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Risk Management for Transportation of Sensitive Goods

Boris Bemeleit (BIBA), Martin Lorenz (TZI)
Jens Schumacher (BIBA), Otthein Herzog (TZI)

Bremen Institute for Industrial Technology and Applied Work Science (BIBA)
University of Bremen
28359 Bremen, Germany

Center for Computing Technologies (TZI)
University of Bremen
28359 Bremen, Germany

ABSTRACT

Sensitive Goods (i.e. fruits, vegetables, paper rolls, cellulose) need a special treatment in a logistic environment. For this reason the logistic processes have to be planned in consideration of special transportation conditions. In this context, the existence of possible hazards and chances has to be regarded. In order to handle the existing risks of logistic systems and especially for sensitive goods we propose a proactive risk management (RM) system to supplement a holistic process management. It supports the design of processes which are robust and insusceptible to existing and occurring anthropogenic and environmental hazards. This paper analyzes essential parts for a convenient risk definition and examines concepts and tools that allow the adequate management of system and process related risk.

INTRODUCTION

Modifications of product life cycles, company structures and information flows alter the requirements for logistic processes. Logistic processes are facing new challenges. These are results by the development of virtual enterprises and the increasing maturity of new ICTs like RFID and ubiquitous computing. The rising complexity of organizational structures leads to a mounting utilization of existing processes. To coordinate all of these processes an increasing demand of required information for just in time deliverables is needed. These requirements exceed the abilities of existing standard logistic processes. This can be realized by the development of autonomous, decentralized control systems, which select alternatives autonomously and decide within a given framework of goals. Experiences show, that a high number of autonomously acting objects lead to an increased sensitivity and higher risk. Direct disturbances of the processes caused by anthropogenic risks and natural hazards have to be identified and reduced by a pro active RM system. The RM system has to regard the transport conditions and the goals of the logistic processes as well as the requirements for the objects which will be transported. The requirements for the transport of the logistic object depend on character of this logistic object. Some objects need a special treatment during the whole transport because they are sensitive and susceptible to damage. This paper will deal with the particular requirements of sensitive goods in a logistic environment of autonomous logistic objects. The content of this paper and the treated problems are the base for this scenario:

A load of fish has to be transported in a truck equipped with a light cooling system. The payload and the truck are represented by agents. While the truck is in a traffic jam on the way from A to B, the agent of the payload perceives that the temperature is getting higher. As a consequence the risk for payload to get spoiled before the truck will reach its goal under this traffic conditions is getting to high. For this reason the agent evaluates a possibility with a lower risk within the framework of goals. He decides that the payload will have to be delivered to C which is closer although the selling price is lower. After deciding the payload agent gives order to the truck agent to drive to C.

RISK AND RISK MANAGEMENT IN LOGISTICS

For a successful development of a pro active RM system which is able to consider special requirements for sensitive goods in transport it is necessary to develop and use a suitable risk term and RM concept. The employed RM concept which will be developed has to contain an appropriate definition of risk and needs the usage of a RM method which is able to consider and classify all relevant risk factors.

After intense examination of existing approaches of risk definitions and analyzing their advantages and their disadvantages it can be said that they provide interesting input but they are not sufficient for logistic purposes. For this reason, a new definition of the term "risk" had to be developed. A definition which seems to fulfil the requirements of a proactive RM system for a logistic purpose is the following:

"Risk is the contingency that the result does not correspond to the goals of the system due to differences."[11] This definition includes uncertainty (about the future and future events), upside und downside risk (represented by chance and hazard), technical, economic, and process related risk as well as internal and external risk.

Following this definition, it is essential to examine different risk concepts and their impact on the definition of risk. Härterich [4] divides risk in three main concepts which: have a different orientation and understanding of risk and RM:

- Risk comprises the possibility of a goal deviation and not the realized goal deviation. A goal deviation is a neutral factor which contains hazard and chance and the common denominator in this concept
    - Risk as a possibility of a wrong decision is part of the goal deviation approach. It also includes a correlation to given goals, because a decision can not be assessed as wrong without goal analysis.
- Risk is characterized as a lack of information in situations where a decision has to be made.
- Risk as a combination of a deficit of information and goal deviation follows from the combination of the goal deviation approach and the information deficit approach. The risk is divided into two components:
    1. description through objective and subjective probability distribution and
    2. a possible goal deviation for symmetric or asymmetric risk

The approach of a risk concept in a logistic environment for the transportation of sensitive goods has to fulfill several requirements. The first requirement is the measurability of the risk and the contained risk factors. In the approach that considers risk as a goal deviation this problem can be solved by splitting the total risk into three main parts. These parts of risk are time, cost and quality which are connected to the given framework of goals.

