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APPLICATION OF AN ELECTRONIC BULLETIN BOARD, AS A MECHANISM OF COORDINATION OF ACTIONS IN COMPLEX SYSTEMS - REFERENCE MODEL

Katarzyna Grzybowska

Poznan University of Technology, Poznan, **Poland**

ABSTRACT. **Background:** In her previous research, the author of this publication indicates that coordination is a dependent variable which has a great driving force and is a very unstable factor. This results in the fact that all of the actions connected with coordination have an impact on other factors of cooperation as well as the integration of the enterprises in the structures of a supply chain type structure.
Material and methods: The article has been divided into two basic parts. The first part regards the reference models in complex systems (supply chain systems). They can constitute a starting point for the modelling of target processes in the built supply chain structure. The second part presents template process models (Reference Models) for selected action coordination mechanisms during enterprise cooperation. The aim of the article is the presentation the model an Electronic Bulletin Board (EBB), as a mechanism of coordination of actions in complex systems.
Results: The article was prepared on the basis of literature from the researched area. The material was also prepared on the basis of interviews with practitioners. They have allowed for the preparation of template process models (Reference Models) for selected action coordination methods in the supply chain.
Conclusions: The result of the work is a prepared model as well as its description in the use of IDEF0. The presented model is a demonstrative model. The proposed reference model makes it possible to define the parameters of a selected mechanism of coordination of actions, and forms a basis for affecting the progression of the process through an analysis of values of identified parameters. The parameterization of elements constitutes the foundation for the monitoring of the process via 1) unambiguous identification of the object of monitoring and 2) analysis of different variants of the progression of the process.

Key words: Coordination of Actions, Reference Model, Complex Systems, Electronic Bulletin Board.

INTRODUCTION

The idea of supply chain management is interpreted not only in the context of logistics but also in the framework of integration and synchronization. Regardless of how the essence of the concept is understood, its distinguishing feature is process orientation, i.e. approaching the supply chain's decisions, actions and flows as processes [Witkowski 2003, Supply Chain Council 2009]. Lambert, Cooper and Pagh mention that to some SCM is seen as the management of relationships both between corporate functions and across companies [Lambert et al. 1998]. The supply chain management is a decision process that not only integrates all of its participants, but also helps to coordinate the basic flows: products/services, information and funds [Sitek, Wikarek 2014].

Modelling always begins with the so-called mental model. Mental models can be found in a variety of disciplines within the humanities. Mental models were first introduced in the field of simulation modelling by Forrester [Forrester 1972]. The historical foundations of

