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A BEHAVIORAL APPROACH FOR COMPETITIVE BUSINESS PROCESS MANAGEMENT

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ABSTRACT

Today's economic context allows corporations and their business environment to produce larger and larger amounts of data relying on the latest information.

For the survival in actual complex and unpredictable environment, the manufacturing system must have the capacity of quick reaction in the sense of resituating on the favorable position on the market. The acquirement and preservation of this capacity is the most difficult overture for enterprises, because it involves many endogenous and exogenous factors and the process is continuous, dynamic and difficult to be predictable.

KEYWORDS: manufacturing system, competitiveness, online learning, technical-economic characteristics of the manufacturing system

1. INTRODUCTION

All over the world, companies are faced with increasingly accelerated and unpredictably dynamic changes. This is influenced by the scientific and technical progress, the dynamics of customers' demands, the scientific approach to management and the mathematical focus on economy. Changes lead to an aggressive competition on a global scale, which calls for the establishment of new balances between economy, technology and society.

The characteristic aspects of the present-day market, in particular case of mechanical components market, are the following: continuously decreasing of the current orders, leading to the design of small series production; strong tendency to personalize the products leading to a pronounced diversity of shapes, sizes and other characteristics of the mechanical components required on the market; flexibility, responsiveness and especially an efficient system management tending to become the characteristics that determine competitiveness on the market of the components manufacturers and the mechanical constructions. The current dynamics of the industrial and business environment is the great global challenge which has to be faced.

To a new global challenge the scientific community responds by a new conceptual paradigm, which, in this case, is the knowledge- based economy (KBE).

Thus, in the U.S., this new orientation is considered a strategic priority, where it is specified that'...Grand Challenge 3 is to *'instantaneously'* transform information from a vast array of diverse sources into useful knowledge and effective decisions… Manufacturing enterprises are fundamentally and inescapably dependent on information technology, including the collection, storage, analysis, distribution, and application of information. If the exponential growth of computer and communication technologies (hardware and software) continues at its present rate, businesses of 2020 should be up to the task. The two main challenges will be (1) to capture and store data and information 'instantaneously' and transform them into useful knowledge and (2) to make this knowledge available to users (human and machine) 'instantaneously' wherever and whenever it is needed in a familiar language and form'.

The Lisbon European Council has marked the EU objectives for the most competitive and dynamic 'knowledge based economy' in the world: 'The March 2000 Lisbon European Council set the objective of making the EU the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better job oportunities and greater social cohesion. This ambitious target cannot be met without the continuing presence of a strong and competitive manufacturing sector'.

The need to adapt technology to the knowledge society is reflected in the EU - FP 7 in order to strengthen the competitiveness of European economy and its technological power. In addition, the concept of eEurope was launched intended for the development of information technologies, for and beyond 2010, and integration of knowledge based society and economy.

2. A REVIEW OF MANUFACTURING SYSTEM MANAGEMENT

This paper is related to manufacturing system management/control, so as to maximize their technical and economic performance. The proposed performance index for the management of these systems is to be both holistic (in the sense that it takes into account not only the economic but also the technical performance) and synthetic (in the sense that it reflects key aspects of the manufacturing system functionality, namely those that are closely related to the reason for which they were created). In the paper, the competitiveness is considered an indicator, both holistic and synthetic, of the technical-economic performance and is used as a criterion for the management of manufacturing systems.

Within this paper, by the manufacturing system we understand all the technological systems that are used to produce a specific product. Each of these technological systems is composed of machine-tool, tools, devices, parts, operator and carries out one of the operations of the technological process of making that product.

The manufacturing system is complete when the product is released to manufacturing and remains there only until the end of the product completion. After this, when another product is released, the problem of structuring the manufacturing systems is taken from the beginning. This ad hoc structure of the manufacturing system is always present with manufacturing lots, but not in mass manufacturing, when all of the technological components of the manufacturing system remains unchanged for a long time.

In the world three conceptual approaches in the field of manufacturing systems management are known.

