Published in: Understanding Autonomous Cooperation & Control - The Impact of Autonomy on Management, Information, Communication, and Material Flow. Springer, Berlin, 2007, pp. 163-167

3 Autonomous Control Methods for the Managment, Information and Communication Layer

3.1 Approaches to Methods of Autonomous Cooperation and Control for the Management-, Information- and Communication-Layer of Logistics

Michael Hülsmann[1], Katja Windt[2]

[1] Management of Sustainable System Development, Institute for Strategic Competence-Management, Faculty of Business Studies and Economics, University of Bremen, Germany

[2] Department of Planning and Control of Production Systems, BIBA, University of Bremen, Germany

Recent changes like short product life cycles, mass customization as well as a decreasing number of lots with a simultaneously rising number of product variants and higher product complexity have led to an increase of complexity of logistics in transportation systems as well as in production systems (Hülsmann / Scholz-Reiter / Freitag / Wycisk / De Beer 2006). Therefore, all participants in supply networks and their processes have to develop new planning and control methods for their logistics in order to cope with these requirements (Scholz-Reiter / Windt / Freitag 2004). To achieve an ability to adapt to these new challenges, the approach of decentralized planning and control by intelligent logistic objects in autonomously controlled production systems is discussed in different disciplines that deal with logistics (e.g Hülsmann / Grapp 2005; Windt 2006). In general, it is postulated that autonomous cooperation and control is one possible approach to cope with rising dynamics and complexity and to increase

the level of emergence and robustness in supply chains and networks (Hülsmann / Windt / Wycisk / Philipp / Grapp / Böse 2006).

However, for the implementation of the principles of autonomous cooperation and control into the organisation domain of supply chains and supply networks, approaches will be needed that allow to transfer the general idea of autonomy in decision making into functional rules of cooperation and control for the different layers of logistics, i.e. the management-, the information-, and the communication layer (Scholz-Reiter / Windt / Freitag 2004). That addresses the need for appropriate methods that allow to reflect the major constitutive characteristics of autonomous cooperation and control – which are e.g. autonomy, heterarchical structures, interaction and interrelations, non-determinism (Hülsmann / Wycisk 2006) – in the modelling, measurement, and management of logistic processes. Therefore, this chapter would like to develop and describe approaches on how existing methods of logistics – like for example the layout of communication networks, the strategizing of logistic service providers, the management of distributed knowledge – can be adopted to the paradigm of autonomy. Additionally, new methods, based solely on the concept of autonomous cooperation and control, should be introduced – such as adaptive business processes within the production logistics domain.

The authors of **"Self-Organization in Management Science"** – Michael Hülsmann, Jörn Grapp, Ying Li, Christine Wycisk – aim to develop a general understanding of self-organization in management science so as to contribute to the establishment of a framework for studying self-organization. The concept of self-organization has its roots in various natural sciences and has the potential for enrichment of management theories by giving new interpretations to key aspects of conventional management approaches. However, in management science, research on self-organization is dispersed, with different angles of observation and a variety of terms used as synonymies. Consequently, this lack of an overarching framework for studying self-organization may impede the recognition and application of this concept in management science. Therefore, this chapter introduces selected concepts using self-organization from management science, compares the characteristics of self-organization implied by these concepts according to selected criteria (organizational structure, behaviour and abilities), and forms a general framework for studying self-organization in management science.

In the chapter **"Autonomous Cooperation – A way to vitalize organizations?"** Michael Hülsmann and Christine Wycisk deal with the question as to how far autonomous cooperation can provide a tool to unlock organi-

zations. A locked organization is the organization trapped in a dilemma between need of a large amount of information, and limited capacity for obtaining and analyzing information, the consequence of which are fewer alternatives for organizational development. Such a dilemma results from the complexity and dynamics in the environment. As being locked implies the risk of collapse of organizations, ways to unlock organizations need to be studied. This chapter proposes autonomous cooperation as an alternative way and analyzes its contribution for the flexibilisation of organizations. The theory applied is competence-based view.

The chapter **"Self-organization Concepts for the Information- and Communication Layer of Autonomous Logistics Processes"** by Markus Becker, Andreas Timm-Giel, Carmelita Görg describes the application of self-organization approaches in the information and communication layer of autonomous logistic processes: the self-organized selection of communication networks, gateway discovery and ad hoc routing. The purpose of applying self-organization approaches is to improve communications between logistic objects. Among others, concepts of Autonomic Communication, Autonomic Computing and Self-Star are most relevant for logistics processes. In this chapter, self-organized selection of communication networks and services regarding communication selection and time are presented. Next, different methods and implementations of service discovery are introduced, followed by description of principles of ad hoc routing and different scenarios.