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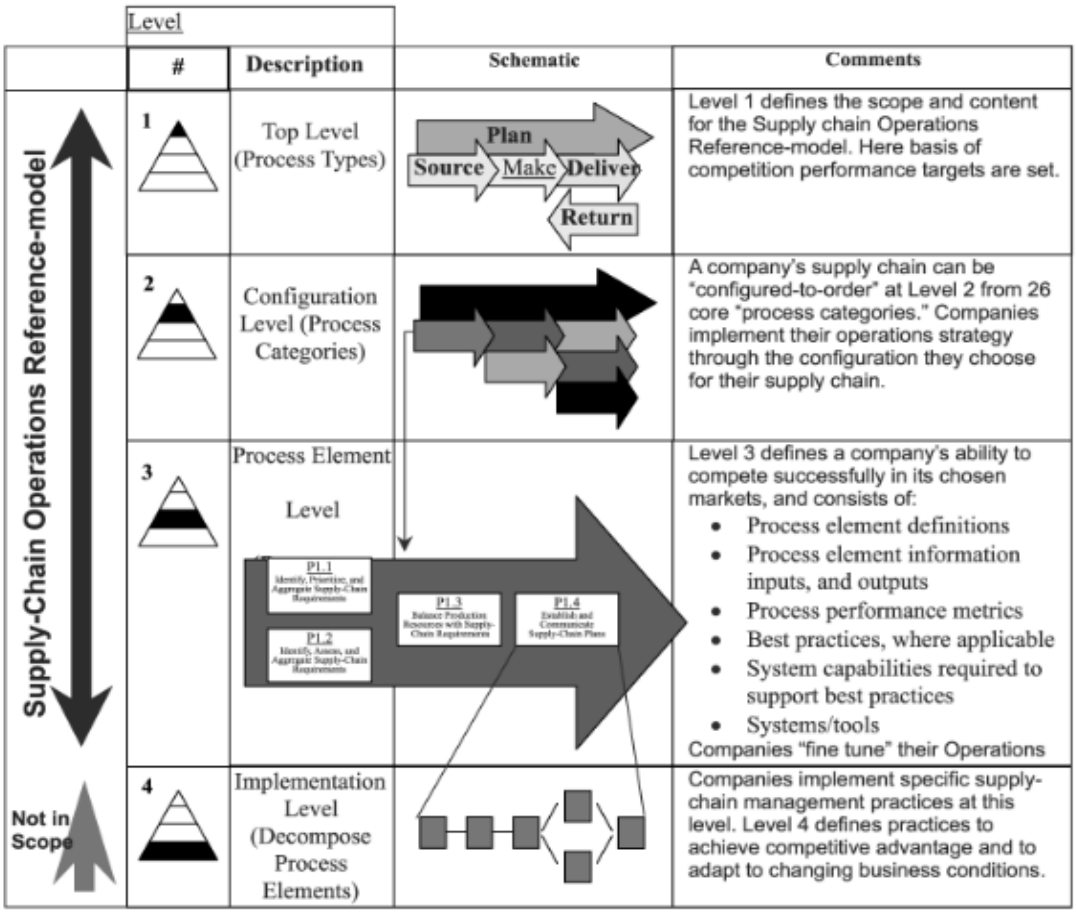
modeling formalism were developed in the USA [Chen 1995], and they resulted in the creation of the family of IDEF methods. Until now, over 70 modeling languages have been developed. However, this large variety makes language selection process difficult (Pawlewski). IDEF0 is a method designed to model the decisions, actions, and activities of an organization or system [Grzybowska, Kovács 2014].

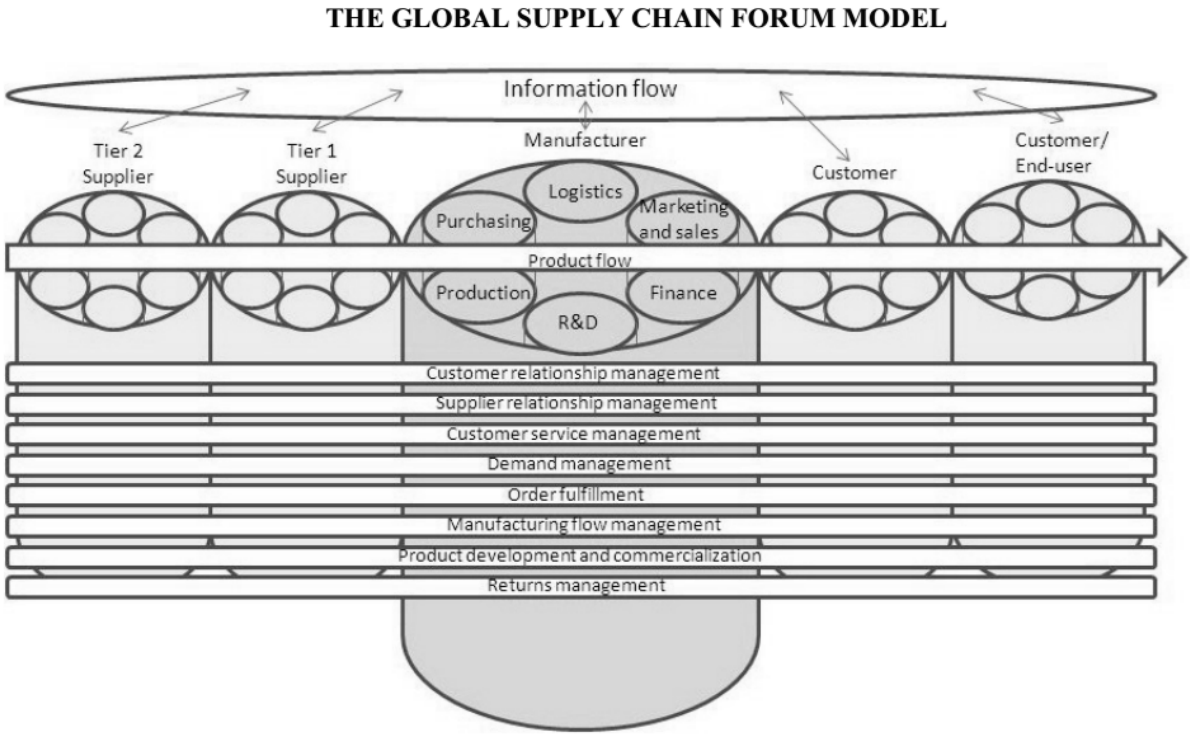
The most commonly cited reference models are:

– The Supply Chain Operations Reference (SCOR) model, developed by the Supply Chain Council (SCC) and AMR Research in 1996 is the most commonly cited SCM framework [Lockamy, McCormack 2004]. The SCOR model "provides a unique framework that links business processes, metrics, best practices and technology features into a unified structure to support communication among supply chain partners and to improve the effectiveness of supply chain management and related supply chain improvement activities" [Supply Chain Council, 2009].
– The Global Supply Chain Forum model, the second most popular framework is developed by the Global Supply Chain Forum (GSCF) [Lambert et al. 1998], at Ohio State University's Supply Chain Management Institute (SCMI). Supply chain management is the management of relationships in the network of organizations, from end customers through original suppliers, using key cross-functional business processes to create value for customers and other stakeholders [Naslund, Williamson 2010]. According to the GSCF framework, when all proper coordination mechanisms are in place across the various functions, the result will be an efficient and effective supply chain.



Source: Lockamy and McCormack, 2004

Fig. 1. Supply-Chain Operations Reference Model (version 4,0)
Rys. 1. Model referencyjny Supply-Chain Operations (wersja 4,0)



Source: http://scm-institute.org/Our-Relationship-Based-Business-Model.htm

Fig. 2. The Global Supply Chain Forum Model
Rys. 2. Model Global Supply Chain Forum

The author in the article "Coordination in the Supply Chain - an Indication of Logistic Management", presented activity coordination techniques that are applied by the enterprises. Fifty enterprises, unrelated to each other in their business activities took part in the conducted research. The respondents had the possibility of indicating more than one answer. The application of three coordination techniques was most often noted: coordination (28% indication), the application of six or seven techniques (4% each) was least common. 16% of the research respondents apply eight of the ten coordination techniques [Grzybowska, 2013].

These studies inspired to work on the problem of coordination. The aim of the article is the presentation the model an Electronic Bulletin Board (EBB), as a mechanism of coordination of actions in complex systems.

THE ELECTRONIC BULLETIN BOARD - A MECHANISM OF COORDINATION OF ACTIONS

Coordination terms and models have been developed in different fields to coordinate the interaction among components and objects, and are nowadays used to model and analyze organizations too [Boella, van der Torre 2006]. When the word coordination was first recorded in 1605, it meant "orderly combination" [Barnhart Dictionary of Etymology, 1988].

The coordination mechanism has a form of interactions among differentiated (in terms of form, targets, intentions, the manner of organization, etc.) and independent entities. Following Kotarbiński, the coordination of actions is understood in terms of agreement. Based on the literature and interviews with practitioners [Toktas-Palut, Ülengin, 2011; Natarajan, 2003; Simatupang, Wright, Sridharan, 2002; Redmiles, van der Hoek, Al-Ani,

Hildenbrand, Quirk, Sarma, Silva Filho, de Souza, Trainer, 2007], it is possible to distinguish several mechanisms/means/forms of coordination of actions that can be employed in the phase of initiating cooperation on an order, and during cooperation and execution of the order. The discussed mechanism is most typically employed during agreements in the phase of initiating cooperation.