- The first approach is based on Petri network, which aims at optimally ordering in time the technological operations that the system has to execute. Although it is well known and applied, this approach does not lead to a significant increase in efficiency, because it completely ignores the actual product manufacturing process, considering that the data about this process is permanently constant [1], [2], [4].
- The second approach is based on the holonic structuring of the manufacturing systems, which, like the first, completely ignores the process. Although not yet applied in industry, experimental implementations and analysis of results reported in literature (which are comprehensively presented), show that it could be applied only to higher levels of process-machine systems (for example at the department or enterprise level) and especially in auxiliary issues (such as inter-operational transport, off-line quality control or others).
- A third approach is based on the flexible integration of the system components, which has led to the concept of reconfigurable manufacturing system, developed eversince 1999, by Prof. Yoram Koren from the University of Michigan (Ann Arbor), and considered in many research centers in the world (such as Porto-Portugal, Germany-Hanover, Leuven-Belgium, to give a few examples). The management is exclusively technical and is based on numerical control. No economic issue is taken into consideration. Researchers' interest is oriented only towards the reconfiguration aspects, especially hardware and software, and control reconfiguration.

3. BEHAVIORAL MODELING

Today's economic context allows corporations and their business environment to produce larger and larger amounts of data relying on the latest information.

Models currently used in the management of the manufacturing systems, whether analytical, numerical or neural (or, in general, algorithmic), refer to the components of the systems. Building models in all cases is based on off-line experimental investigation of an element, making up a set of experimental data and using it to select, out of a given family of data, the most appropriate model.

There are no cases reported in literature of behavioral modeled systems where, by monitoring the current operation of the manufacturing system concerned, to extract on-line knowledge which relates to the interactions taking place in said manufacturing system, although, for a competitive management, it is in fact required to model the interaction between the system components. The control/management of the manufacturing systems is developed based on behavioral modeling, which will describe the interaction between elements (technological system, manufactured products, the market).

For presenting the behavioral modeling notion, we consider two elements H1 and H2, which interact with each other (Fig. 1. a). Model H1 of the first element establishes a connection between the input x and output y. If x and y are at the same time input and output of another element, whose model is H2, then the two elements interact with each other.

Modeling their interaction (behavioral modeling) means setting the pairs of values (x, y) which satisfy the transfer functions H1 and H2. The multitude of solutions which satisfy both transfer functions H1 and

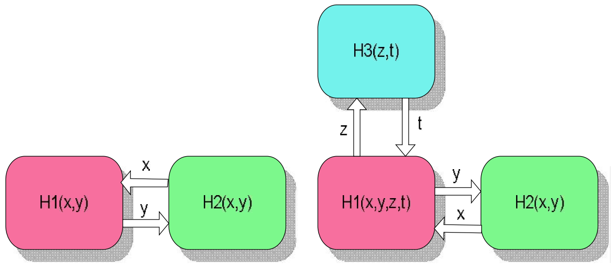

Fig. 1. Behavioral modeling

H2 represent the behavioral model because they describe the behavior of the elements during their interaction.

For instance, under the theme concerned, H1 could stand for the manufacturing system while H2, for the market . Behavioral modeling becomes increasingly complex as the number of interacting elements is growing too.

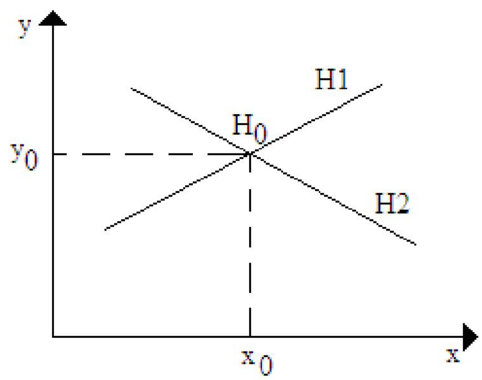

Fig. 2. Behavioral model with unique solution

For example, in case of Fig. 1.b, three elements interact and the behavioral model represents the relationship between the values of x, y, z and t for which the three elements can interact.

Considering the elements H1 and H2 with the following transfer functions:

$$\begin{cases} H1(x,y)=0 \\ H2(x,y)=0 \end{cases} \qquad (1)$$

then, the solutions of the system (1) represent the behavior model of H1-H2 assembly. If the solution is unique, then the behavioral model is reduced to one operational point.

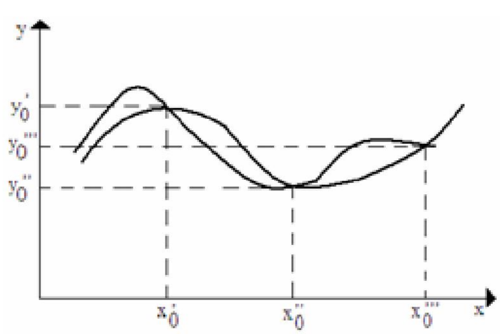

Fig. 3. Behavioral model with multiple solution

Considering H1(x,y) and H2(x,y) as being two lines, then the solution of the system is the intersection point H0 (Fig. 2).

