RESEARCH IN LOGISTICS & PRODUCTION

OBJECT-ORIENTATION IN TRANSFORMATIONS OF PRODUCTION PROCESSES

Jarosław Badurek*

* Faculty of Management and Economics, Gdansk University of Technology, Gdansk 80-233, ul. Narutowicza 11/12, Poland, Email: j_badurek@yahoo.com

Abstract The article examines the relationship between object-orientation and transformations of manufacturing processes. For this purpose, the information- enterprise was defined, as characterized by a change of balance between the processing of materials and processing of information. In section 1 the genesis of the considered transformations was identified, proposing their classification on three levels. Section 2 was devoted to the characteristics of the information-enterprise as an organization of self-learning, virtuality, networking and bio organization. The importance of industrial development trends 4.0 was mentioned. In section 3 features of object-oriented programming were connected to examples of solutions in industrial practice. The business model of information and its surroundings was definded. The summary pointed out the advantages of object-oriented approach to transformations in production.

Paper type: Research Paper

Published online: 30 April 2016
Vol. 6, No. 2, pp. 107-116
DOI: 10.21008/j.2083-4950.2016.6.2.1

ISSN 2083-4942 (Print)
ISSN 2083-4950 (Online)

Keywords: *object-orientation, transformations in manufacturing and production information- enterprise, reference systems*

1. INTRODUCTION

The dynamics of the global economy makes increasingly important transformations of production processes in modern enterprises. In essence, this means also the transformation of the combined business organization, which is associated with complex projects – hence the question of their effective modelling. Therefore, the main purpose of the article was formulated as follows: based on theoretical and empirical prerequisites – specify the essential features of these transformations and propose a model of management, increasing the probability of success of the transformation. So defined the main objective, implies the following specific objectives:

- systematize the basic terms related to the topic,
- definition of a strategic framework for the transformation project,
- indication of the significance of reference systems for the transformation,
- proposal of object-oriented paradigm for the transformation,
- identification of development and manufacturing megatrends of company,
- the characteristics of the object factory,
- positive consequences of the proposed approach.

We used the following reasoning scheme. In the section 1 the concept of transformation in the manufacturing system was defined, proposing its material-information model. Different levels of transformation were considered and the object-oriented nature of the database-orientation was shown. The second section developed the phenomenon of information-oriented company, identifying main trends in the context of the manufacturing – industry 4.0. It highlights the key elements of the systems cyberphisical systems. On this basis, in section 3, the model of object-oriented factory was proposed. It pointed to the importance of the reference systems for such understood enterprise. The summary shows the positive effects of object-oriented transformations in production processes. He term transformation in the production sphere can be defined as the design and implementation of economic strategies, to anticipate changes and respond to them, according to the challenges of the market, i.e. considering customers and products (Nair, 2011).

Transformation T can be interpreted as a process of status change in the production system S.

$$T_I: S_i \rightarrow S_i+1 \qquad (1)$$

where TI is the process, transforming goal oriented S, from state Si to state Si+1, with the help of an information factor I. The term S means the production environment defined by its material and information components

$$S = \langle R, I \rangle \rightarrow S = \langle T, V, M, E, I \rangle \qquad (2)$$

where

R – the real world (production reality),

T – time as a measure (one of many) of changes,

V – three-dimensional space in which changes exist,
M – matter (mass) narrowly understood, as a subject of transformations,
E – energy, as a driver of changes,
I – information that defines the logic of changes (control information).

The last 5 categories (T, V, M, E, I) compose the wider matter, i.e. the reality consisting the informative dimension as well. The consequences of the model, with respect to transformations, are:

- understanding of information as the organization of transformed matter,
- understanding the management of transformations as information processing.

These interpretations show the importance of the information factor in transformation processes, while the understanding of information corresponds with the definition of a database tuple (Date, 2012):

<name of the object, characteristics of the object, value of characteristics, time>

Therefore, in the later part of this article we will show the importance of object-orientation for the considered transformations, as a paradigm linking the realms: of manufacturing and information technology. In turn, the basis for the analysis of transformation processes may be their division proposed in the tab. 1.

