AUTONOMOUS CONTROL IN EVENT LOGISTICS

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ABSTRACT

The conflict between economic interests and order-related requirements complicates the scheduling and control of orders in the field of event logistics. Often, dynamic influences, such as rush orders, thefts or damage to material and equipment, require an adaptive replanning of events, resources and transport routes. In these cases, it is very difficult to determine the optimal trade-off between the utilization of transport devices, the adherence to due dates and customer wishes. This paper introduces a concept for the implementation of autonomous control in event logistics. At this, the focus lays on the three key aspects of autonomously controlled systems; the modelling process, the object representation and the structuring of the communication processes. A use case illustrates the starting points of the implementation.

Keywords: event logistics, autonomous control, decentralised decision making, modelling and simulation

1. INTRODUCTION

The management of public events, such as concerts, company anniversaries and so on, involves high customer requirements concerning the adherence to due dates, the flexibility, cost-effectiveness and technical reliability. This applies both for the scheduling and control of events and the related logistic processes. The efficient execution of these processes often implies a conflict between the order- or event-oriented requirements and economic motives. At this, the optimal utilization of transport capacities reduces the mobility of equipment, such as stages, speakers, headlights and so on and therefore complicates a dynamic replanning.

These aspects further increase, when a close temporal sequence of events makes a return of the equipment to storage impossible. This results in a manual disposal of equipment for subsequent events directly at a venue. In combination with dynamic effects, such as damages or thefts, the consequences are multitude, often inefficient and underemployed transports with corresponding costs and time exposure.

From a scientific point of view, this problem constitutes a combination of an event-oriented scheduling (Gudehus 2006) and a Dynamic Multi Vehicle PDPTW (Pick-up and Delivery Problem with Time Window) (Parragh 2008).

With regard to these two sub-problems, the current state of the art may be summarised as follows. In the field of event-oriented scheduling, exiting approaches are already able to handle the problem of resource allocation within logistic networks satisfactorily with regard to the dispatching of articles, the vehicle utilization and -order (Gudehus 2006). However, most of the available approaches consider central planning processes and the related structures of information acquisition and processing. The desired application in the field of event logistics requires a scheduling procedure that is able to cope with dynamically changing conditions and constrains in decentralised structures.

The question for the optimal or best possible route defines a NP-hard problem, which is often referred to as the Traveling Salesman Problem (TSP) in operations research(Applegate 2006). It is possible to find optimal solutions for a slight TSP, but the required computing time often limits the practicality. Therefore, heuristics came into operation to find approximately optimal solutions for larger cases of application. Unfortunately, they are not able to guarantee the optimality of the solution(Applegate 2006).

Further enhancements of the TSP consider multiple vehicles, time windows, and an incomplete list of destinations at the departure as well as restrictions of the transport capacity. These problem class is called a Vehicle Routing Problem (VRP)(Parragh 2008). Depending on the kind of the considered restrictions, it is possible to distinguish between different versions of the problem, such as the dynamic VRP(Larsen 2000). In order to stay applicable in practice, these versions often consider a limited number of restrictions and/or target functions(Fabri 2006; Gendreau 2006).

As the scheduling and control of events require a consideration of both the real-world dynamic and manifold individual restrictions and target functions for the logistic objects, the adaption of the existing heuristics is difficult. The application of methods from the field of autonomous control seems to be a promising approach to cope with this problem.

The paradigm of autonomous control denotes a decentralised decision making of autonomous logistics objects in heterarchic structures (Windt 2007). At this, the central planning and disposal shifts to a distributed and flexible proceeding, where the decision-making falls to single objects such as transport vehicles, goods, and so on.

This paper focuses on a concept regarding the implementation of autonomous control in the scheduling and transport processes in event logistics. The objective is an autonomously controlled system that optimizes the resource allocation and makes the considered logistic processes more robust at the same time. The conception and operation of the system are based on specialised modelling and simulation techniques for autonomously controlled processes. A SME (small or medium enterprise) from the field of event logistics serves as a use case.

The structure is as follows. Section 2 gives an overview of autonomous control in general and introduces the basics of event logistics. Section 3 deals with the use case, the considered processes and the related weak points. The following section 4 describes the implementation concept, before the paper finishes with a short summary and outlook in section 5.