The possible split up of relevant risk factor is shown in the following figure:

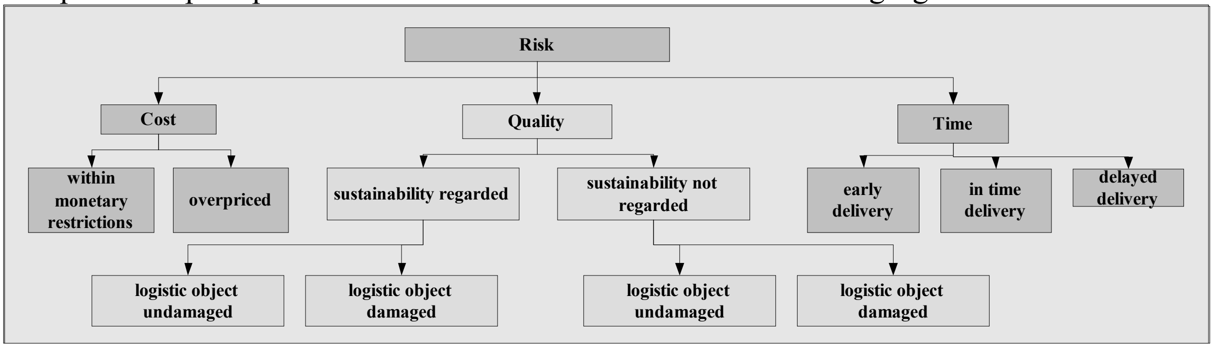

Figure 1: Risk Split up with focus on delivery quality for sensitive goods

It is possible to measure the relevant risk factor for a sufficient risk assessment with this idea. The "Risk as a deficit of information" approach is not able to fulfil the requirement of measuring risk adequately, because risk is reduced to a probability distribution but the flexible characteristics (additional cost, delay in delivery, damaged object) remain unconsidered. But the state of quality is very important for the transportation of sensitive goods.

After consideration of these facts about the attributes of risk concepts and special requirements for sensitive goods we have the highest fit for logistic objects by usage of the goal oriented approach or the approach where risk is defined as a combination of a deficit of information and goal deviation. The subset "risk as a possibility of a wrong decision" of the goal oriented approach is not sufficient for a RM approach which fulfils the requirements for future oriented logistics, because in this approach risk is limited to the decision points and can not occur during the realization of a decision. Another reason which constricts this concept for an application in a logistic environment is the fact that the real risk can only be assessed after a logistic process has finished and all states and decision that lead to an optimal result are known. Yet, another reason for the refusal of the subset "risk as a possibility of a wrong decision" is the difficulty in allocating unexpected events and certain decisions. The difference between these related concepts will be pointed out in figure 2:

