AGENT-BASED DISPOSITION IN EVENT LOGISTICS

Florian Harjes* and Bernd Scholz-Reiter**

* BIBA - Bremer Institut für Produktion und Logistik GmbH at the University of Bremen, Bremen, 28359, Germany, Email: haj@biba.uni-bremen.de
** University of Bremen, Bremen, 28359, Germany, Email: bsr@uni-bemen.de

Abstract The scheduling of orders and disposition of related rental articles in event logistics constitutes a complex and dynamic logistic problem. Varying venues, close temporal relations between consecutive events and additional effects, such as rush orders, thefts, damaged articles or misloadings, complicate the planning processes. Therefore, established planning and control systems often reach their limits. The principle of autonomous control offers the potential to cope with these problems. This paper presents preliminary results from a research project that addresses the development of an autonomously controlled disposition system in event logistics based on soft-ware agents. At this, the focus lies on the design of the target process and the modelling of the corres-ponding logistic objects as autonomous agents within the system. A use case illustrates the proceeding.

Paper type: Research Papers

Published online: 30 April 2013
Vol. 3, No. 2, pp. 137-150

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

Keywords: *Event Logistics, Autonomous Control, Resource Allocation Order Disposition*

1. INTRODUCTION

In general, event logistics is a sub-process of event management. The latter comprises all activities related to the organisation and accomplishment of events, such as concerts, company anniversaries or private occasions (Harjes & Scholz-Reiter, 2012). The corresponding logistic services mainly focus on the transport of event equipment, reaching form stairs over catering supplies up to complete stages (Allen, O'Toole, Harris, & McDonnel, 2010). Further, event logistics includes the setup and deconstruction of the equipment at the different venues (Holzbaur, Jettinger, Knau, Moser, & Zeller, 2005).

In general, the execution of events comes along with high customer requirements regarding due dates, flexibility, technical reliability and cost-effectiveness (Harjes & Scholz-Reiter, 2012).These customer wishes often conflict with the economic interests of the organiser and lead to multitude and complicated planning processes. The dynamic occurrence of thefts, damages, misloadings or rush orders further complicates the logistic service provision, especially in larger networks (Warden, Porzel, Gehrke, Langer, & Malaka, 2010). In many cases, the consequences are inefficient and underemployed transports with a corresponding time and cost exposure. As a result, established planning and control approaches reach their limits and new methods of modelling and operating come into focus (Warden, Porzel, Gehrke, Langer, & Malaka, 2010). For example, the application of autonomous control within the corresponding processes offers the possibility to cope with these problems (Schuldt, 2011). At this, the paradigm of autonomous control aims to an increase of stability and robustness basing on a decentralised decision-making of cooperating autonomous objects (Phillip, de Beer, & Scholz-Reiter, 2007) (Windt & Hülsmann, Changing Paradigms in Logistics - Understanding the Shift from Conventional Control to Autonomous Cooperation and Control, 2007). This paper illustrates the first modelling and implementation steps of an autonomously controlled system for the transport and scheduling processes in event logistics that bases on software agents.

At this, it specifies the milestones of a concept, the authors introduced in (Harjes & Scholz-Reiter, 2012). The structure is as follows. Section 2 gives a short overview of the basics that are relevant for the comprehension of the paper. At this, the focus lies on the scientific introduction of the individual points and the reflection with regard to the use case as well. Section 3 introduces the use case, before section 4 specifies the details of the agent based disposition. The paper finishes with a combined summary and outlook on future work in section 5.

2. BASICS

2.1. Vehicle Routing

From the scientific perspective, the problem of disposition in event logistics addresses a combination of several sub-problems. The determination of the best possible route for the involved transport vehicles is one of them. In its basic form, this problem is often referred to as Travelling Salesman Problem (TSP) (Applegate, Bixby, Chvatal, & Cook, 2006). Mathematically, the TSP is NP-hard and solvable for slight sets of variables. For larger sets, the required computing time limits the practical applicability. Heuristics are able to find approximately optimal solutions for larger cases of application. This leads to shorter computing times, but does not guarantee the optimality of the solution (Applegate, Bixby, Chvatal, & Cook, 2006).

Additional parameters, such as time windows, capacity restrictions and varying numbers of vehicles or destinations, extend the TSP to a Multiple Online TSP or Vehicle Routing Problem (VRP) (Parragh, Doerner, & Hartl, 2008). This paper focuses on a use case that corresponds to the Vehicle Routing Problem with backhauls or the Dynamic Multi Vehicle Pick-up and Delivery Problem with Time Windows (DMVPDPTW), respectively. This class of problems deal with a central storage, multiple transport vehicles and destinations. It further regards time windows and further environmental restrictions (Larsen, 2001) (Ghaziri & Osman, 2006).