Table 1 Levels of micro- and microsystem transformations

Level	Interpretation	Examples
global	macrosystem paradigmatic changes	network economy, virtual enterprises, teleworking, ditributed structures, ever-relations of phenomenons, interdisciplinarism, determined chaos, artificial intelligence, robotics, flexibility, sustained ecology
strategical	macrosysystemic changes in the managament sphere	knowledge and quality management, reference systems, customer orientation, just-in-time production, intelligent production systems, tensor organizations, fractal factories
tactical-operational	microsystemic design and implementation actions	ergonomics of man-machine dialog, hardware-software integration (virtualization), cloud technologies, RFID, industry 4.0

The shown transformational levels are connected by the coupling of innovation lifecycle: new paradigms of economic and social developments lead to the new strategies of management, which in turn generate implementations at the enterprise level i.e. applications of IT (information technology). At the same time, the feedback coupling loop of realized transformations and associated to them the new requirements, support these processes. On a global scale, we can observe such phenomena as the network economy (Beck, 2006) or the partnership of virtual enterprises (Khan, 2011) in the turbulent environment. They lead to new market requirements, which such elements as: tensor organizations (Baldegger, 2012) or bio organizations (Fulekar, 2009). They are translate into implementing projects, taking into account, among another things: software interfaces, mobility, miniaturization and openness – aided with key-innovations technologies, e.g. RFID (Radio-Frequency Identification) (Evdokimov, 2011).

2. INFORMATION-ORIENTATION OF MANUFACTURING PROCESSES

New socio-economic paradigms, defining innovative management strategies, lead to the phenomenon of information-oriented enterprise, i.e. one in which IT technologies, to a large extent, determine its effectiveness. Information-oriented enterprises are characterized by varying the proportions between the processing of matter and processing of information – in favour of the latter. The value of modern enterprise increasingly depends on the level of its IT applications. They are increasingly co-deciding on whether production will be flexible and effective: in the pursuit of the ideals of mass individualization (mass customization) (Boer, 2013), allowing to achieve the economic parameters in the production of series like in the production of individual products. Even only the above example shows the genesis of the presence of IT systems in the production environment, associated with the desire for mastery, modelling and reduction of its complexity, for achieving the economic optima.

Informational-orientation of manufacturing processes (more broadly: production and logistics) is in fact a new organization a paradigm with the following characteristics (Fig. 1):

1. The organization striving for the ideal of self-learning i.e. with such features as self-evolution (stable market development, new types of production), self-growth (improving of performance indicators), selfreproduktion (durability of solutions, including ecological) selfadaptation (flexible responses to changes),
2. Virtuality of hardware and software, escalating to cloud solutions (Weinmann, 2013) and to the virtual manufacturing network VMN (Khan, 2011),
3. Mobile and miniaturized devices, supporting the networking of distributed applications, a hierarchical economic structures, corresponding to the net-working of the information society (Dijk, 2012).
4. Moving of biological ideals to the sphere of manufacturing in the area of algorithms and management practices – bio organization, genetic applications, bionic manufacturing systems (BMS).

Fig. 1 also points to the importance of reference models for the optimization of manufacturing systems and their associated information models (ITIL) (Brewster, 2012) and the megatrend development associated with the Industry 4.0 (Brettel, Friedrichsen, Keller & Rosenberg, 2014).

Information-orientation of manufacturing means to realize a postulate: the transformation of material states of the system should generate changes in associated IT system.

