Open Services Provider for Supply Chains

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Abstract—**There is proposed a new software solution for supply chains management based in virtualization of intermediary services. 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. A new concept of sixth party logistics (6PL) Intermediary Provider is given by analogy with fifth party logistics (5PL) provider, which is based on implementation of a number of open services for customers, suppliers and shippers provided by the specially designed software platform.**

I. Introduction

In order to provide high competitive power and soundness modern 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 that acts as a virtual intermediary agent to help the suppliers and buyers better cooperate.

The proposed concept for Open Service Provider (OSP) allows distributed enterprises incorporating their data flows and resources. OSP targets 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. Some of the solution details are introduced in this paper.

II. State of the art

Basic challenges of modern supply chain management are concerned with a necessity to support cooperation between a number of enterprises with various goals and constraints. Negotiation of these enterprises is characterized by an autonomous behavior that can result both either in active and effective cooperation or in counterproductive conflicts. Taking into account a positive effect from competition all the supply chain members should move to common goals, which is hard to follow in case of high autonomy of decision makers.

Supply chain parties represent different layers of logistics management and have recently become a challenging subject of research for managers and software developers in respect of implementing different aspects of outsourcing. One of the most up-to-date trends in transportation logistics introduces 5PL (Fifth Party Logistics) concept [1], which is introduced by analogy with 3PL that provides the process of outsourcing of transportation resources and 4PL that describes a concept of Lead logistics integrator (still there is no general definition of it in the business world) [2].

5PL provider owns no transportation resources itself but makes available a special service able to link suppliers and buyers. This service is based on the IT infrastructure, which plays the general role in 5PL business. Customer representatives, transport managers, shippers, carriers, and even drivers become users of a certain IT platform. The purpose of this platform is to allocate incoming orders to appropriate resources, consolidate them improving consolidation and reducing idle time and generate efficient schedules for drivers and vehicles. This concept becomes popular in transportation logistics as an effective solution to allocate transportation orders to possible executors. 5PL platform is open for transportation companies and helps them negotiating with customers in integrated information space.

Still 5PL software platform supports only operative negotiation of customers and shippers. It is effective for situational management of allocation of new incoming orders in real time, but does not consider the partnership between the parties. However the knowledge of possible and existing cooperation can help improving the quality of services integration and aggregation and declining of their costs for target consumers.

To capture this knowledge and introduce new features there can be proposed a concept of 6PL intermediary provider that develops stable and dynamic relations between the contractors. In addition to 5PL functionality 6PL platform provides the means of strategic management in transportation logistics over the comparatively long time horizon. This idea is close to the popular SaaS (Software as a Service) business model, according to which software and associated data are centrally hosted on the cloud. Such service becomes attractive for small transportation companies and allows outsourcing dispatching functions for large logistics operators.

To generalize the ideas of 5PL and 6PL providers there can be proposed a concept of Open Service Provider, that takes an intermediary role in supply chain parties interaction [3]. Open service provider is implemented by a software platform with Internet portal able to match service requests (orders or applications) and opportunities and generate profitable options of integrated services. An OSP concept is similar to the idea of «One Internet» governance [4]. 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.

To ensure high efficiency of OSP both for customers and executors in terms of time and costs there is a request to implement modern technologies of business processes management based on decentralized architectures, distributed intelligence and multi-agent technology. This happens because of the increasing number of decision makers, high uncertainty and dynamics of changes, and flexibility of decision making logic. Multi-agent technology helps stimulating negotiation, generate effective allocation options and provide decision making support there can be implemented a multi-agent software solution [5], which provides the flexibility of actors' interaction and their self-organization and can deal with high uncertainty in number and time of resources available. The example of using multi-agent technology for business processes simulation can be found at [6], [7].

As soon as the information space provided by OSP software platform can be treated as a complex network of continuously running and co-evolving actors, the whole solution can be based on holons paradigm and bio-inspired approach. This paradigm and approach offer a way of designing adaptive systems with decentralization over distributed and autonomous entities organized in hierarchical structures formed by intermediate stable forms. It's implementation in practice requires development of new methods and tools for supporting fundamental mechanisms of self-organization and evolution similar to living organisms (colonies of ants, swarms of bees, etc).

The actors compete and cooperate, coordinate and adapt their behaviors, aggregate their services to users and take various requirements individually. Each event that occurs here can influence the whole network and needs a collaborative reaction from all subjects that take into account personal objectives and constraints of each decision making member. Another requirement for the decision making process based on subject' negotiation is that the final decision can require a complicated and time consuming process of data exchange between the actors. That's why it should be managed to consider time factor and assure functioning in real time.