2.2. Scheduling

In the field of operations management, the term scheduling generally describes the determination of a timetable that indicates what work should be done when and where (Chambers, Slack, & Johnston, 2007). At this, scheduling covers a wide range of planning and control activities, reaching from the scheduling of jobs for machines over the sequencing of computing tasks in computer science to the organisation of complete supply chains (Eiselt & Sandblom, 2012) (Vidyarthi, Sarker, & Tripathi, 2008) (Herrmann, 2010).

In event logistics, the planning of transports between a storage and multitude venues as well as between the venues is from central interest. Due to the unexpected occurrences mentioned above, the related scheduling follows a dynamic and event-driven proceeding (Gudehus, 2012). As these occurrences take place quite often, the planning effort increases correspondingly. In addition, the central planning for resources with decentral dependencies among themselves and frequently changing venues further complicates the scheduling.

2.3. Autonomous Control

The basic idea of autonomous control addresses the decentralised and heterarchical planning and control by shifting decision functions to autonomous objects (Böse & Windt, 2007). At this, the main objective is an increase in exibility and robustness for the overall system (Windt 2008). The level of autonomous control depends on several parameters, such as the integration of required information and communication technologies (ICT), economic reflections or the compatibility to already present IT-systems (Enterprise Resource Planning (ERP), Manufacturing Execution Systems (MES), etc.) (Veigt, Ganji, Morales Kluge, & Scholz-Reiter, 2011).

In this context, the ICT-technologies play a central role. The presence of technologies for identification, location, communication and decision-making is an indispensable prerequisite for the application of autonomous control. The logistic scenario within the use case comprises the transport of an article mix that is inhomogeneous in size, weight, number and load carrier. In addition, the environment for the load and unloading processes is mostly rough. This is especially the case, when the corresponding activities take place in a hurry and/or the venue is open-air (concerts, rallies, etc.). Correspondingly, it is not possible to equip every individual article with the complete set of ICT-devices. To establish autonomously controlled processes nevertheless, the use of software agents is a suitable option. Multi-Agent Systems (MAS) offer the possibility to represent every autonomous object within a system through a corresponding software agent (Schuldt, 2011). This proceeding enables a decision-making without the demand for one data processing unit per object. To ensure the required communication, identification and localisation, it is possible to use permanently installed hardware. Possible are, for example, RFID-gates (RFID = Radio Frequency Identification), existing telematics within transport vehicles and so on.

2.4 Multi-Agent Systems

Multi-Agent Systems constitute a fast growing discipline within artificial intelligence (AI). They can be defined as a set of software agents that interact together and coordinate their behaviour to achieve a certain objective (Ferber, Gutknecht, & Michel, 2004). Their strength is the ability to solve distributed problems in a flexible manner (Balaji & Srinivasan, 2010). As a consequence, MAS are widespread, for example, in the field of power trade, for production management or transportation tasks.

Dependent on their application area, different types and/or architectures for agents are possible. Established categories for the classification of agents are reactive (subcognitive), adaptive or cognitive agents (Wooldridge, 2009). Reactive agents do not have tacit knowledge. Therefore, their behaviour follows a stimulus-response model (Büttner, 2011). Adaptive agents work with a model of their own processes and parameters and are able to involve their own decisions in the past to realise situation-adaptive decisions. Finally, cognitive agents base on a model of their environment. Therefore, they are able to plan their actions and to act target-oriented. Their behaviour is often referred to as the BDI-model (Belief, Desire, Intentions) (Büttner, 2011).

Within the presented work, a system of cognitive agents comes into operation. The corresponding framework for MAS-simulation is a special adaption for the design and application of autonomous agents in logistic networks, called PlaS-MA (Platform for Simulation with Multiple Agents) (Warden, Porzel, Gehrke, Langer, & Malaka, 2010).

3. USE CASE

The use case is a SME (small or medium enterprise) from the field of event logistics. The company employs about 60 employees in a central storage and seven branches. The latter are only responsible for marketing and customer services. The main business is the organisation of events, the letting of equipment and the related transport services (Harjes & Scholz-Reiter, 2012).