One method of activity coordination is self-coordination, understood as the voluntary cooperation of units- as during an open market fair. "The possibility of coordination through voluntary cooperation is based on the fundamental truth, although often negated - that both parties to the transaction gain a benefit from it, under the condition that this is a transaction that is voluntary and conscious from both sides" [Friedman 1993]. One of the methods of the voluntary cooperation of entities is the Open Method of Coordination - OMC. The open method of coordination is based on:

- the mutual identification of aims to be achieved in a complex, multi-agent system,
- the joint establishment of means aimed at the achievement of goals (in the form of statistics, indicators and guidelines),
- analyses, which entail the comparison of system element activities and the ex-change of good practices.

The coordination mechanism with the use of the Electronic Bulletin Board is a modified form of the classic form of coordination - contracting. Coordination with the use of an Electronic Bulletin Board is applied when the order has a very well defined sub-order or sub-task structure. As a result, the order can be structured into its simpler sub-tasks.

The structuring of the order entails its decomposition into a series of sub-orders in order to separate the structure of the order. This is a strictly indicated system resulting from the combining of sub-orders of the entire order. Structuring enables:

- the creation of a complete overview of the entire order and its aim,
- the division of the order into smaller sub-orders, which can be given for completion to sub-contractors,
- the indication of borderline conditions for the planning, steering and supervision over the completion of the order,
- the indication of all of the resources necessary to complete the order,
- the enabling of the current review of the costs of the order,
- the establishment of the control points of the order,
- placing the efficiency gauges in order.

THE ELECTRONIC BULLETIN BOARD - REFERENCE MODEL

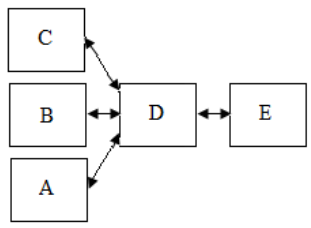
The Electronic Bulletin Board is a general term applicable to the technological/IT solution. The solution can refer to the electronic platform, logistics platform and integration platform. It can also apply to different forms of bidding/auction, shopping or group web portals (systems). Finally, the name "Electronic Bulletin Board" can be applied to solutions designed for the exchange of information, dedicated to the needs of industrial clusters which are characterized by quick adaptability to the changing needs of the market and diverse requirements through cooperation and application of new technologies. The Electronic Bulletin Board is consistent with new trends in technology. The core idea behind EBB is to coordinate multiple collaborating enterprises concurrently in the phase of initiating cooperation. The duration of coordination activities in this phase is usually set by the initiator of cooperation. The proposed reference model concerning the coordination of actions using the Electronic Bulletin Board does not take into account detailed terms of cooperation within the network, e.g. trust between partners, sharing of information and knowledge, organizational compatibility, etc.

It must also be emphasized that the presented reference model should be understood as a course of actions. Its referential nature carries an additional benefit, namely high flexibility of the model ensuring the applicability of general schemes to specific conditions in a given organization. The reference model was created using IDEF0

methodology modified specifically for the purposes of the model.

The model has been divided into two areas ("pools"), principal (client) and agent (supplier, subcontractor). Between the two pools there is the Electronic Bulletin Board represented in the form of a common (shared) block (Fig. 3) containing data and information available to all users. It is also possible to identify a narrow group of users. The model also contains elements in the form of cubes which refer to actions or activities implemented within the framework of a process relating to the coordination of actions. The cubes feature a unique combination of letters and characters ("alphanumeric index") which make it possible to quickly find them and accurately identify actions. The index note localizes functions (process/action/activity) in a complex hierarchical diagram structure. The cubes are interconnected by arrows. The arrows are objects of mutual relations between functions (cubes) which define information and illustrate relationships existing between actions.