Hagen Langer, Jan D. Gehrke, Otthein Herzog introduce with **"Distributed Knowledge Management in Dynamic Environment"** an approach to the agent-based modeling of logistic processes which makes use of an explicit knowledge management system and hence enables agents to fulfill complex logistic tasks in dynamic environments. This task is driven by the realization that conventional optimization models neglect the important role of knowledge and communication in real-world process and the dynamics of parameter values. This chapter introduces agents as basic components as a framework for modeling, discusses agent-based approaches to logistics, and depicts distributed knowledge management for multi-agent systems (agent roles, decision parameters, and an interaction protocol).

The chapter **"Proactive Knowledge-based Risk Management"** – contributed by Martin Lorenz, Boris Bemeleit, Otthein Herzog and Jens Schumacher – presents the description of new possibilities in reducing damage, lateness and other aberrations to given goals for autonomous logistic objects through the usage of a suitable risk management concept. The increased complexity of logistic systems is followed by a more com-

plicated planning and control of logistic systems and of the related processes in combination with an increased sensitivity of the total system to disturbances and malfunctions. This fragility calls for a risk management system to ensure successful realization of autonomous logistic objects. Therefore, this chapter gives an overview of different levels of risk and risk management for planning and controlling the logistic processes by agent based autonomous objects. Besides, the basic risk management concept and technical realization of a local risk management system is introduced and discussed regarding the requirements for agent based logistic objects.

The chapter **"Autonomy in Software Systems"**, written by Ingo J. Timm, Peter Knirsch, Hans-Jörg Kreowski, and Andreas Timm-Giel, presents one of the main characteristics of autonomous cooperation and control – i.e. autonomy – as a core property of innovative software systems, like agents and autonomous units. Therefore, the ideas of agency in software systems are sketched. That is the basis for analysing how communities of autonomous units deal with autonomous decision makers in comparison with multi-agent-systems. The relationship between autonomous units as a graph-transformation-based approach to handling autonomous decisions in a rule-based formal framework and agents as a widely used logical structure in artificial intelligence is discussed in this article regarding environmental states, transformation steps, perception, and decision-making.

Bernd Scholz-Reiter, Jan Kolditz, and Torsten Hildebrandt present in their article **"Specifying Adaptive Business Processes within the Production Logistics Domain — A new Modelling Concept and its Challenges"** the idea of autonomous logistic processes and focus on a concept for modelling such processes. Today, enterprises are exposed to an increasingly dynamic environment. Last but not least, increasing competition caused by globalisation more and more necessitates gaining competitive advantages by improved process control, within and beyond the borders of production companies. One possibility to cope with increasing dynamics is the autonomous control of logistic processes. This chapter gives a short overview of the concept of autonomous logistic processes, presents the overall system development cycle and discusses process modelling under the paradigm of autonomy.

References

Hülsmann M, Grapp J (2005) Autonomous Cooperation in International-Supply-Networks – The Need for a Shift from Centralized Planning to Decentralized Decision Making in Logistic Processes. In: Pawar KS et al (eds) Proceedings of the 10th International Symposium on Logistics (10th ISL). Loughborough, United Kingdom, pp 243-249

Hülsmann M, Scholz-Reiter B, Freitag M, Wycisk C, De Beer C (2006) Autonomous Cooperation as a Method to cope with Complexity and Dynamics? – A Simulation based Analyses and Measurement Concept Approach. In: Proceedings of the International Conference on Complex Systems (ICCS 2006). Boston, MA, USA. Web-publication. http://necsi.org/events/iccs6/viewpaper.php?d=339. 8 pages

Hülsmann M, Windt K, Wycisk C, Philipp T, Grapp J, Böse F (2006) Identification, Evaluation and Measuring of Autonomous Cooperation in Supply Networks and other Logistic Systems. In: Baltaciglu T (ed) Proceedings of the 4th International Logistics and Supply Chain Congress. Izmir, Turkey, pp 216-225

Hülsmann M, Wycisk C, (2006) Selbstorganisation als Ansatz zur Flexibilisierung der Kompetenzstrukturen. In: Burmann C.; Freiling J.; Hülsmann M. (Hrsg) Neue Perspektiven des Strategischen Kompetenz-Managements. Deutscher Universitätsverlag, Wiesbaden, pp 323-350

Scholz-Reiter B, Windt K, Freitag M (2004) Autonomous logistic processes: New demands and first approaches. In Monostori L (ed) Proceedings of the 37th CIRP International Seminar on Manufacturing Systems, Budapest, pp 357-362

Windt K (2006) Selbststeuerung intelligenter Objekte in der Logistik. In: Hütt M., Vec M., Freund A. (Hrsg) Selbstorganisation: Ein Denksystem für Natur und Gesellschaft. Böhlau Verlag, Köln Weimar Wien, pp 271-314