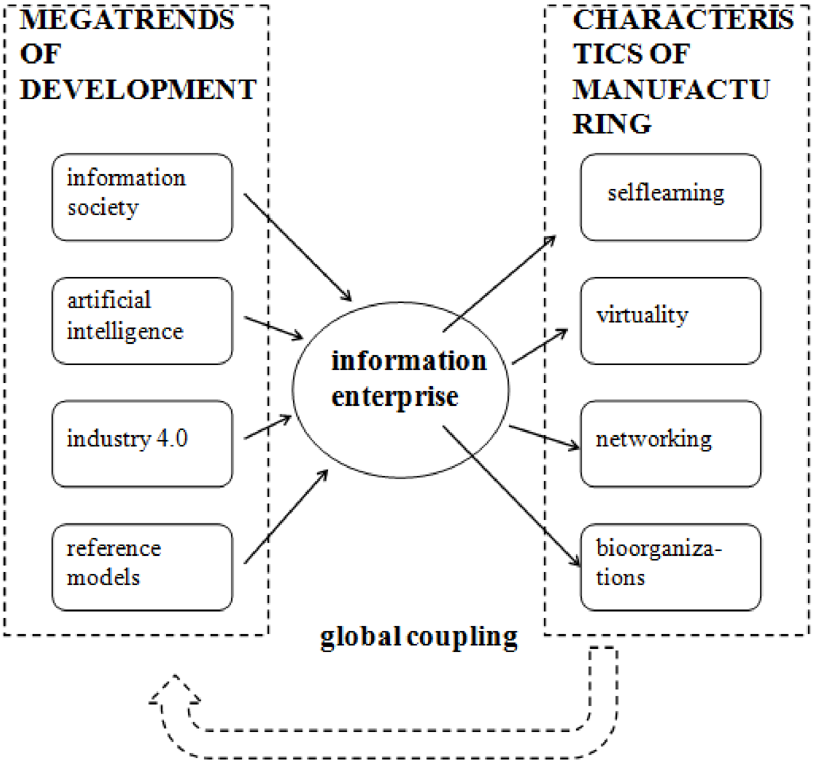

Fig. 1 The information enterprise – trends and characteristics

The given above example of information enterprise, can be connected to the postulate of "digitization of matter" – he corresponds with formulas (1), (2). The demand is also characteristic for reference models, which can be used for computer-aided production and for the trend indicated earlier – industry 4.0. Generally we can even notice that the industry 4.0 is the digitization of production matter, controlled with the help of cyber-phisical systems in the Internet of Things environment.

The basis of the IoT (Internet of Things) (Evdokimov, 2011) is the marking of material objects (e.g. RFID, s. Fig. 1), which can communicate with each other in the network by using the available services. We have therefore:

$$IoT = IoS + IoM$$

where

IoS – Internet of Service,

IoM – Internet of Media.

On the other side, the analysis of the concept of cyber-physical systems (CPS), presented in the works (Brettel, Friedrichsen, Keller & Rosenberg, 2014), (Hu 2013), allows to identify their most important components:

- computers (microprocessors), as an integral part of the manufacturing device in the form of embedded modules,
- sensor networks (WSN Wireless Sensor Network) constructed from nodes, in the form of sensors, that communicate autonomously for the realization of a task (e.g. to monitor the status of devices)
- Internet infrastructure, global "network of networks" (evernet) with its multimedia services (e.g. semantics of hypertext),
- real-time systems, that use GPS positioning (Global Positioning System) / RFID in logistics and JiT production (just-in-time) coordinated with the detailed planning and production of MES/class (Manufacturing Execution System),
- autonomous processing AC (Autonomic Computing), i.e. self-managing of computer systems (Lalande, McCann & Diaconescu, 2013) with self-learning abilities.

3. OBJECT-ORIENTED FACTORY

Characteristics of enterprise information (section 2) and organizational characteristics of the transformational trends (section 1) raised the question of relationships between both spheres, i.e. their (meta)model and the common paradigm. We can look for it in the area of systems theory, assuming that it is present in both spheres: the manufacturing and the associated IT (Daft, Murphy, & Willmott, 2010). An alternative (meta) feature here is also the object-orientation. Its genesis is the software engineering and such approach can be used in the phase of production system definition and during its operation (Ramnath & Dathan, 2011). Therefore we define object-orientation as a kind of modeling, implementing and maintenance of production systems based on extracted and communicated elements (objects) having the properties (attributes) and functionality (methods) with using of classes and abstractions, as well encapsulation, inheritance and polymorphism (s. formula (3)).

Now we comment the last four mentioned characteristics of object-orientation in the context of manufacturing.

1. class and abstractions imply structuring of objects based on uniform set of attributes and services, which contributes to the formalization of modeling and thereby to optimization of the associated algorithms,
2. encapsulation is the integration of data and functions performed on them in such a way, that the processing of data is realized only with the some specified methods,

3. inheritance is the possibility of creating child classes (derived subclass) from the base classes (superclass),
4. polymorphism means (gr.) the ability of specific reactions of different objects on the same signal (call).

