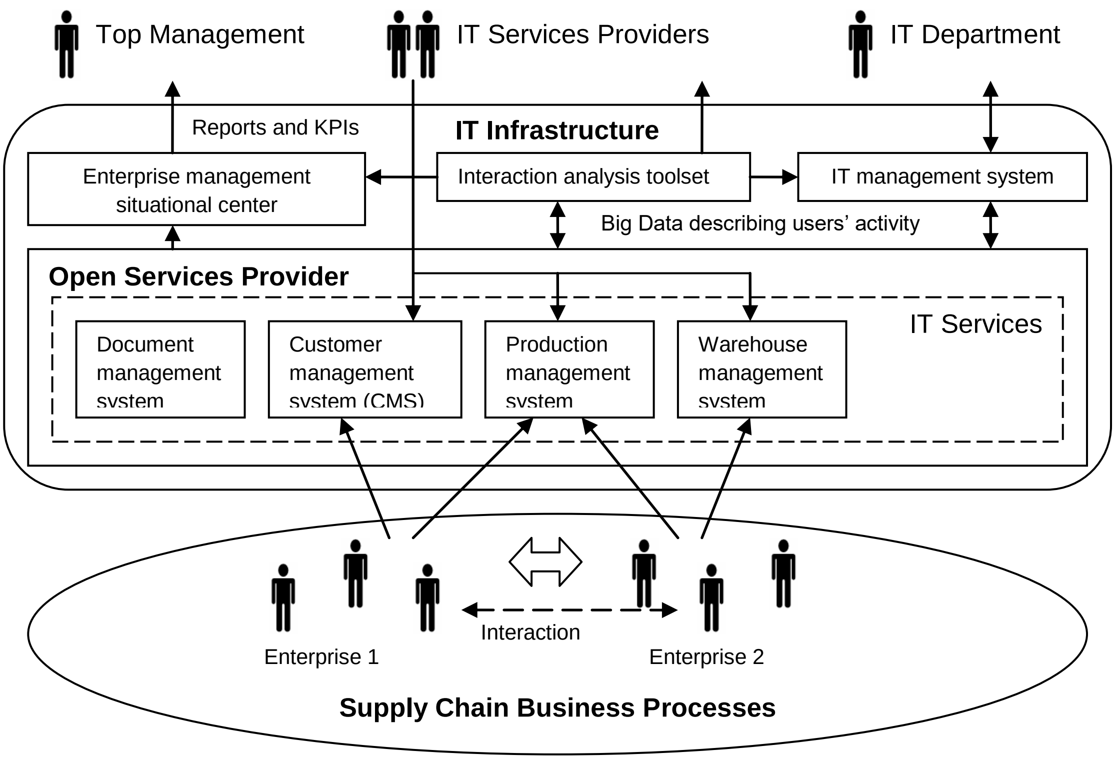

Fig. 1. An open service provider concept.