The event accomplishment follows a five staged proceeding that begins with a rough planning directly after the receipt of an order and ends, when the equipment and vehicles reach the storage again. For a complete overview, please refer to (Harjes & Scholz-Reiter, 2012). The activities that are relevant for this paper take place largely within the last phase of the process execution. The focus lies on the transport between the storage and the venue and further includes the setup of the equipment before the event and the deconstruction after it. Fig. 1 shows the relevant parts of the material flow at the venue and the preparations at the storage.

It further marks the procedural weak-points of the current event execution. Besides the dynamic influences, the problems of the central planning come into effect. The former require a frequent replanning, while the applied planning and control systems are often not able to accomplish this efficiently. One reason for this is an insufficient information transparency at the venue. There is no automatic documentation of loading or unloading activities after the vehicles leave the storage, where fixed RFID-gates capture the corresponding data. Therefore, exact information regarding the position and condition of the articles is not available until the return to the storage.

The second reason directly results from the first. If a close temporal distance to the subsequent events does not allow a back-haul to the storage, the commissioning for following events takes place at the current venue. It occurs that articles are applied several times before their return. As the central planning instance has no sufficient information, the planning often leads to insufficient transports with underemployed or overloaded vehicles and high personnel costs with a corresponding loss of time.

Summarised, the current planning is insufficient due to a centralised planning approach that is not able to handle the dynamic and complex effects of decentral commissioning. The lack of information transparency outside the storage further strengthens these problems.

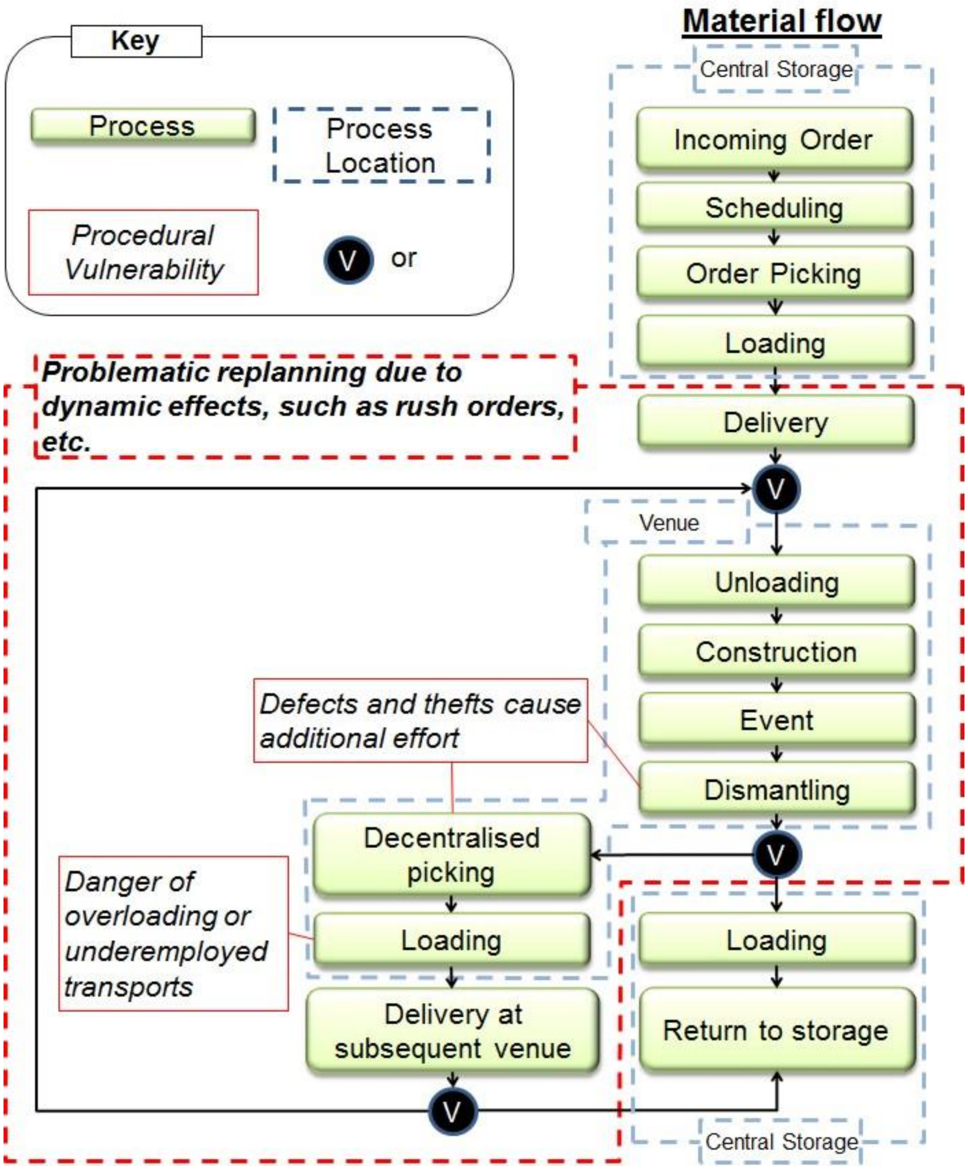

Fig. 1 General process and material flow (Harjes & Scholz-Reiter, 2012)