In many cases however, real-time awareness provided by event processing is not sufficient; real time actions need to be triggered not only by events, but also upon evaluation of additional background knowledge. This knowledge captures semantic metadata descriptions (the domain of interest), and the context related to critical actions and decisions. Its purpose is to be evaluated during detection of complex events in order to on-the-fly enriched events with relevant background information or to propose certain intelligent recommendations in real time.

Recent developments in the area of modern enterprises and factories automation explore the possibility to increase the efficiency of decision making support on the basis of ontologies [8]. In this area the problem of semantic data integration and visualization becomes challenging [9 – 11], which makes it important to develop new software platforms and architectures to provide knowledge based integrates services.

On the basis of analysis of the current trends of automation of logistics parties' interaction in integrated information space powered by intelligent multi-agent technologies there was identified a following challenge. Most of software solutions provide operative dispatching and allocation of orders in real time or automate scheduling based on the current resources availability. Optimization software tools provide long term scheduling for a concrete and limited set of resources. 5PL platform allow situational allocating of new coming orders to currently available resources with very limited planning horizon. In order to combine these two approaches there should be proposed a 6PL solution based on the flexibility of interaction with autonomous shippers provided by 5PL and getting new opportunities of contracts formation and execution, which allows long term scheduling.

III. Intermediary model of cooperation

Let us consider a generalized business model where orders (or jobs) w_i are proceeded to actors u_j. Any actor can be assigned to perform any order, incurring some cost that may vary depending on the exact assignment. It is required to perform all the orders by assigning exactly one order to each actor in such a way that the total cost of the assignment is minimized. The centre is introduced as a solid dispatching agent that offers the orders to actors and ensures the effectiveness of the whole system.

The objective of the order agent is to be proceeded by any actor available on time (particular the KPIs can be formulated as "early average absorption"). The actor's objective is to receive the most corresponding orders with the highest relevance.

Let us set the following order lifecycle events, represented by Boolean variables:

$e^*(w_i, t^*_i) \in \{0, 1\}$ – appearance of w_i, t^*_i is the time of its appearance;

$e(w_i, u_j, t_{i,j}) \in \{0, 1\}$ – offer of w_i to u_j at time $t_{i,j}$;

$e'(w_i, u_j, t'_{i,j}) \in \{0, 1\}$ – assignment of w_i to u_j at time $t'_{i,j}$;

$e''(w_i, t''_i) \in \{0, 1\}$ – escape of w_i at time t''_i in case of order rejection.

These events describe the history of interaction in integrated information space and form a study subject for various technologies of Big Data analysis.

The cost of order w_i execution by actor u_j is $c_{i,j}$. It is determined by the actor and proposed to the center. Let us assume that one actor cannot execute several orders at a time. The allocation problem for this model can be represented as

$$\begin{gathered} \sum_{i=1}^{N_w} \sum_{j=1}^{N_u} e'(w_i, u_j, t'_{i,j}) \cdot c_{i,j} \to \min, \\ \sum_{j=1}^{N_u} e'(w_i, u_j, t'_{i,j}) = 1, \quad i = 1..N_w, \end{gathered} \tag{1}$$

$$\sum_{i=1}^{N_w}\sum_{j=1}^{N_u} e^*\left(w_i,t^*_i\right)\cdot e'\left(w_i,u_j,t'_{i,j}\right)\cdot\left(t'_{i,j}-t^*_i\right)\to \min, \quad (2)$$

where N_w is the total number of orders and N_u is the total number of actors.

For the order flow $e^*\left(w_i,t^*_i\right)$ there should be developed a strategy (schedule of offers) $e\left(w_i,u_j,t_{i,j}\right)$ for a set of u_j that will reach (1) and (2).

From the other side, each actor considering the order flow $e\left(w_i,u_j,t_{i,j}\right)$ should decide on the strategy $e'\left(w_i,u_j,t_{i,j}\right)$ that comes out at

$$\forall u_j : \sum_{i=1}^{N_w}\sum_{k=1}^{N_u} e\left(w_i,u_j,t_{i,j}\right)\cdot e'\left(w_i,u_j,t'_{i,j}\right)\cdot \left(1-e'\left(w_i,u_k,t'_{i,k}\right)\right)\cdot c_{i,j}\to \max \quad (3)$$

In case the actor starts execution as soon as the order is allocated the following limitation is valid:

$$\forall u_j : \sum_{i=1}^{N_w}\sum_{l=1}^{N_w} e'\left(w_i,u_j,t'_{i,j}\right)\cdot e'\left(w_l,u_j,t'_{l,j}\right)\cdot \left(1-\theta\left(t'_{l,j}-t'_{i,j}\right)\cdot\theta\left(t'_{i,j}+\Delta t_{i,j}-t'_{l,j}\right)\right)=0, \quad (4)$$

where $\theta(x)$ – Heavyside step function [10]: $\theta(x)=\begin{cases}0, x<0\\ 1, x\ge 0\end{cases}$.