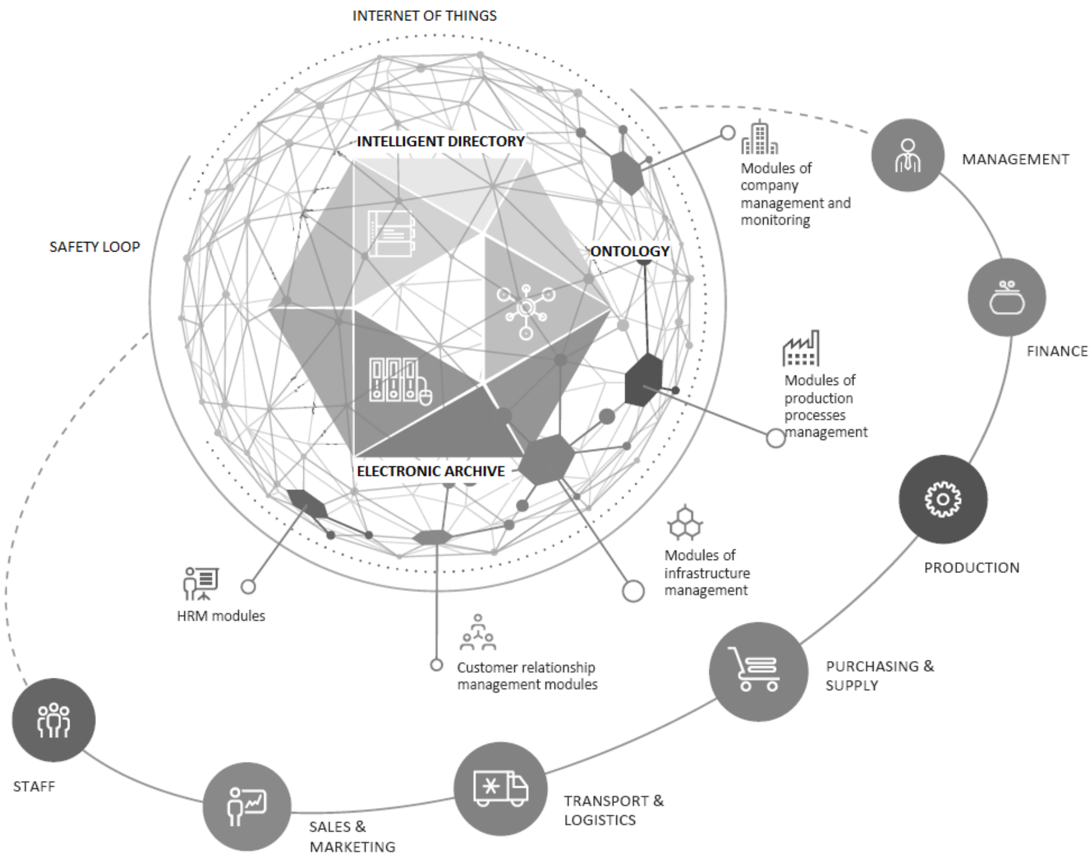

Fig. 2. An "Open Code" OSP solution.

5. OSP architecture

Implementation of the proposed concept and approach was performed by SEC “Open Code” for a number of IT solutions of complex automation of industrial 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.

OSP becomes an open platform to provide enterprises different services 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.

6. Implementation

The example of OSP implementation for large production group of companies is given in Fig. 3. Organizational project management system represents set of the subdivisions or enterprises combined by a solid supply chain that are connected by relations and subordinations. In the case of management structure creation, it is necessary to consider specifies of enterprises’ activities and features of theirs interactions with an external environment.

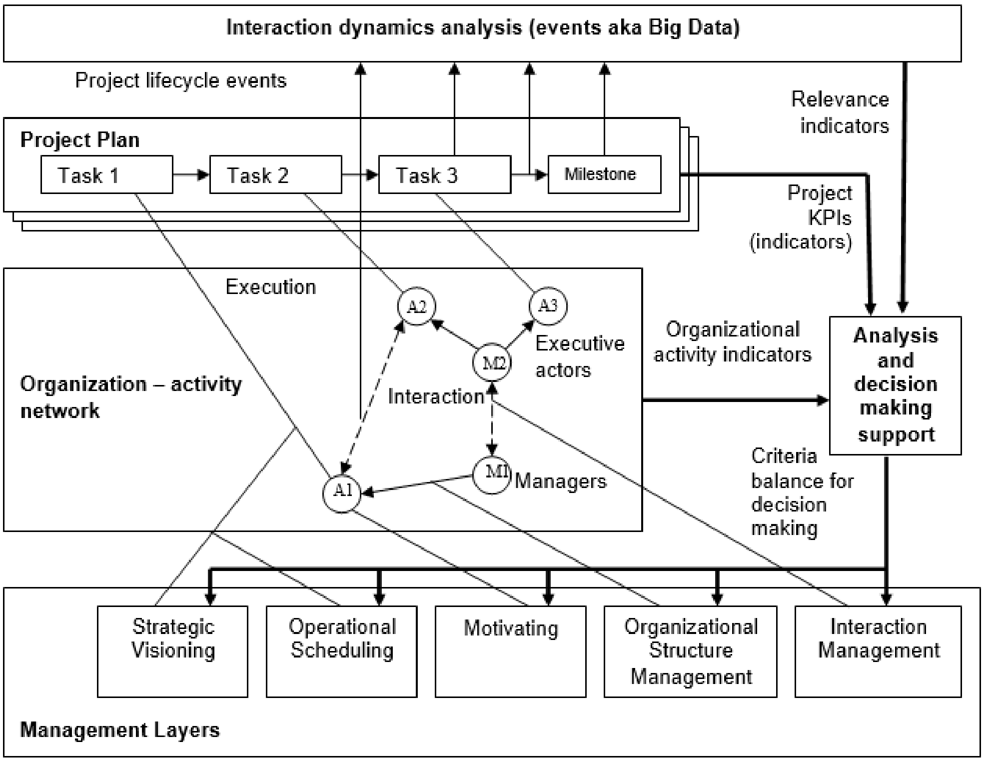

Fig. 3. Coordination of plans based on Big Data analysis.

The process the organization structure formation of project management usually includes three main stages: determination the type of the organization structure (direct subordination, functional, matrix, etc.); separation of structural subdivisions (administrative staff, independent subdivisions, applications programs, etc.); delegating/devolution of the authority and responsibility for parts of the project to the subordinate authority levels (governance relation – subordination, the centralization relation – decentralization, organizational mechanisms of coordination and monitoring, a regulation of subdivisions' activities, development of regulations in structural subdivisions and positions).