4. AGENT-BASED DISPOSITION

In previous work, the authors introduce the concept of an autonomous proceeding for the disposition of rental articles in general and for event-related equipment in the field of event logistics in particular (Harjes & Scholz-Reiter, 2012). The following subsections describe the current state of the corresponding implementation.

4.1 Starting Point

The first step towards an autonomous disposition is the development of a target process. This process bases on the current situation within the use case and aims to solve the present weak-points. Within this work, the general phase model from (Harjes & Scholz-Reiter, 2012) stays untouched, while the last phase (Fig.1) is the starting point for the autonomous control. At this, the information flow and the decision-making entities are subject to some modifications. As autonomous control involves a shift from central instances towards a decentralised proceeding, a set of autonomous logistic objects supersedes the central planning system. The set of objects comprises the rental articles within the event equipment, the transport vehicles and the related employees, including drivers, technical staff and assistants for storage, setup and deconstruction tasks.

The planning process itself forks into negotiations between agents that represent the individual resources. By this means, every object can follow its individual target function, such as the adherence to due dates, shortest routes, highest possible utilization and so on. Besides the established key figures, every situation or resource-specific objective is possible, which leads to a flexible and robust system. The planning processes as such take place within PlaSMA-simulations. At this, the underlying information come from the use case`s order database. Relevant are for example the date and place of events, the chosen equipment, required staff and so on. The resulting data set flows into the simulation and supports the decisions of the autonomous objects. The number and properties of the objects are derived from the use case. Here, the car pool, the staff and the article portfolio are from interest. All those objects plus the orders get a representing agent.

The PlaSMA-simulations replace the central planning system and aim to an autonomous assignment of vehicles, articles and employees to orders. The results of an iteration are packing lists and routes for the vehicles, picking lists for the staff at the storage and a corresponding personnel planning. In the case of a dynamic effects or changes to orders, the simulation is carried out again in consideration of the changed basis for planning. The second aspect of the procedural optimisation focuses on the required information transparency. As an autonomous decision-making depends crucially on the availability and quality of the underlying information, the gap between the leaving and (re-)entering of the storage has to be closed. Therefore, the target process includes the development of a hardware prototype to create the technical requirements for an accurate identification and localisation of the involved resources. This also comprises the communication between the individual objects. As this paper focuses on the agent-based decision-making for scheduling purposes, the correct functionality of the underlying ICT-hardware is assumed from now on.

4.2 Agents and Ressources

The central issue of an autonomous decision-making on the basis of software agents is the specification of the involved agents` features, abilities, knowledge and objectives. Every resource within the system requires a representing agent. With regard to the field of event logistics, the relevant resources are the event equipment, the transport vehicles, the orders and the employees. For the modelling of the corresponding autonomous software agents, the ALEM framework (Autonomous Logistics Engineering Methodology) comes into operation (Kolditz, 2009) (Scholz-Reiter, Kolditz, & Hildebrandt, 2009). This framework provides a notation and a guideline for the modelling process of autonomous logistic networks.

During the conception of the system, every logistic object gets a corresponding agent with a certain lifespan and a set of possible behaviours. Further steps of the process define the communication possibilities and the knowledge that underlies the decisions of every agent. Fig. 2 shows the example of an agent, the so-called list manager. This agent manages the article list of an specific event.

At this, the agent is responsible to assure the availability of the required equipment for his event. Every order has a corresponding list manager, which is alive as long as the event (in general through the whole duration of a scenario) is in progress. The agent has a set of possible actions, that is distinguishable into initial behaviours and sub-behaviours. The first are actions, that activate or involve subordinated agents. The latter are decisions and/or determinations basing on decisions. In the case of the list manager, the agent requests the availability of articles for an event, assigns the articles to the event if possible, or starts a new search for equivalent articles as replacement. At this, the list manager communicates with the article manager. Every article manager is responsible for a certain class of technically identical articles. For example, there is one article manager for all microphones of the type x, one for all of type y and so on. This structure is applicable for all available articles and a specific of the use case, where all articles within the present warehouse management system are organised this way.