The coordination with the use of the Electronic Bulletin Board is maintaining the coordination and supervision of all of the works, even those at the lowest level of complexity, by the main ordering party. In such a case, when a sub-contractor is found for some sub-order, the scope of the works of this sub-order is decomposed into sub-sub-orders by the main sub-contractor. One can observe a repeating action (most often repeated multiple times) of the same instruction (schedule of activities) in the loop.



Source: own study

Fig. 3. Concentrated nature
Rys. 3. Skoncentrowany charakter

In such a layout, cell D, who is the main ordering party, has the most advantageous position, having the full coordination of the activities and control over the completion of the order (Fig. 3).

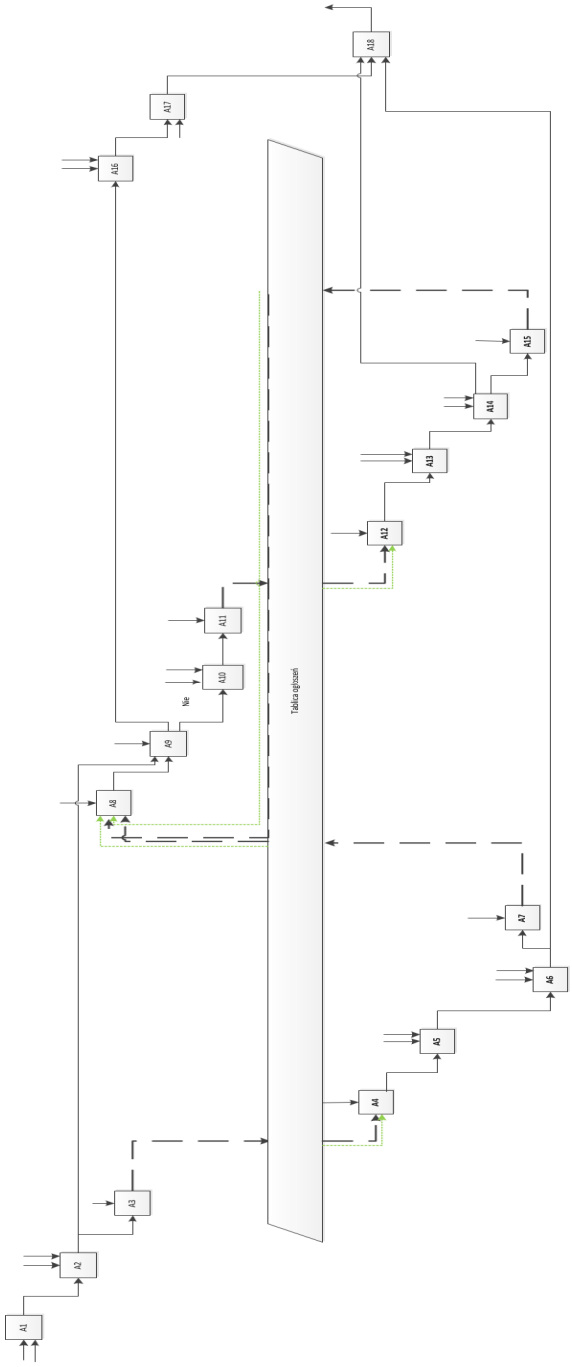
The structuring of the order entails its decomposition into a series of sub-orders in order to separate the structure of the order. This is a strictly indicated system resulting from the combining of sub-orders of the entire order. Structuring enables:

- the creation of a complete overview of the entire order and its aim,
- the division of the order into smaller sub-orders, which can be given for completion to sub-contractors,
- the indication of borderline conditions for the planning, steering and supervision over the completion of the order,
- the indication of all of the resources necessary to complete the order,
- the enabling of the current review of the costs of the order,
- the establishment of the control points of the order,
- placing the efficiency gauges in order.