If there is a values, string x_0 and y_0 as solutions of the system (1), then the behavioral model includes all these points (Fig. 3): (x_0', y_0'), (x_0'', y_0''), (x_0''', y_0''').

If the system (1) is incompatible, then there isn't any behavioral model that meets H1 and H2 assembly. In the case of Fig.1.b, the case of the interaction of three elements H1, H2, H3, the behavioral model is given by (x_0, y_0, z_0, t_0), the system solution:

$$\begin{cases} H1(x,y,z,t)=0 \\ H2(x,y)=0 \\ H3(z,t)=0 \end{cases} \quad . \qquad (2)$$

As the number of variables is more than equations, we expect the system (2) to be indeterminate. The model will include an infinite points number.

The behavioral modeling method of the manufacturing system-market assembly is developed on these assumptions:

- elements H1 (manufacturing system) and H2 (market) operate and are monitored on-line;
- during operation, elements H1 and H2 pass through different states, that means they operate with various values of the state parameters. For example, H1, the manufacturing system, processes various products with various machining parameters and with various time, material consumptions. Element H2, market, operate similarly, selling various products with various prices in various supply conditions.
- elements H1 and H2 interact, but not throughout their operation (the manufacturing system can interact with other markets).

4. DEVISING A METHODOLOGY FOR MODELING IN REAL-TIME, BASED ON REINFORCEMENT LEARNING, THE RELATIONSHIP OF THE MANUFACTURING SYSTEM WITH THE ECONOMIC ENVIRONMENT

The learning process , in general, is an action in which the manufacturing system can improve its ability to react so that, during subsequent requests, this should take actions more efficiently.

Devising a real-time modeling methodology, based on reinforcement learning (which is a specific non supervised learning technique) of the manufacturing system relationship with the economic environment means that the manufacturing system 'learns' what actions to perform in certain situations, based on the data supplied by the economic environment , so that such actions increase the possibilities of achieving the aim pursued.The system should 'exploit' what it already knows to bring profit, but, at the same time, it must 'explore' the possibility of finding other suitable actions for the future. The manufacturing system should try a variety of actions and then choose those that seem best.

The market-manufacturing system relationship by reinforcement learning, from the data supplied by the marketing section of the enterprise (auctions' situation) , an evolution of the economic environment for a period of time is carried out and an overall modeling is provided on the basis of past events.

Reinforcement learning is to be understood as the manufacturing system capacity to 'learn' in permanent interaction with the economic environment, to inform and update the information about the auctions and to anticipate, before deciding to conclude a contract, the level of costs , profit and what is the best way to act. Modeling the market-manufacturing system relationship simulates, based on a state of the environment and an action of the manufacturing system, the behavior of the assembly and can predict what will be the next state and the result obtained.

The relationship is used for planning, to take decisions regarding the behavioral modeling of the manufacturing system – market assembly while considering possible future cases before such situations are experimented.

After each possible situation, the manufacturing system will adapt its behavior, so that it tends towards its next most favorable state . By the learning process, the manufacturing system will be allowed to execute a number of actions in accordance with the instructions from the behavioral model operation of the assembly and that action will be selected likely to bring it to the maximum competitiveness state.

The methodology consists in the following steps:

a) extraction of data mining of information on the status of the auctions' database from the marketing department of the company and defining an evaluation function;

b) developing the behavioral model of the manufacturing system based on the data mining information;

c) developing a reinforcement learning algorithm and its application to the manufacturing system operation in relation to the economic environment in order to obtain maximum profit;

d) integration of the model algorithm into the methodology for modeling in real-time, based on reinforcement learning, the relationship of the manufacturing system with the economic environment.

5. CONCLUSION

Note that we propose to give managers a model so that they can interact with the economic environment (market). Practically, this happens before the actual work of manufacturing system, so that we have to deal with a function of anticipation.

The method of manufacturing systems management based on behavioral modeling of the market-manufacturing system assembly and on the implementation of the management to the manufacturing system is generally applicable and appropriate to the current market demands.

By using the reinforcement learning method is ensured the enterprise adaptability to the market demands.

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