Applied Mathematical Sciences, Vol. 8, 2014, no. 25, 1231 - 1238
HIKARI Ltd, www.m-hikari.com
http://dx.doi.org/10.12988/ams.2014.4165

Mathematical Model of Sustainability and Support of Enterprises in Organizational Networks

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Abstract

The concepts of networking support and sustainability of enterprises are introduced in this work. Analyzing the processes of resources redistribution in the structure of a large holding company organizational network, a method of algorithmic computing the coefficients of sustainability and networking enterprises support is proposed and conditions of expediency of an enterprise entrance to the structure of organizational network are identified.

Keywords: generalized stability, ranked vendors, corporate network, critical performance event

1 Introduction

Sustainability and stability of enterprises in the structure of a large holding organizational network are the most important factor of stability and economic sustainability of large companies. Enterprises do not function by themselves, they function in the structure of clearly defined organizational networks, where the established rules of enterprises functioning, the laws of interaction and the rules of resources redistribution, aimed to solve general industrial problems, are applied. Therefore, study of concepts of sustainability and stability of enterprises is an important problem, directly related to ensuring stable work of large holding companies and economy as a whole.

In many practical cases company's sustainability is understood as its stability in ensuring required kinds of resources (material, informational, financial and etc.) The

concept of sustainability of enterprises is considered in papers [1, 2]. Sustainability of enterprises is understood as probability of absence of abnormal manufacturing situations requiring operative managerial influence for their removal. In this work we introduce a concept of the enterprise networking support coefficient reflecting increase of company's stability and sustainability when it is functioning in the organizational network structure. This coefficient shows company's sustainability increase from its inclusion to organizational structure.

The manufacturing situation at the enterprise P_0 will be *stable* if in this case the enterprise P_0 is provided with required volume of resources to solve the challenges of its manufacturing tasks. Otherwise, when volumes of supplies are less than required by the enterprise P_0, the manufacturing situation will be critical as in the [3-5].

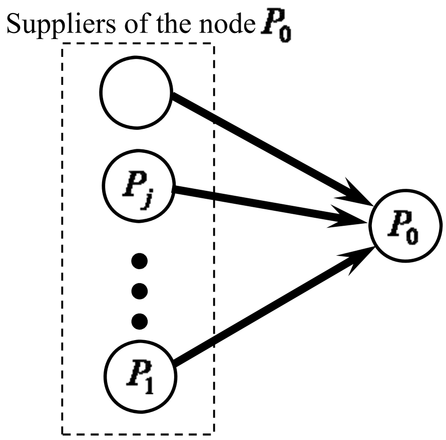

Fig. 1. The node P_0 in conjunction with suppliers allocated from the network structure

We need two special characteristics: the coefficient of the enterprise isolated sustainability and the networking sustainability coefficient. These coefficients characterize stability of an enterprise in the resource endowments.

The coefficient of the enterprise isolated sustainability is defined by the following way. Apply approaches close to papers [6-13]. Let's distinguish the considered node P_0 form the organizational networking structure and consider it separately, only in conjunction with its direct suppliers (Fig. 1). The coefficient of the enterprise P_0 isolated sustainability is probability P_0 of stable production situation appearance on this enterprise (i.e. its resource endowments), when the enterprise P_0 interacts and gets resources only from its direct suppliers as in the case when the organizational network, where the enterprise P_0 locates, does not exist.

It is obvious that the coefficient of the enterprise P_0 isolated sustainability in resource endowments depends on many factors such as the number of suppliers, their reliability, contractual policy of the enterprise P_0 (i.e. the volumes of possible additional supplies specified in contracts), internal sustainability of the enterprise P_0 and etc. Studying and analysis of the factors influencing to the value of the company's isolated stability are actual and practically important research problem.

The coefficient p_0 of the enterprise P_0 isolated sustainability is a probabilistic characteristic which practical calculation requires random multiple generations of manufacturing situations on the enterprise P_0. Using the random number generator, a sequence of random variables $\xi_1, \xi_2, ..., \xi_j$ is generated, where sequence $\xi_1, \xi_2, ..., \xi_j$ is volumes of resources shipments by suppliers and a random variable η_0 which is volume required by company. Generated random variables are random variables of a special type describing probable failures in the supply of resources by suppliers in real production situations and possible increase of the enterprise P_0 needs as a result of any force majeure situations. Values ($\xi_1, \xi_2, ..., \xi_j$, η_0) should obey natural practical requirements, formulation and analysis of which are given in [1]. Every time after random manufacturing situation generation ($\xi_1, \xi_2, ..., \xi_j$, η_0) one should check its stability, i.e. verify compliance of inequality $\sum_i \xi_i \geq \eta_0$ for this situation.

If there are $N_0 \leq N$ stable manufacturing situations in the series of N computer experiments, the relative frequency $p_0 \approx N_0/N$ of a stable production situations occurrence will be accepted as the coefficient of the enterprise P_0 isolated stability. At the same time according to the law of large numbers, the more accurate the equality $p_0 \approx N_0/N$ is, the bigger the number of carried out experience N is.