From the previous considerations results that in the center of modeling and implementation of information enterprise we can extract an object-oriented metamodel with the specified properties. These relate directly to the implemented software but also to the system (object-oriented) analysis, which in turn leads to the reference models (Lankhorst, 2012). In this way, the information enterprise can be treated as object-oriented (Fig. 2). Components of the so understood system, both internal and external, are modeled as object-oriented with the use of reference systems – some of them are listed in Fig. 2, i.e.:

- ITIL (IT Infrastructure Library), (Brewster, 2012),
- COBIT (Control Objectives for Information and Related Technology) (Cobit, 2005),
- TOGAF (The Open Group Architecture Framework), (Togaf, 2009).

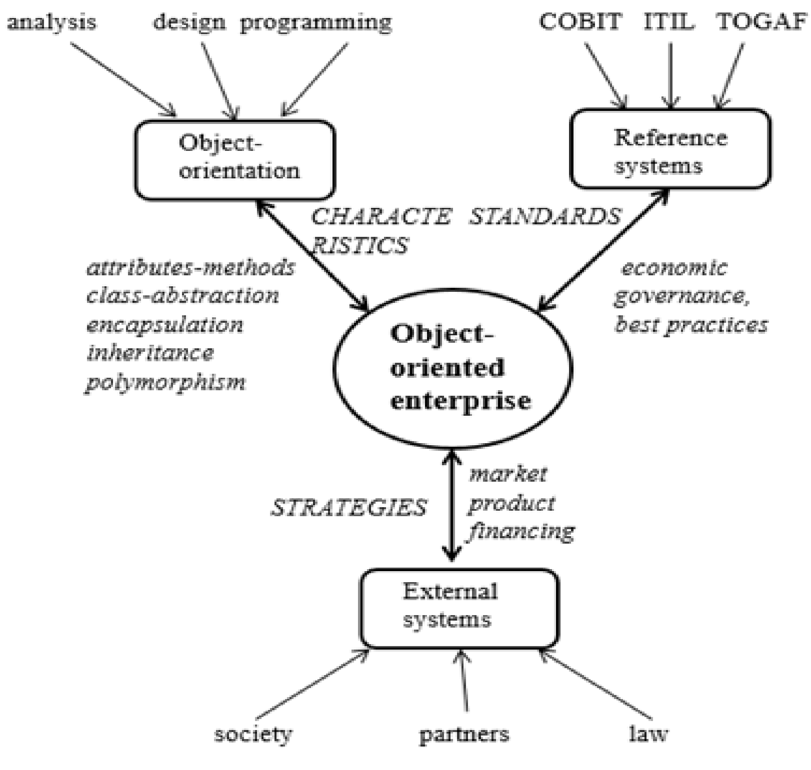

Fig. 2 Object-oriented enterprise and its environment

Fig. 2 also identifies external systems, called likewise situational, which at the strategic level are combined with the company in: market, product and financial way. The components of object-oriented enterprise create layers, which can be interpreted in the manufacturing (material) and information dimensions (IT applications).

4. CONCLUSION

In the preceding paragraphs, was shown that the use of object-orientation in the modeling and implementation processes and the implementation of computer-aided manufacturing allows to expect a consistent approach, with a high level of integration, due to the following reasons:

- object-orientation is an extension of previous methods, for example structural (Ramnath & Dathan, 2011),
- the modeled real world, both in manufacturing and information spheres, consists of objects and their classes,
- operations of manufacturing processes can be modeled in conjunction with processed materials (a characteristic of object-orientation),
- object-orientation suits for modeling of complex systems and at the same time fast-changeable systems (the feature of flexible manufacturing systems),
- the inheritance feature allows to reduce the amount of necessary changes in the system (organizational and in data structures) resulting from changes in the production environment,
- the polymorphism joins with the desired scalability of defined applications, i.e. the possibility of their use in systems of different sizes,
- the encapsulation supports to achieve a greater modularity of the system.