The statement (1 – 3) is introduced as a problem of "proactive allocation". Its direct solution is not possible as soon as the number and availability time frames of resources and orders changes with time. To prove it there can be specified the following logic. Firstly, the statement (3), being summarized by u_j, results in a contradiction with (1). Secondly, to solve (1) one needs to fix the number of events considered, but at any moment of time t^* there is no information about the events $e^*\left(w_i,t^*_i\right): t^*_i > t^*$, and there cannot be proposed any substantial approach on how to pick-out the orders w_i accepted by the platform for scheduling in real time.

The solution of (1 – 3) problem is formalized as a schedule of allocation events $S(t^*)=\left\{e'\left(w_i,u_j,t'_{i,j}\right), t'_{i,j}>t^*\right\}$ that is generated at the moment of time moment of time t^* as a response to incoming order flow. The size of this set is an indicator of OSP quality. In order to increase it the system should motivate the actors to give more determinacy and confidence in $e^*\left(w_i,t^*_i\right)$. To solve this problem there can be proposed an rule of rhythmical assignment: there is developed a schedule of assignment events that form time frames for contract agreements.

So the following challenges can be specified for an OSP provider:

- attract customers and executors in order to increase the number of options for each order allocation;
- enforce interaction conditions to support competition and cooperation between the users of the platform, which is beneficial for them;
- capture and reuse permanent allocations in a form of contract agreements that formalize stable and dynamic relations between the contractors;
- develop long term schedules based on rhythmical assignment.

IV. Solution vision

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. OSP was introduced to bring together these services. The resulting solution is presented in Fig. 1.

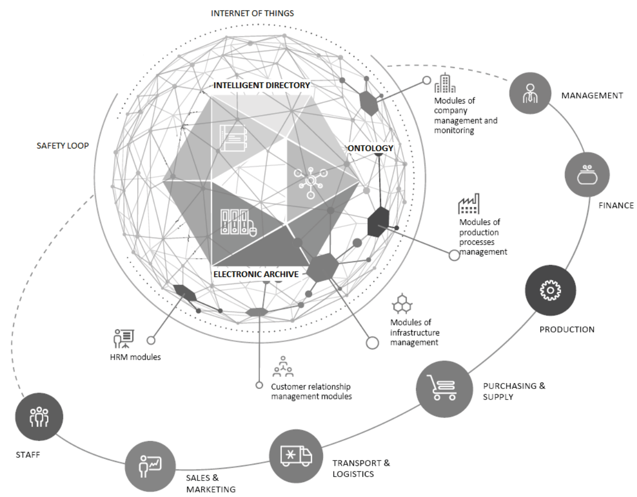

Fig. 1. An "Open Code" OSP solution

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.

The example of OSP implementation for large production group of companies is given in Fig. 2. 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.

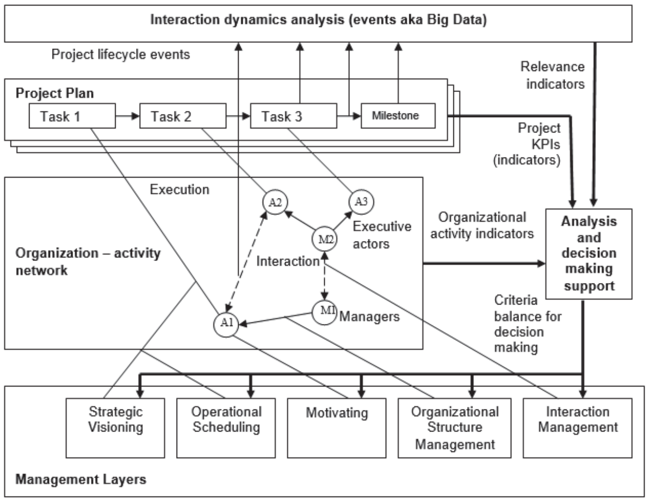

Fig. 2. Coordination of plans based on Big Data analysis

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. From this point of view there can be studied three major types of planning horizons that can help managers achieve their organization's goals: strategic, tactical, and operational. Operational plans lead to the achievement of tactical plans, which in turn lead to the attainment of strategic plans. In addition to these three types of plans, managers should also develop a contingency plan in case their original plans fail. The specific results expected from departments, work groups, and individuals are the operational goals and refer to operational plans. These goals are precise and measurable. An operational plan is one that a manager uses to accomplish his or her job responsibilities. Supervisors, team leaders, and facilitators develop operational plans to support tactical plans.