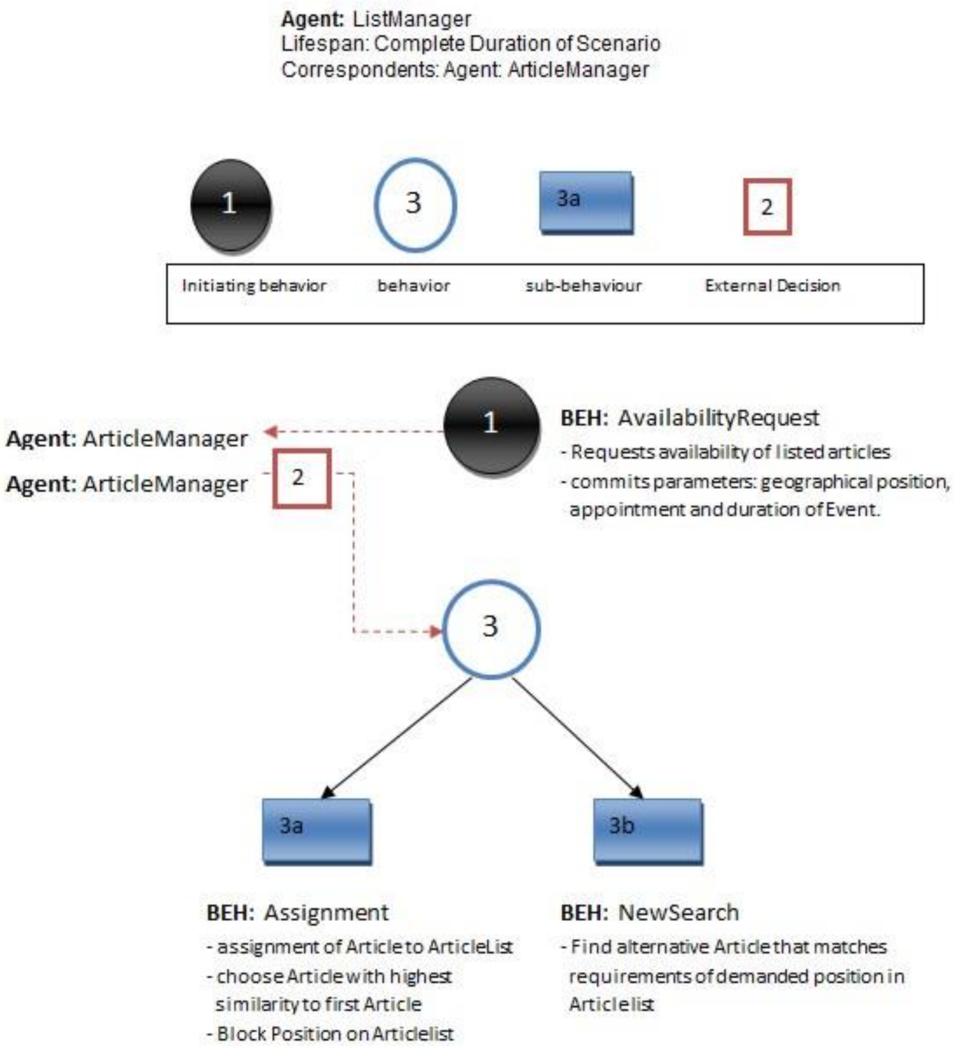

Fig. 2 Exemplary structure of an agent

The resources and the corresponding agents further divide into devices, their possible components, staff and vehicles. Devices are, in the context of the above mentioned example, microphones of the same type. But some of the larger articles can comprise several components. A stage for example, consists of floor parts, supporting pillars, spotlights and so on. With regard to the utilisation of the transport vehicles, these components have an individual agent to enable a transport split up on several vehicles. Staff and transport vehicles follow a similar approach. For these groups, the important classification criteria are skills, the capacity of transporting, etc. The implementation of all involved objects as agents leads to an hierarchical order of six agent classes with corresponding managers altogether. Fig. 3 shows an overview of these classes and the corresponding resource groups. The number of agents within a PlaSMA-simulation depends on the number of related articles and active orders. As mentioned, there is one list manager per order. Additionally, every article group has an article manager and every device within such a group has a device manager. If the device consists of more than one component, these components also have an component manager.