2. BASICS

2.1. Autonomous control

Today`s logistic processes face an increase in dynamic and complexity(Scholz-Reiter 2004). As established production planning and control systems reach their limits, new concepts on the basis of technologies such as RFID (Radio Frequency Identification) or GPS (Global Positioning System) came into focus. Autonomous control combines these technologies and related methods to shift from a centralised planning and control to a decentralised decision-making of autonomous objects(Windt 2007).

Within autonomously controlled systems, single objects have the ability and possibility for independent decisions. For this purpose, every object is equipped with the necessary technical requirements to detect its own position, to interact with other objects within or outside the system and to make own decisions following individual targets(Windt 2008). The main objective of autonomous control is the improvement of the overall system`s robustness by enabling a flexible and distributed handling of dynamic and complexity(Windt 2007).

2.2. Event logistics

In this paper, event logistics comprises the logistic processes related to the planning and execution of company anniversaries, concerts, festivals, public performances, fairs, and so on. Often, event logistics is embedded into several phases of event management (Allen 2008). Typically, the event execution follows a multi-stage planning of organisational and artistic aspects. Figure 1 depicts an exemplary overview of the procedure that is inspired by an example use case.

The procedure consists of five phases, ranging from the rough planning after the order receipt to the concrete event execution directly at the venue. In phase one, the determination of the event parameters and the related services takes place. In general, a project meeting with the customer specifies the individual wishes, while an inspection of the event location contributes technical and local restrictions.

In phase two, the event management company develops a concept, including the required equipment, services and logistics. If the customer agrees, the order is finally confirmed and the detailed planning begins (phase three).

Phase four comprises the execution of the logistic planning including the personnel and equipment allocation as well as possible leasing orders. Finally, the last phase five covers the event accomplishment from the warehouse exit over the assembly and dismantling of the equipment back to the warehouse entry. The final billing completes the process. For reasons of simplification, this phase is not further mentioned.

The processes, relevant to this paper, mainly take place in the phases three and five. Generally, they comprise the transport planning and execution for equipment between one or more warehouses, belonging to the event organiser or a subcontractor, and the venue.

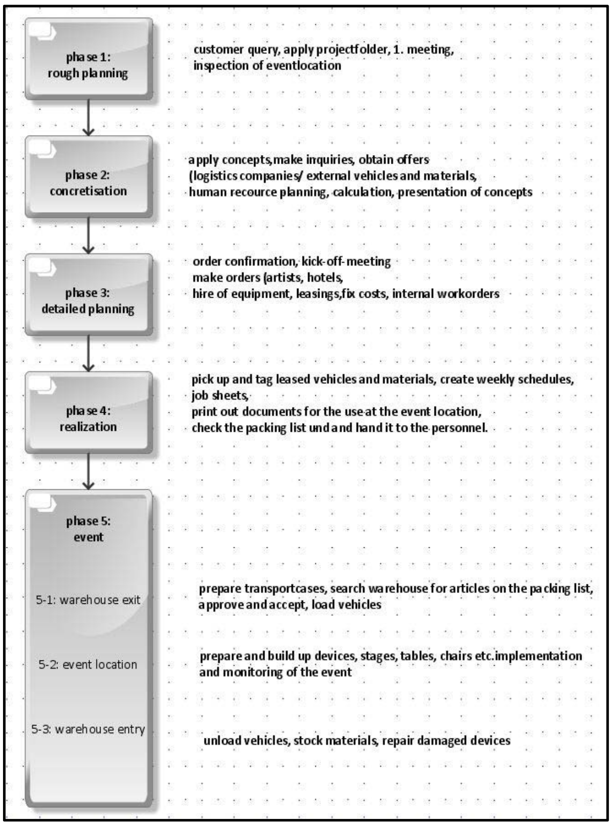


Figure 1: Exemplary Procedure of Event Management (own depiction)

3. USE CASE

In the following, a use case shall act as an example scenario for the application of autonomous control in event logistics. The use case considers a full-service-agency from the branch of event marketing. With 60 employees and an annual turnover of ca. 7 million €, the agency constitutes a typical SME (small or medium enterprise). The main business segment is the letting of event related equipment, reaching from chairs and cloak hangers over stage elements up to electronic devices.