A tactical plan is concerned with what the lower level units within each division must do, how they must do it, and who is in charge at each level. Tactics are the means needed to activate a strategy and make it work. Tactical plans are concerned with shorter time frames and narrower scopes than are strategic plans. These plans usually span one year or less because they are considered short-term goals.

Long-term goals, on the other hand, can take several years or more to accomplish. Normally, it is the middle manager's responsibility to take the broad strategic plan and identify specific tactical actions. A strategic plan is an outline of steps designed with the goals of the entire organization as a whole in mind, rather than with the goals of specific divisions or departments. Strategic planning begins with an organization's mission. Strategic plans look ahead over the next two, three, five, or even more years to move the organization from where it currently is to where it wants to be. Top-level management develops the directional objectives for the entire organization, while lower levels of management develop compatible objectives and plans to achieve them. Top management's strategic plan for the entire organization becomes the framework and sets dimensions for the lower level planning.

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.

V. OSP IMPLEMENTATION FOR 6PL

This section describes the principles of OSP implementation for a mentioned above solution of 6PL. On the level of 6PL there are formed the conditions of supply chain members interaction in integrated information space that are being expressed in the form of contract agreements that reflect the cases of permanent cooperation between the actors.

OSP platform (see Fig 3) can be introduced as 6PL provider implementing the functionality of logistics supply chain resources management, manufacturing scheduling, Web portals, enterprise resources planning, business processes simulation and modeling and decision-making support. Ontology as a knowledge base is formed and updated on the basis of negotiation statistics analysis for 6PL operator and is used to establish effective contract agreements between the supply chain parties.

6PL intermediary provider, being based on OSP for realizing the interaction of the participants of logistics supply chain in the integrated information space, forms the options of executing orders and offers them to actors. In contrast to the 5PL provider logic that does not change the conditions of interaction and does not limit decision making by the actors, 6PL provider can generate new contract relations that define long-term cooperation and competition between the actors. 6PL provider is also based on the software that realizes system management of interaction based on the analysis of interaction statistics.

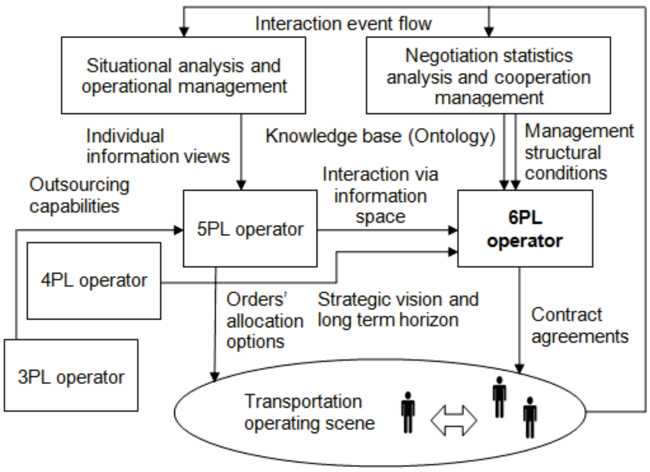

Fig. 3. 6PL solution vision

6PL solution for intermediary service provider was implemented using multi-agent technology. Agents are introduced to represent the actors and orders in the integrated information space and can be triggered both for simulation of actors activity and for representing the real actors in the process of searching for the orders allocation options. The are introduced three types of agents for orders w_i and actors u_j that can interact according to their objectives and constraints and establish the links of cooperation according to allocation options generated. The strategies of agents correspond to the goals (1 – 3).

The agents can act in real time under a continuous flow of incoming events. The main problem of optimizing algorithms is not only the possible failure to function in real time, but also the necessity to introduce a number of heuristics to process service routes that are partially delivered. The multi-agent solution can help to overcome these problems as soon as it operates the current scene which changes together with the real world. In order to make this process convergent we propose to introduce the following logic supplementary to the general negotiating strategies: the orders look for the possibility of allocation based on the statistics of generalized actors' capabilities.

Implementation of the proposed approach in transportation logistics is illustrated by Fig. 4. In the given example the order 5 (that came later than others) is reduced from the view of Actor 1. Besides the set of orders 2, 3, and 4 are hidden from Actor 2. As a result both actors are interested in order 1. Is should be mentioned that the hidden data will appear for the actors with time, so in any case they retain an option to wait till the situation changes.