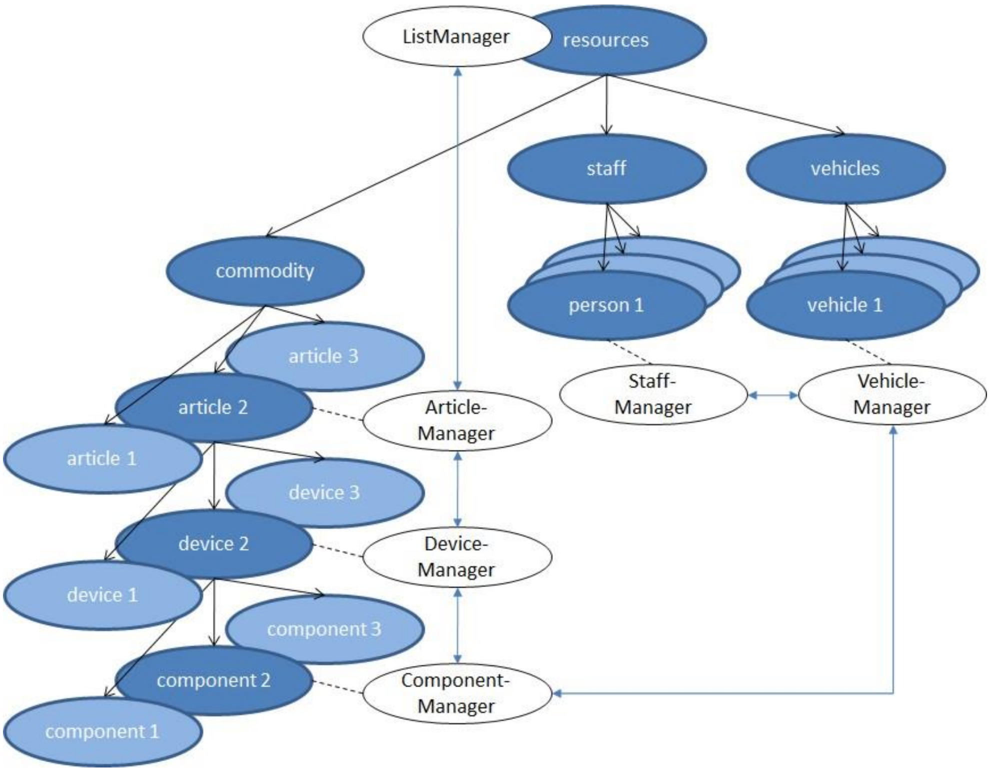

Fig. 3 Agent Classes

4.3 Autonomous Decision-Making

The autonomous decision-making bases on the hierarchical relationship between the agents. At this, the negotiations between the individual agents follow a top-down and a bottom-up proceeding as well. The first part of the negotiations comprises requests, the second one concerns the corresponding answers or offers, respectively. On the various levels, an arbitrary number of iterations or regresses are possible. In the following, the general proceeding is introduced step by step.

Directly after the receipt of an order, the artistic planning takes place. When the first discussions with the customer and inspections of the venue are finished, the resulting article list and additional information such as place and time of the event constitute the input for the autonomous scheduling process. Now, the PlaSMA-simulation creates a corresponding list manager. This list manager contacts the subordinate article managers that are responsible for the articles on the list and requests their availability at the given time and place. The article managers forward the request to the individual devices that belong to their article group. If a device is occupied during the requested time, it directly sends a rejection. If not, the device in turn negotiates with the transport vehicles about the transfer to the venue. If the device comprises several components, the respective component is responsible for the transport negotiations. This negotiations constitute the end of the top-down phase. In the case that all articles of a group are occupied, the list agent tries to find a suitable replacement. If there is none, the scheduling process is cancelled. At this point, an iteration of the artistic planning becomes necessary. Another possibility is the provisioning of foreign material (e.g. to rent missing articles for the duration of the event).

If the required devices are available, the order phase begins in a bottom-up manner. The transport vehicles process the request and make offers corresponding to their whereabouts and the available capacity at the required time. At this, the latter also considers the time window for setup and deconstruction before and after the venue. If more than one offer for the transport exist, the device or component manager chooses the best one following its individual target function. If no transport vehicle is available at the requested time and place or the capacity is insuffcient, a request for the application of an rental vehicle is send to the person in charge. When a device has a transport opportunity, it sends a corresponding message to the article manager. This agent chooses the best suitable device and informs the list agent. The proceeding is repeated for all articles on the list. During the process, implications complement the interplay of requests and offers. If, for example, a device or component requires specialised personnel, a commitment is only achieved, when personnel and hardware are available at the same time. The overall planning process is complete, if all demands are met.