This architecture affects the organization structure of enterprises' functioning, project part, management system, units of the analysis and analytics, product life cycle events, the functional relations. Resource assignment is provided according to the performed project specification (tasks) in the form of the oriented organization – activity network. The nodes represent the staff of the enterprise (performers and their principals), and the links – the relations between the employees. Based on the proposed solution there can be introduced the following process of project management using Big Data analysis for knowledge engineering.

At the first stage, the enterprise management makes decision in implementation of a certain project. Then, it makes a decision about the decomposition of the project in a number of tasks. The project implementation (elaboration of each task) is followed by the set of project life cycle events, and the efficiency of all projects' implementation depends on effective activity. It is worth mentioning that for large enterprises, project life cycle events form the Big Data.

Therefore, the processes of the overall performance analysis of the enterprise and the processes of finding the closest optimal decision are more complicated at each stage. Contingency planning involves identifying alternative courses of action that can be implemented if and when the original plan proves inadequate because of changing circumstances. Events beyond a manager's control may cause even the most carefully prepared alternative future scenarios to go awry. Unexpected problems and events frequently occur. When they do, managers may need to change their plans. Anticipating change during the planning process is best in case things don't go as expected. Management can then develop alternatives to the existing plan and ready them for use when and if circumstances make these alternatives appropriate.

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7. Evaluation. OSP for Russian post office management

One of the successful examples of OSP implementation in practice is a software solution for Post office management, which was deployed and probated at Samara post office. This system was used to solve the problem of mail processing scheduling by Samara main mail sorting facility, which is a basic management unit of a posting supply chain. It requires effective allocation and scheduling of various resources that affect the post sorting procedures. On of the business features nowadays is the increasing outsourcing facilities: mail services extensively involve 3rd parties for e.g. transportation and delivery. Expected scheduling horizon is one month. Each transportation logistics unit has an own schedule that can be affected by unpredictable events, delays of other parties and failures of man force and equipment. In addition to this seasonal fluctuations and human factor has a strong implication over the business processes. All this information is big in volume changes in time, which makes it Big Data. The designed and delivered software solution is presented in Fig. 4 – 5.