The related services comprise the provision, construction and dismantling of equipment at the venues, including the logistics. For the latter, a car pool consisting of a lorry and several compact vans comes into operation. Further, the agency operates a central storage for the equipment. If required, additional vehicles and equipment are hired.

Figure 2 gives an overview of an event accomplishment. In general, every order represents an event and is linked to a material list, depending on the event`s requirements. In the following, the required equipment is put together in accordance to the list and allocated to a suitable transport vehicle. After the route planning, the transport leaves the storage and delivers the ordered equipment directly to the venue. Subsequently, the unloading and construction takes place. After the event, the procedure happens similar in the opposite direction.

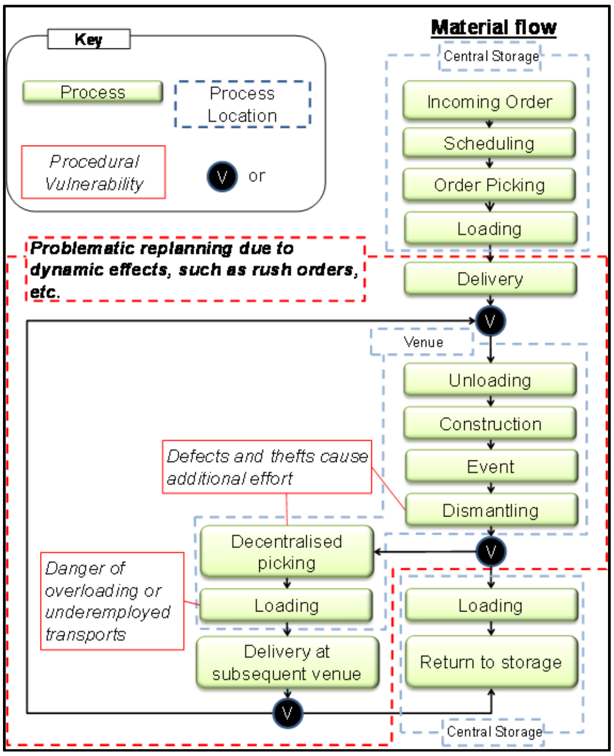
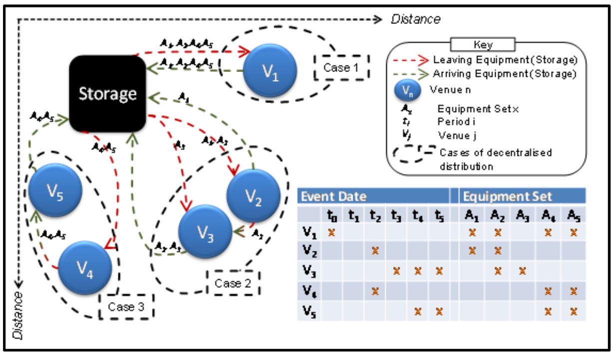


Figure 2: General Process Flow

Subsequent events or rush orders often require a deviant proceeding. If the following event begins with a close temporal distance, a decentralised planning becomes necessary. Figure 3 depicts two such cases of decentralised (re-)planning (cases 2 and 3) as well as a single event (case 1). In case 2, the available equipment has to be split up into one transport to the storage and one to the subsequent venue. This either results in two underemployed transports or implies the inclusion of the subsequent venue as a stopover into the way back direction. The latter implies a transport of equipment that is unnecessary for the specific event. Additionally, this material is not available for other events during this time and dynamic effects, such as thefts or defects, further complicate the proceeding. Case 3 depicts an uncomplicated sequence of events which have no time conflict and require the same set of equipment.



	Event Date						Equipment Set				
	t_0	t_1	t_2	t_3	t_4	t_5	A_1	A_2	A_3	A_4	A_5
V_1	x						x	x		x	x
V_2			x				x	x			
V_3				x	x	x		x	x		
V_4			x							x	x
V_5					x	x				x	x

Figure 3: Cases of Decentralised Planning

Currently, a central planning system is responsible for the allocation of all resources. Especially the rush orders and the related decentralised replanning at a venue for subsequent events brings this system to its limits. This results in unstable planning and scheduling processes.