2 The model of sustainability and support of enterprises in organizational networks

Let's define a concept of the enterprise networking stability in organizational structure of the network. In order to do this, let's consider the enterprise P_0 without its allocating from the organizational structure of the whole network. The concept of the graded organizational network is introduced in the works [1-4]. The graded organizational network **G** is a network which has a homomorphism $\varphi: \mathbf{G} \to \{1,2,...,N\}$ onto the initial segment of the natural series $\{1,2,...,N\}$. In fact, graduation φ assigns a natural number to the nodes (enterprises) of the **G** network. This number is a priority or rank which means importance and significance of the enterprise in the network in terms of its

manufacturing functions. The more important the enterprise P_j of the **G** network in terms of the network's production problems is, the bigger its rank (priority) $\varphi(P_j)$ is.

Examples of the graduated networks are networks of the railway subdivisions (distance of a path, departments, major gateways), networks of suppliers of goods and services, required for the transportation process organization, hierarchies of administrative managing authorities.

There is resources redistribution in the graduated networks according to the enterprises rank. Increasing the demand of the node in some kind of resources (for instance, in the case of force majeure), except the increase of resources supplies stipulated in contracts with suppliers, leads to transfer resources from the nodes with lower priority to the nodes with higher rank in the network (the lower rank nodes in the network become suppliers of the higher rank nodes). An opportunity of this resource relocation is the essence of companies' support in the graduated organizational networks.

In order to facilitate the analysis of redistribution of resources, arising in the graded organizational network G, let's divide the nodes of the G network into the groups of nodes with the same rank (priority) and let's present the groups with similar rank, lying in the relevant separate planes [1] (fig.2).

An important fact distinguishing and complicating the analysis of the enterprises resource endowment in the structure of the network (in comparison to the isolated sustainability of the node) is registration of the mandatory redirection of resources inside the network in the case of critical situation or force majeure at the one or several enterprises. In addition, resources reallocation in the network can be implemented due to any other reasons connected to the motives of political and economic character.

A decision about resources redirection in the G network, i.e. announcement the situation as emergency and *critical,* and assistance to it by other enterprises is accepted by the superior governance structures. In our reasoning we consider the sampling of the network nodes as random.

When implementing the calculations one should take into account that in the emergency case at this enterprise the selection of resources in its favor is implemented only from resources of the lower or equal rank (i.e. from the less or equally important nodes) and withdrawal of resources for the critical node P_0 from the resources with higher rank is not allowed. Formally it means that in case of critical situation at the node, all other nodes of the less or equal rank in the G network in result of rules of resources reallocation in the graduated network become "suppliers" of the affected node P_0.