The proposed reference model provides replies to the following questions:

- What actions (and in what order) should be executed?
- What information is necessary for the execution of actions?
- What effects are to be expected?
- What methods of analysis can be employed for the execution of actions?

The proposed reference model identifies relationships between business partners. It fills the gap with respect to the formalization of mechanisms applied for the coordination of actions, and forms a foundation for the development of a suitable simulation model.



Source: own study

Fig. 4. The electronic bulletin board - concentrated coordination of actions
Rys. 4. Elektroniczna tablica ogłoszeń - skoncentrowane koordynowanie działań

Table 1. Identification of actions - the electronic bulletin board - focused coordination of actions
Tabela 1. Identyfikacja działań - elektroniczna tablica ogłoszeń - skoncentrowane koordynowanie działań

ID	Name of the activity
A1	Commencing works of the request from the client
A2	Decomposition of the request into tasks, with consideration of a chosen criterion
A3	Adding the tasks to the information board
A4	Reading the tasks allocated on the board
A5	Evaluating the possibilities and profitability of the allocated task
A6	Making a decision about the possibility and profitability of performance of the task
A7	Putting the answer on the board
A8	Reading all records - collecting offers and answers with a resignation
A9	Verification of compliance of tasks with offers
A10	Making a decision about the possibility to obtain the lacking resources through decomposing the tasks
A11	Terminating the works
A12	Decomposition of the tasks into sub-tasks
A13	Adding the sub-tasks to the information board
A14	Reading the allocated sub-tasks
A15	Evaluating the possibility of performance and probability of the allocated sub-task
A16	Making a decision about the possibility and profitability of performance of the sub-task
A17	Putting the answer on the board
A18	Choosing an optimal composition of offers
A19	Allocating the tasks to subcontractors – request
A20	Confirming the commencement of works over the request

Source: own study

CONCLUSIONS

The methodology of reference modelling is used for the representation of complex systems and interactions existing between their constituent elements. Reference models are designed for the presentation of concepts of operation of different elements (objects), and illustrate their actions (processes). Reference models make it possible to build a complex system structure and select suitable tools that will support the automation of actions (processes) described by the models. Last but not least, reference modelling allows the development of structural and methodological frameworks that prove useful for the optimization of complex systems.

Consequently, the next step in exploring the coordination of actions using the Electronic Bulletin Board will be the development of a simulation model. The model will serve as an analytical tool for the purpose of monitoring the probability of accomplishment of goals set by users of the Electronic Bulletin Board functioning in a complex system. The simulation modelling apparatus will be employed as a tool for analyzing parameters connected to the mechanism of coordination of actions between participants of complex systems, taking into account randomly occurring temporal and personal limitations.

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ZASTOSOWANIE ELEKTRONICZNEJ TABLICY OGŁOSZEŃ, JAKO MECHANIZM KOORDYNACJI DZIAŁAŃ W SYSTEMACH ZŁOŻONYCH - MODEL REFERENCYJNY

STRESZCZENIE. **Wstęp:** Autorka we wcześniejszych badaniach wskazuje, że koordynacja działań jest zmienną zależną, która ma wpływ na siłę napędową i jest czynnikiem bardzo niestabilnym. Wynika to z faktu, że wszystkie czynności związanych z koordynacją działań wpływają na inne czynniki współpracy oraz integracji przedsiębiorstw w strukturach typu łańcuch dostaw.