Besides the dynamically occurring external influences, further internal problems regarding the data transparency and availability reduce the process reliability. In the current state, RFID-gates gather loading processes only, when transport vehicles leave or enter the storage. Loading or unloading at the different venues is not recorded automatically, so that the position of equipment is often unclear, until it returns to storage again.

Summarized, the weak points of the current processes are the insufficient handling of dynamic effects due to the centralised approach and the lack of up-to date information concerning the position of the equipment after leaving the storage.

4. CONCEPT

In order to cope with the problems, this paper suggests the implementation of autonomous control for the logistic processes of the example SME. Autonomous control in logistics systems is characterised by the ability of logistic objects to process information, to render and to execute decisions on their own(Windt 2008). Due to this definition, autonomously controlled processes require the representation of the involved entities as autonomous objects with their belonging knowledge, abilities and objectives.

Therefore, the identification of the relevant objects is the first step of the implementation. With regard to the processes of the example SME, the car pool and the event equipment are from central interest. In the current centralised planning system, both classes of objects only constitute allocable resources. Within the planned autonomous control system, all those objects are capable to act both independently and in cooperation.

As this approach differs from the traditional perspective, the modelling process requires an adopted methodology. The design of the presented work bases on the Autonomous Logistics Engineering Methodology (ALEM). ALEM is a multipart framework for modelling autonomously controlled processes in logistic systems(Scholz-Reiter 2009). It comprises three components, each covering a special aspect of the modelling process.

ALEM-N (ALEM-Notation) defines a view concept for the representation of specific aspects of the modelled logistic system. It further provides the notational elements and their meaning within the framework. ALEM-P (ALEM-Procedure) describes the steps of the modelling process and acts as a guideline for the analysis and specification of the intended logistic system. ALEM-T (ALEM-Tool) combines both components into a software tool and adds a reference that enables a reuse of existing models(Scholz-Reiter 2009).

The result of the modelling process with ALEM is a system representation, where every object is defined as class with belonging features, abilities and knowledge. Figure 4 shows a simplified description of the transport vehicles as autonomous objects.

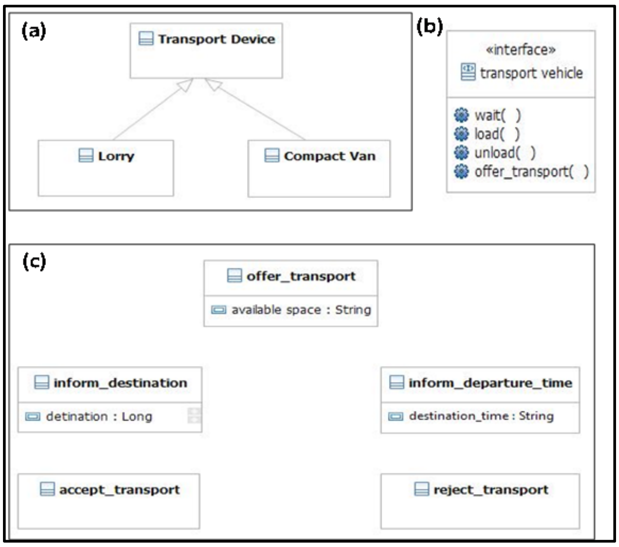


Figure 4: Transport Vehicles as Autonomous Objects (simplified)

Part (a) of the figure depicts the ALEM class view, where transport vehicle defines a general class. The classes lorry and compact van define more specific derivations. Part (b) shows the general abilities that all transport vehicles share. For example, all vehicles can wait for an order, load or unload equipment or offer a transport. The communication view on part (c) defines an excerpt of the messages, transport vehicles can exchange within negotiations with other objects. The modelling of other objects follows a similar procedure.

The second step of the implementation focusses on the technical aspects of the distributed decision-making process. In general, two approaches exist. They differ in the underlying technical infrastructure. The first possibility is to equip every single object with the required technology for positioning, communication and decision making. This procedure is suitable, if all objects are physically large enough and the amount of objects to equip is not to large. If the objects are too small to include the required devices or so numerous, that an individual equipping would be very sophisticated and expensive, a client-server architecture could be suitable.