Also object-oriented optimization of informational integration of manufacturing (shown on p. 2 – digitization of matter) is the subject to the rules of the management cycle: from specifications of the project goal, through the defining of the resources needed for its implementation, to the final inspection of results, leading to the next cycle (operational). From the point of view of software engineering (Schmidt, 2013) in the initial phase a rough design of project is formed (draft), which is associated with the step of variants creation, which results in a report based on the implementation offers. At the same time, in the described process, we have to do with the dynamics of continuous improvement CI (Mohapatra, 2013).

REFERENCES

Baldegger R., (2012), Management in a Dynamic Environment, Concepts, Methods and Tools, Springer-Gabler Science+Business Media, Wiesbaden.

Beck R., (2006), The Network(ed) Economy, The Nature Addoption, Diffusion of Communications Standards, DUV, Springer Science+Business Media, Wiesbaden, 2006.
Boër C.R., (2013), Mass Customization and Sustainablility An Assessment Framework and Industrial Implementation, Springer, London, UK.
Brettel M., Friedrichsen N., Keller M., & Rosenberg M., (2014), How Virtualization, Decentralization and Network Building Change the Manufacturing Landscape, An Industry 4.0 Perspective, World Academy of Science, Engineering and Technology, International Journal of Mechanical, Industrial Science and Engineering Vol. 8 No.1, Riverside, Connecticut, CT, USA, pp. 37-44.
Brewster E., (2012), IT Service Managament, a Guide for ITIL Foundation. British Informatics Society Limited (BISL), Swindon, UK.
Cobit, (2005), Cobit 4.0: Control Objectives Management Guidelines Maturity Models. IT Governance Institute, Rolling Meadows, IL, USA, KPMG Vienna.
Daft R.L., Murphy J., & Willmott H., (2010), Organization, Theory and Design. Cengage Learning EMEA, Andover, Hampshire, UK.
Date C.J., (2012), SQL and the relational theory, O‘Reilly Media Inc., Sebastopol, USA.
Dijk van J., (2012), The Network Society, SAGE Publications Ltd., London, UK.
Evdokimov S., (2011), RFID and the Internet of Things, Technology,Applications and Security Challenges. Publishers Inc., Hanover, MA, USA.
Fulekar M.H., (2009), Bioinformatics, applications in life and environmental sciences, Springer, New York, USA.
Hu F., (2013), Cyber-Physical Systems, Integrated Computing and Engineering Design, Taylor & Francis Group, Boca Raton, FL, USA.
Khan W.A., (2011), Virtual Manufacturing, Springer, New York, USA.
Lankhorst M., (2012), Enterprise Architecture at Work, Modelling, Communication and Analysis. Springer, London, UK.
Mohapatra S. (2013), Business Process Reengineering, Automation Decision Points in Process Reengineering Springer Science+Business Media, New York, USA.
Nair M., (2011), Strategic Business Transformation, John Wiley & Sons Inc., Hoboken New Jersey USA.
Ramnath S. & Dathan B., (2011): Object-Oriented Analysis and Design. Springer, London, UK.
Schmidt R., (2013), Software Engineering, Architecture-Driven Software Development. Elsevier Inc., Waltham, MA, USA.
Togaf, (2009), Togaf: The Open Group Architecture Framework, The Open Group, Reading, Berkshire, United Kingdom.
Weinmann J., (2013), Cloudonomics, The Business Value of Cloud Computing. John Wiley & Sons, Inc., Hoboken, New Jersey, USA.

BIOGRAPHICAL NOTES

Jarosław Badurek is a graduate of Computer Science at the Faculty of Electronical Engineering and Organization and Industry Management at the Gdańsk Technical University, a doctorate degree in computer economic science at the Faculty of Management and Computer Science of Wrocław University of Economics. For over twenty years of experience in industrial practice, taking part in a multinational information technology projects, as administrator, systems integrator and designer of computer-aided manufacturing organization, currently a group of companies in the food industry (Germany). A specialist in the area of databases (e.g. Oracle) and ERP (e.g. SAP). Scientifically cooperating with the Faculty of Management and Economics, Technical University of Gdańsk. Interests: integration of computer systems, production planning and control, logistics and quality control, organization of IT projects.