5. SUMMARY AND OUTLOOK

This paper deals with the autonomous decision-making for scheduling purposes in event logistics basing on software agents. At this, it specifies a concept given in (Harjes & Scholz-Reiter, 2012) and depicts the current status of the system design and implementation. In detail, the transition of the involved resources into autonomous objects as well as the corresponding representation as software agents comes up. Further, the paper addresses the software issues with regard to the multi-agent simulations with PlaSMA. Finally, the general procedure of a scheduling process is explained by means of an example. For clarification, a use cases comes into operation to define the characteristics and requirements in event logistics.

Outstanding dues for the completion of the system is the integration of the vehicle routing into the scheduling process. At this, the adaptation of the DLRP (Distributed Logistics Routing Protocol (Rekersbrink, Makuschewitz, & Scholz-Reiter, 2008)) as a behaviour for the transport vehicle agents is from major interest. Further, the evaluation of different possible target functions and the benchmarking of the overall results in comparison to other scheduling approaches is central.

ACKNOWLEDGEMENTS

This research is supported by the German Research Foundation (DFG) as part of the Collaborative Research Centre 637 “Autonomous Cooperating Logistic Processes – A Paradigm Shift and its Limitations" at the University of Bremen.

REFERENCES

Allen, J., O'Toole, W., Harris, R., & McDonnel, I. (2010). Festival and Special Event Management (5. Ed.). Hoboken, NY, USA: John Wiley and Sons.

Applegate, D., Bixby, R., Chvatal, V., & Cook, W. (2006). The Travelling Salesman Problem: A Computational Study. Princeton: Princeton University Press.

Balaji, P., & Srinivasan, D. (2010). An Introduction to Multi-Agent Systems. In D. Srinavasan, & J. Jain, Studies in Computational Intelligence: Innovations in Multi-Agent Systems and Applications -1, Vol. 31, pp. 1-27.

Böse, F., & Windt, K. (2007). Catalogue of criteria for autonomous control in logistics. In M. Hülsmann, & K. Windt (Eds.), Understanding Autonomous Cooperation and Control in Logistics, Berlin,Heidelberg: Springer Verlag.

Büttner, R. (2011). Organisation, Akteure und Agenten. In R. Büttner, Automatisierte Verhandlungen in Multi-Agenten Systemen, Wiesbaden: Gabler Verlag.

Chambers, S., Slack, N., & Johnston, R. (2007). Operations Management (5 Ed.). Upper Saddle River, NJ, USA: Prentice Hall.

Eiselt, H., & Sandblom, C.-L. (2012). Machine scheduling. Operations Research, Springer Texts in Business and Economics.

Ferber, J., Gutknecht, O., & Michel, F. (2004). From agents to organisations: An organisational view of multi-agent systems. In P. Giorgini, J. Möller, & J. Odell (Eds.), Lecture Notes in Computer Science - Agent-Oriented Software Engineering IV, Vol. 2935, pp. 214-230.

Ghaziri, H., & Osman, I. (2006). Self-Organizing Feature Maps for the Vehicle Routing Problem with Backhauls. Journal of Scheduling, 9, pp. 97 - 114.

Gudehus, T. (2012). Dynamische Disposition - Strategien, Algorithmen und Werkzeuge zur optimalen Auftrags-, Bestands- und Fertigungsdisposition (3. Ed.). Berlin: Springer Verlag.

Harjes, F., & Scholz-Reiter, B. (2012). Autonomous control in event logistics. In M. Affenzeller, A. Bruzonne, F. De Felice, C. Del Rio Vilas, M. Frydman, M. Massei, et al. (Hrsg.), Proceedings of the 11th International Conference on Modeling and Applied Simulation 2012 (pp. 302-308). Rende (CS), Italy: DIME, University of Genua.

Herrmann, J. (2010). Ablaufplanung. In Supply Chain Scheduling, Betriebswirtschaftlicher Verlag Gabler.

Holzbaur, U., Jettinger, E., Knau, B., Moser, R., & Zeller, M. (2005). Logistik. In Eventmanagement - Veranstaltungen professionell zum Erfolg führen, Berlin/Heidelberg: Springer Verlag.

Kolditz, J. (2009). Vorgehensmodell zur Erstellung von Fachkonzepten für selbststeuernde produktionslogistische Prozesse, Berlin: Gito Verlag.

Larsen, A. (2001). The Dynamic Vehicle Routing Problem. PhD Thesis. Lyngby: IMM.