This architecture divides the information acquisition and the decision-making processes spatially. The information acquisition takes place in a decentralised manner, while a multi-agent based simulation (MAS) on a central server takes over the decision-making processes. At this, every object is capable to locate itself and to send the related information to the central server. Within the MAS-system, every software agent represents one individual autonomous object. The agent performs the decision-making for this object depending on the locally acquired information and the corresponding objectives. He is further able to negotiate and cooperate with the other agents.

For the use case, an adapted version of the client-server infrastructure comes into operation. As the event-related processes often take place in a hurry, the treatment of the equipment is commonly not very careful. Thus, adding sensitive devices to every single autonomous object is not advisable, although the majority of the objects is large enough and they are generally not to numerous. As a middle course, the transport devices act as a kind of information hub. They will be equipped with a GPS-system for positioning, an RFID-reader for the identification of the loaded objects, and an UMTS-device (Universal Mobile Telecommunications System) for the data transfer. Correspondingly, every autonomous object carries a RFID-transponder that allows a clear identification. By this means, the transport vehicles ensure that the required positioning information for the software agents is available at all times. The objectives and therefore the target function for every object are derived from the order database. Relevant is for example the due date of the event or transport-related information, such as weight and size.

For the implementation of the MAS-system, the PlaSMA approach (Platform for Simulations with Multiple Agents) finds a use. PlaSMA is a method for the evaluation of autonomously controlled logistic processes by simulations of multi-agent systems (Warden 2010). Technically, PlaSMA bases on the Java Agent Development Framework (JADE) (Applegate 2006). Within PlaSMA, an individual software agent represents every autonomous system element and interacts representatively with other agents in the system. At this, the agent`s decisions base upon available situation specific information and follow an individual target function (Gehrke 2010).

In order to use the PlaSMA-Simulation as a part of a control method, the simulation has to run permanently after the initialisation. During the initialisation phase, a world model defines the physical basics of the simulation. This comprises information about the relevant physical properties and elements, such as streets, places, distances and so on. This information is later used for the route planning. Further, number and kind of transport devices and event equipment enhances the initial database and determines the generation of the required agents.

Within the running simulation, it is possible to add new elements, such as additional equipment, transport devices, orders and so on dynamically. Only changes related to the physical world model require a restart of the simulation. This is for example the case for new streets.

Following the principles of autonomous control, the results of the simulation agents' negotiations constitute planning decisions. As the PlaSMA approach implements a time-discrete procedure, it is necessary to write back the corresponding data sets periodically, so that the corresponding processes for the execution can take place.

The third step of the implementation focusses on the route planning and the corresponding communication procedures within the logistic system. To enable individual routing decisions for every object, the DLRP (Distributed Logistic Routing Protocol) comes into operation. The DLRP focuses on the autonomous routing of logistic objects through dynamic logistic systems (Rekersbrink 2009). Its fundamental functionality is derived from established data routing protocols in decentralised communication networks, such as the internet or cell phone networks(Scholz-Reiter 2006). For this, the protocol provides communication standards and procedures for the collaboration between transport vehicles, commodities and logistic hubs(Rekersbrink 2009).

5. SUMMARY AND OUTLOOK

This paper introduces the technical aspects of a concept for the implementation of autonomous control in event logistics. At this, the current contribution focusses on the modelling process, the representation of the involved objects as autonomous entities and the structuring of the communication and cooperation between these objects.

As the concept currently addresses the technical implementation, future work will concentrate on the underlying methods for planning and scheduling in detail. At this, the control strategy for the objects will be from central interest.

In combination, the technical and methodical aspects aim to the evaluation of the general applicability of autonomous control for the dynamically influenced dispatching of circulation rental articles. Furthermore, a main motivation is to improve the performance and robustness in dynamic logistic systems with manifold restrictions and changing transport nodes.

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In BIBA, **Dipl.-Inf. Florian Harjes** was 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 between 2009 and 2012. Since the beginning of 2012 he works on a project regarding the autonomously controlled dispatching of rental articles in the field of event management.

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