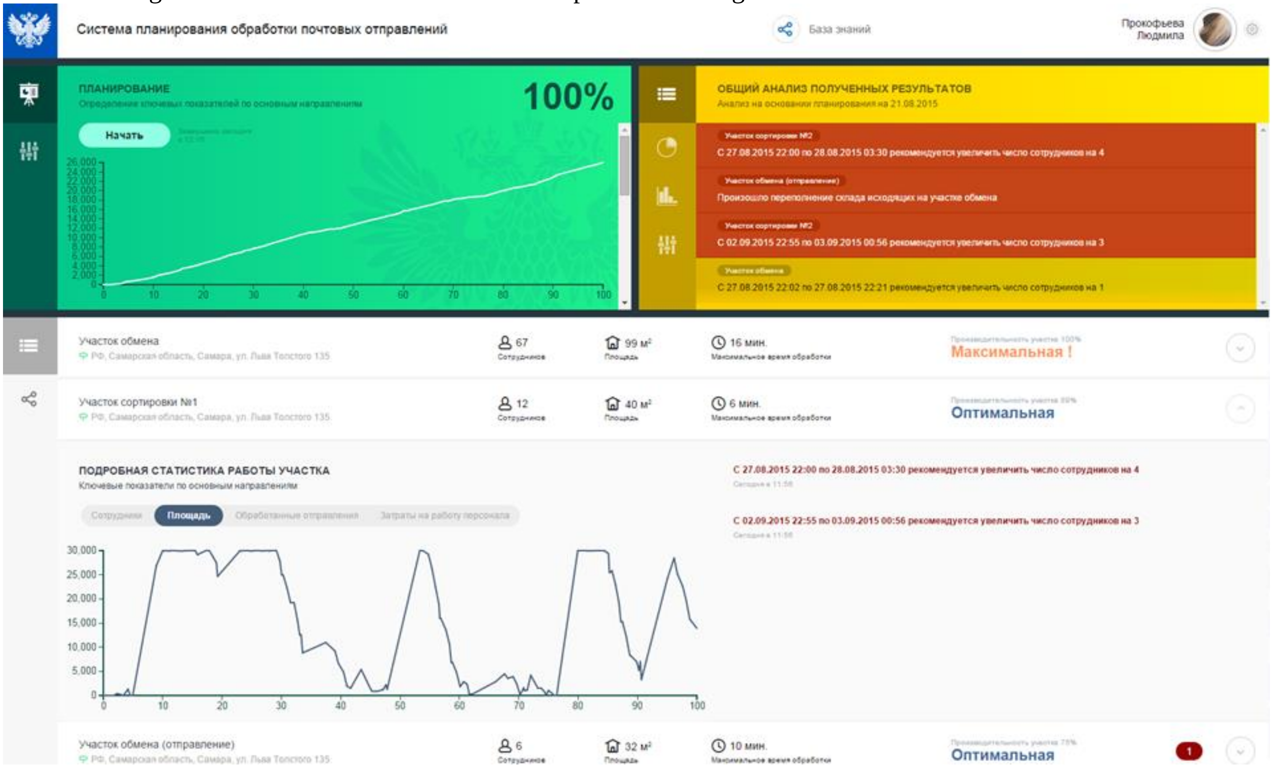

Fig. 4. Service providers statistics.

According to the introduced OSP model there were specified a number of services like transportation, sorting and delivery and service requirements on sorting personnel, space and time. This model allowed to state and solve an optimization problem of mail sorting processes optimization.

Software functionality is distributed between the widgets that present the enterprise KPIs for efficiency monitoring in real time, detailed information on mail sorting services, and automatically generated recommendation for decision making support. At the bottom there is presented a details statistics on resources utilization for a specified service. OSP concept allows to organize the scheduling system as an open platform for integrated services provided by various resources and therefore allow operator a toolset for their coordination and optimization in real time.

First results of the proposed solution probation in practice allowed to reduce the required man force by 20 employees per sorting center, reduce transportation costs by 720 000 RUB per year, and reduce the queues of mail by minimization of time needed for its sorting at the sorting center. This result has proven the benefits of OSP.

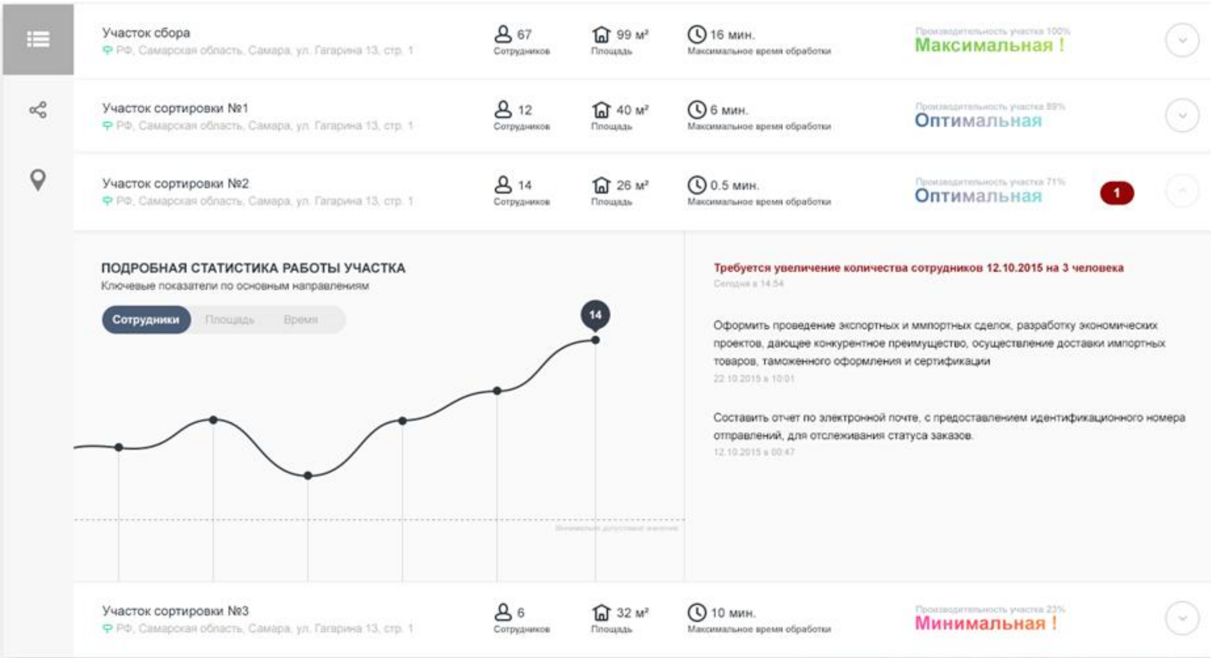

Fig. 5. System recommendations for decision making support.

8. Conclusion

The proposed concept for Open Service Provider allows enterprises to incorporate their data flows and resources and construct a distributed and flexible matrix management architecture. 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.

9. Acknowledgment

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