Parragh, S., Doerner, K., & Hartl, R. (2008). A survey on pickup and delivery problems. Part II: Transportation between pickup and delivery locations. Journal für Betriebswirtschaft.(58), pp. 81-117.

Phillip, T., de Beer, C. W., & Scholz-Reiter, B. (2007). Evaluation of Autonomous Logistic Processes. In M. Hülsmann, & K. Windt, Understanding Autonomous Cooperation and Control in Logistics: The Impact of Autonomy on Management, Information, communication and Material Flow (pp. 303-324). Berlin, Heidelberg: Springer Verlag.

Rekersbrink, H., Makuschewitz, T., & Scholz-Reiter, B. (2008). A Distributed Routing Concept for Vehicle Routing Problems. Logistics Research, 1, pp. 45-52.

Scholz-Reiter, B., Kolditz, J., & Hildebrandt, T. (2009). Engineering Autonomously Controlled Logistic Systems. International Journal of Production Research, 6, pp. 1449-1468.

Schuldt, A. (2011). Autonomous Control in Logistics. Berlin, Heidelberg: Springer Verlag.

Veigt, M., Ganji, F., Morales Kluge, E., & Scholz-Reiter, B. (2011). Autonomous Control in Production Planning and Control: How to integrate Autonomous Control into Existing Production Planning and Control Structures. In M. Hülsmann, K. Windt, & B. Scholz-Reiter, Autonomous Cooperation and Control in Logistics (pp. 313-329). Berlin, Heidelberg: Springer Verlag.

Vidyarthi, D., Sarker, B., & Tripathi, A. Y. (2008). Scheduling Problem. In D. Vidyarthi, B. Sarker, & A. Y. Tripathi, Scheduling in Distributed Computing Systems - Analysis, Design and Models (1. Ed., pp. 1-16). New York: Springer US.

Warden, T., Porzel, R., Gehrke, J. H., Langer, H., & Malaka, R. (2010). Towards Ontology-based Multiagent Simulations: the PlaSMA Approach. In E. Bargelia, A. Azam, S. Ali, & D. Crowley (Hrsg.), 24th European Conference on Modeling and Simulation (ECMS2010), (pp. 50-56). Kuala Lumpur.

Windt, K. (2008). Ermittlung des angemessenen Selbststeuerungsgrades in der Logistik - Grenzen der Selbststeuerung. In P. Nyhius (Hrsg.), Beiträge zu einer Theorie der Logistik (pp. 349-372). Berlin/Heidelberg: Springer Verlag.

Windt, K., & Hülsmann, M. (2007). Changing Paradigms in Logistics - Understanding the Shift from Conventional Control to Autonomous Cooperation and Control. In M. Hülsmann, & K. Windt (Eds.), Understanding Autonomous Cooperation & Control - The Impact of Autonomy on Management, Information, Communication and Material Flow (pp. 4-16). Berlin: Springer Verlag.

Wooldridge, M. (2009). An Introduction to MultiAgent Systems (2 Ed.). Hoboken, NJ, USA: John Wiley & Sons.

BIOGRAPHICAL NOTES

Florian Harjes, born in 1981, is a scientific research assistant at the Bremer Institut für Produktion und Logistik GmbH (BIBA) at the University of Bremen. He received a diploma in computer science from the University Bremen in 2008, where he pursued his thesis “Exact synthesis of multiplexor circuits” at the same year. During this time, he developed a tool for the automated synthesis of minimal multiplexor circuits for a corresponding Boolean function. In BIBA, Dipl.-Inf. Florian Harjes is in charge of long time simulations of neural networks and the development of a hybrid architecture for the continuous learning of neural networks in production control. He further investigates the application of autonomous control methods in event logistics.

Bernd Scholz Reiter, born in 1957, studied Industrial Engineering and Management at the Technical University of Berlin. After his doctorate in 1990, he was an IBM World Trade Post Doctoral Fellow in Manufacturing Research until the end of 1991. Subsequently, he worked as a research assistant at the Technical University of Berlin and in 1994 was appointed to the chair of Industrial Information Technology at the Brandenburg Technical University of Cottbus. From 1998 to 2000, he was head of and founder of the Fraunhofer Application Center for Logistics Systems Planning and Information Systems in Cottbus. Since 2000 he heads the chair of Planning and Control of Production Systems in the Department of Manufacturing Engineering at the University of Bremen. At the Bremer Institut für Produktion and Logistik (BIBA), Prof. Scholz-Reiter works in applied and industrial contract research. Since 2013, he is director of the University of Bremen.