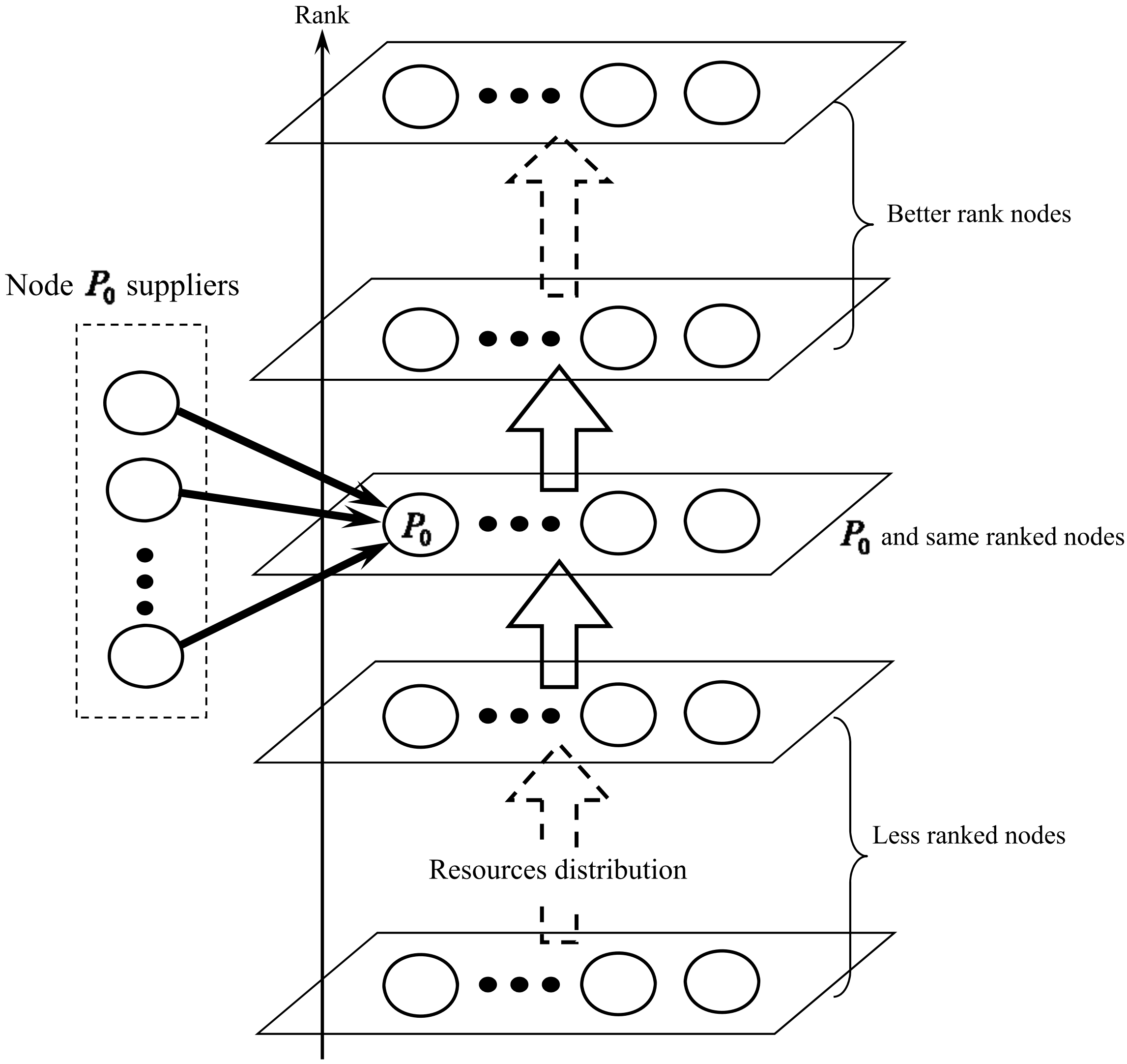

Fig. 2. Dividing the multiplicity of the graduated network enterprises on the plane of the nodes with

When calculations are carried out, one should assume that selection of resources from the stable node of the network P_j to the affected node P_j is implemented in the volume proportional to the volume of resources at the enterprise P_j. Proportionality of withdrawal share of resources to the own consumption volumes of the nodes is explained by the following considerations. In the case of emergency of force majeure, for example at the railway, undoubtedly, “everything is taken” from the nearby road segments and it is sent to reconstruction of damaged node. In the real situation all available resources are immediately directed to recovery of the damaged sector. However, the factors of equability (on the average) of distribution the resources delivery in time from the enterprises-suppliers allow considering our point of view as a right one.

Indeed, let in the case, for instance, of railroad erosion from floods during the whole week all resources of the railway are sent to the restoration of the destroyed area. At the same time the reporting period accepted for defining stability coefficients is one month than means that the quarter of the volumes of resources shipments of each "fleecing" node will be aimed for the accident liquidation (a week is a quarter of month, and resources to the enterprise come to the enterprise from suppliers evenly).

The network stability coefficient of the enterprise P_0 is a probability of occurrence of the stable production situation p_0^* at this enterprise (i.e. its resources endowment) when the enterprise P_0 functions in the graduated organizational network G, gets recourses from its direct suppliers and gets or give recourses to the enterprises of the G network according to the rules of resources reallocation when it is needed.

The network stability coefficient of the enterprise P_0 is a probability characteristic. For its practical calculation it is necessary multiple times (for instance, using a computer) randomly generate production situations. In order to do this by means of random number generator a sequence of random numbers $(\xi_1, \xi_2, ..., \xi_j, ...; \eta_0; \ \eta_1, \eta_2, ..., \eta_i, ...)$ is generated. This sequence means the volumes of delivers from the enterprise P_0 suppliers and the volumes of required resources by the network G enterprises. Every time after the random production situation generation it is necessary to check its stability for the enterprise P_0, i.e. one should check the enterprise P_0 is provided with resources considering their redistribution in the G network.

For each enterprise which participates in the organizational network the most important question is the following. For how many percents is the networking sustainability of this enterprise higher than its own sustainability? How does inclusion of the company to the organizational network increase its stability and sustainability in resources endowments, required for implementation of its production activity?

For the quantitative assessment of the enterprise stability increase at its entrance to the organizational network, let's define a coefficient $\sigma(P_0)$ of the enterprise P_0 networking support as a relative value of the enterprise P_0 sustainability coefficient increase at its including to the organizational network G in comparison to its isolated sustainability p_0 outside the network G, in percentage:

$$\sigma(P_0) = \left((p_0^* - p_0)/p_0\right) \cdot 100\%$$

Thus, the networking support coefficient $\sigma(P_0)$ shows how many percent the network stability p_0^* of the enterprise P_0 is higher than its isolated sustainability p_0, i.e. how the enterprise P_0 becomes more stable by means of its introduction to the organizational network G. Having the networking support coefficient $\sigma(P_0)$ of each enterprise P_j in the G network allows ranking the enterprises according to the extent of received support from the network.

3 Conclusion

For different network G configurations and various types of enterprises in different branches of industry, the networking support coefficient $\sigma(P_0)$ can be significantly differ in its values and mode (the most preferable values). The task of defining the optimal diapasons for the coefficients of the networking support of enterprises in organizational networks of holding type is important and actual.

Acknowledgements
Supported under the Agreement 02.A03.21.0006 of 27.08.2013 between the Ministry of Education and Science of the Russian Federation and Ural Federal University.
Supported under the President Russian Federation Grant MK-4227.2013.1

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Received: January 25, 2014