Metody: Artykuł został podzielony na dwie zasadnicze części. Pierwsza część odnosi się do wybranego mechanizmu koordynacji działań tj. koordynacji działań przy wykorzystaniu elektronicznej tablicy ogłoszeń. Część druga pracy zawiera model referencyjny omawianego mechanizmu. Model ten może stanowić punkt wyjścia do modelowania procesów docelowych w zbudowanej strukturze łańcucha dostaw.
Rezultaty: Artykuł został przygotowany na podstawie literatury z badanego obszaru. Przygotowano również materiał na podstawie wywiadów z praktykami. Informacje zaczerpnięte od praktyków, podbudowane literaturą pozwalają na przygotowanie modeli procesów (modele referencyjne) dla wybranych metod koordynacji działań w łańcuchu dostaw.
Wnioski: Wynikiem pracy jest model referencyjny, rozumiany jako sposób postępowania, (została zastosowana zmodyfikowana metodologia IDEF0) oraz jego opis. Prezentowany model ma charakter poglądowy. Proponowany model odniesienia umożliwia określenie parametrów wybranego mechanizmu koordynacji działań i tworzy podstawę do analizy wartości wskazanych parametrów. Parametryzacja elementów stanowi podstawę do monitorowania procesu przez 1) jednoznaczną identyfikację obiektu monitorowania i 2) analizę różnych wariantów postępu procesu.

Słowa kluczowe: koordynacja działań, model referencyjny, system złożony, elektroniczna tablica ogłoszeń

DIE ANWENDUNG VON ELEKTRONISCHER VERKÜNDUNGS-TAFEL ALS MECHANISMUS FÜR DIE KOORDINIERUNG VON AKTIVITÄTEN IN KOMPLEXEN SYSTEMEN - EIN REFERENZ-MODELL

ZUSAMMENFASSUNG. Einleitung: Die Autorin weist in ihren früheren Forschungen darauf hin, dass die Koordinierung von Aktivitäten eine abhängige Variable ist, die die Antriebskraft beeinflusst und als ein sehr unstabiler Faktor anzusehen ist. Dies resultiert aus der Tatsache, laut deren alle mit der Koordination verbundenen Aktivitäten andere Faktoren der Zusammenarbeit und der Integration von Unternehmen innerhalb der lieferkettenmäßigen Strukturen mit beieinflussen.
Methoden: Der Artikel wurde in zwei Hauptteile aufgeteilt. Der erste Teil bezieht sich auf den ausgewählten Mechanismus der Koordinierung von Aktivitäten, d.h. der Koordinierung von Handlungen unter Anwendung einer elektronischen Verkündungstafel. Der andere Teil umfasst das Referenzmodell des besagten Mechanismus. Das Modell kann als Ausgangspunkt für Modellierung von Zielprozessen in einer aufgebauten Struktur einer Lieferkette bestehen.
Ergebnisse: Dem Artikel liegt die Fachliteratur aus dem betreffenden Bereich zugrunde. Das Material hat man auch mithilfe von Interviews mit Praktikern ermittelt. Die von den Praktikern gewonnenen, mit der Fachliteratur untermauerten Informationen erlauben es, die Prozeßmodelle (Referenzmodelle) für die ausgewählten Methoden der Koordinierung der Aktivitäten innerhalb von Lieferketten zu erstellen.
Fazit: Als Arbeitsergebnis gelten das als eine bestimmte Vorgehensweise aufgefasste Referenzmodell (dabei wurde die modifizierte IDEF0-Methodologie angewendet), sowie dessen Beschreibung. Das dargestellte Modell besitzt einen Anschauungscharakter. Das vorgeschlagene Referenzmodell ermöglicht die Bestimmung von Parametern des ausgewählten Mechanismus für die Koordinierung der Handlungen und schafft somit eine Grundlage für die Analyse von Werten der genannten Parameter. Die Parametrisierung der Elemente ist die Voraussetzung eines effizienten Prozeß-Monitorings, realiziert durch: 1) eine eindeutige Identifizierung des wahrgenommenen Objektes und durch: 2) die Analyse unterschiedlicher Varianten des Prozeßablaufes.

Codewörter: Koordinierung von Aktivitäten, Referenzmodell, komplexes System, elektronische Verkündungstafel

Katarzyna Grzybowska
Department of Organization and Management
Poznan University of Technology
Strzelecka 11 St., 61-695 Poznan, **Poland**
e-mail: katarzyna.grzybowska@put.poznan.pl