In the Fig. 3 Actors 1 and 2 get independent description of the current scene in the form of an overlay network. This network is generated by the system by transformation of the actual situation citation based on multi-agent allocation at 5PL level considering priorities formed at 6PL level on the basis of long term contract agreements.

Implementation of the introduced solution allows solving the stated problem by giving the orders and actors an opportunity to look for each other. The system helps them to find the best combination of services, but the final decisions are made by the users themselves. Such an approach provides self-organization and therefore corresponds to the ideas of subject-oriented management. According to the current situation characterized by a number of orders and actors available, the actors will choose the following types of interaction peculiar to self-organized communities:

- Competition, e.g. a contest between the actors to get the order from the preferable provider earlier;
- Cooperation, e.g. collaboration between the actors to increase the number of contract agreements.

To meet this requirements 6PL operator should encourage either competition or cooperation between the actors according to the current situation.

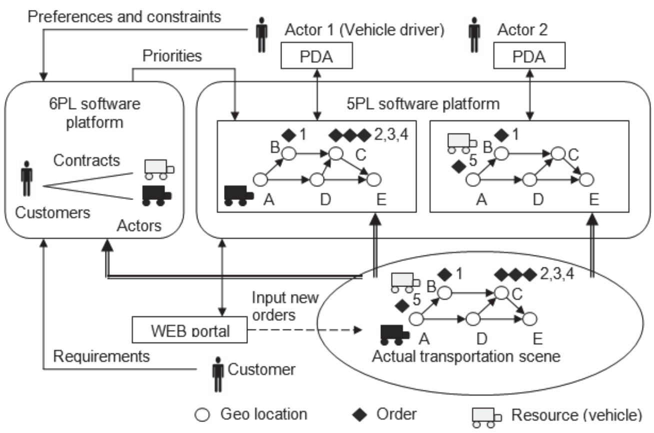

Fig. 4. 6PL multi-agent implementation

Competition can be organized in the form of auctions. Auction is a public sale of a lot representing an order according to the rules predefined by the platform. The exact form of an auction can be different and depends on the features of exact logistics industry.

VI. VISUALIZATION AND ANALYSIS

On the basis of the proposed approach there was developed a system of decision-making support (see Fig. 5) based on the data of digital archives with the use of knowledge bases technologies will make for achieving the following challenges:

- to provide the storage of the archive information electronically;
- to provide independence of places for storing the documents from work places;
- to make the provision of information continual regardless of the location of work place and the schedule of archive work;
- to make the processing of inquiries and the provision of archive data quicker;
- the integration into a unified information infrastructure;
- to make the provision of the response and the making of decisions complex situations quicker;
- to improve the quality of the management decisions which are made.

Fig. 5. Interactive dashboard for decision-making support

Intelligent analysis and the annotation of scanned documents allows to transform the information to knowledge by adding semantic descriptors. The transformation of documents to knowledge is made automatically using the artificial intelligence system principles based on the use of knowledge – ontologies, that considerably reduce the need to attract the expert regarding knowledge. Navigation and search are made based on the semantics of the documents, that allows to not just increase the relevance of the results, but also to introduce the user into the documents, of the existence of which they were never aware, but which would be relevant for them.

Semantic web permits to describe extremely complicated and diversified connections between the documents. An opportunity to set random attributes of a document allows to describe it more precisely that will certainly improve the quality of search. In the mode of interactive dialogue with a user, there is an opportunity to do not just keyword search, but also reach the documents that are somehow related to the found ones. The introduced functionality of 6PL provider can result mostly in higher attractiveness of software scheduling solution to possible customers.

Table I illustrates the features of party logistics in the aspect of working with the resources. 6PL operator provides both high autonomy of resources together with high reliability, which makes it reasonable for transportation logistics.

TABLE I. FEATURES OF LOGISTICS PARTIES

Logistics type	Resources	Interaction with resources
1PL	Own resources	No autonomy
2PL	Separated department	Low autonomy
3PL	Outsourcing	High autonomy
4PL	Long term cooperation	High autonomy
5PL	Mobilization of new resources by Internet	Variety of available resources, Multiple possible options, Low predictability
6PL	Web-based cooperation with shippers	Variety of possible allocation options, High autonomy, High reliability

VII. CONCLUSION

There is proposed an OSP software solution for supply chains management based in virtualization of intermediary services. A new concept of sixth party logistics (6PL) Intermediary Provider is given, which is based on implementation of a number of open services for the involved parties.

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