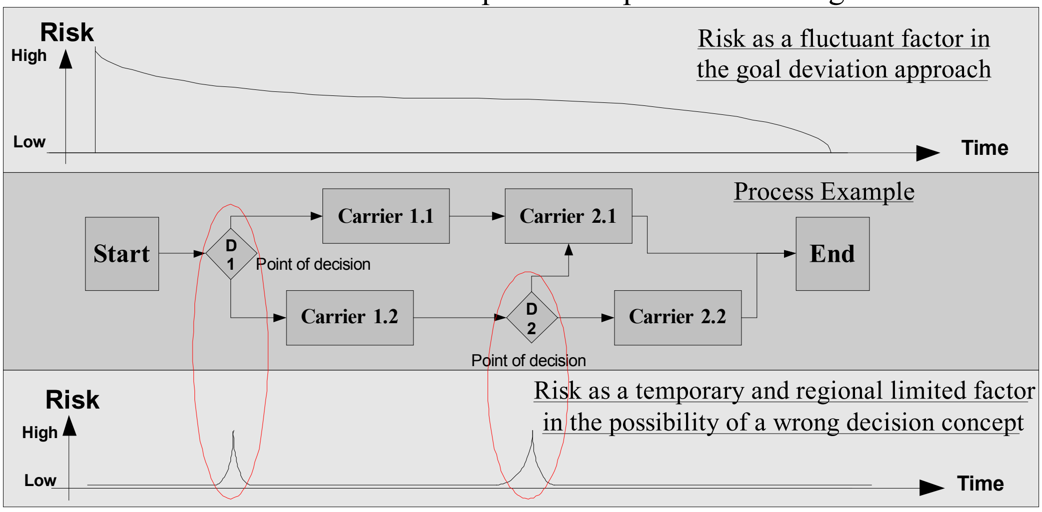

Figure 2: Difference between two risk concepts

But the possibility to assess risk during the planning phase and the accomplishment of logistic processes is a necessary feature for a proactive RM. To enable a proactive RM in complex logistic systems and for logistic processes it is indispensable to conduct a well structured and broad risk analysis. The purpose of this risk analysis is the identification of information which is relevant for the risk assessment. It is the point of origin of the RM process that is the base for all following processes [6]. At an early stage risk identification enables the exertion of influence on the logistic process for that it is possible to avoid or to reduce risk which may endanger the success of the process. For this reason it is necessary to identify all possible risk factors. The identification is a qualitative analysis where the causes of the risk factors remain unconsidered. After the interpretation of new information and the identification of possible risk factors it is essential to analyze and weight the identified risk factors to obtain a qualitative and quantitative risk analysis. This can be done by the usage of a tool supported RM which may be implemented in an agent based environment.

TOOL SUPPORTED RISK MANAGEMENT AND –IDENTIFICATION

Computer based tools that assist in the RM process are an upcoming field of research in various computer science communities. RM not only in financial and insurance industries is supported by IT products[1] since several years and quite a lot of methodologies have been developed in computer science as well as economic science (c.f., [7] with focus on chemical plant risks, [8] with focus on project management risks, and [6,] which outline various aspects of IT support for financial RM). But also logistics have been subject to RM research for quite some time c.f., [3]. In this context IT-tool support however is rather marginal.

A number of methodologies for organisational risk identification and management can be found in the literature [2,]. The techniques proposed – especially for risk identification, which is the first, and in our case most interesting step in the RM process – are mainly of organizational nature, i.e. check-lists of risks and their factors, brainstorming, cross functional teams, interviews with stakeholders and domain experts, etc.

In order to employ those methodologies to the proposed approach of (autonomous) logistic control RM has to be taken as part of the logistic control process. Therefore the RM itself needs to work autonomously, i.e., independent from human interference at least at run-time.

We therefore propose a knowledge based risk identification methodology on top of an autonomous agent based logistic control to achieve this. In this context Zoysa and Russel [15] give an exhaustive overview. Knowledge-based risk identification based solely on sensory data, i.e., a fully automated knowledge-based RM system has not yet been proposed to the best of our knowledge.

RISK IN AGENT-BASED LOGISTIC CONTROL

The smallest controlling entity in our approach, an *agent*, is commonly described as anything that is able to "perceive its environment through sensors and act upon that environment through actuators" [12]. This definition includes biological as well as artificial agents and does not set any constraints on its behavioural (i.e., externally perceivable) nor internal constitution. The system architcture we consider, the *multiagent system* (MAS), is one that consists of a number of agents, which interact with one-another. Hereby a percieveable common behaviour emerges.

We consider a single agent within the MAS to be "intelligent"[2] (every entity within a multiagent system – each agent – has an internal model of the world and can infer on its sensor input with respect to the world model) and "deliberative" (the behaviour of an agent is not only guided by stimulus-response rules but by reasoning based on possibly conflicting higher level goals and the world model). In our scenario every packing lot (e.g., a box containing a number of fishes) would be an agent as well as the truck, the cooling unit, the warestore, etc.

Multiagent-systems (MAS) have been applied to logistics control in various projects. In the TeleTruck approach [1] Bürckert et.al. describe a fleet scheduling system based on their concept of a holonic MAS. Hofmann et.al. [] concentrate on the information exchange for tracking and tracing in a logistics domain. They develop a decentralized agent based search on demand information infrastructure as a more flexible replacement of EDIFACT based pushing of information. The focus of Moyaux et.al. [] is on the supply chain and the well known bullwhip effect. A MAS-based coordination technique to reduce the fluctuations of orders is proposed.

The strategy followed by the collaborative research centre 637 "Autonomous Cooperating Logistic Processes: A Paradigm Shift and its Limitations" (www.sfb637.uni-bremen.de) also applies multiagent technologies to model and implement the proposed new paradigm. Hereby the whole logistic system consisting of packets, vessels, routes, storage facilities, etc. is modelled as a multiagent system. Each entity is capable of local optimization and can

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[1] http://www.capterra.com/financial-risk-management-software lists 31 dedicated financial risk management IT-solutions (state: Apr-22-2005)

[2] In contrast to "swarm" or "ant" approaches wherein the intelligence emerges from the interplay of many (usually thousands) more or less dumb individuals.

furthermore negotiate with other entities. That way we break down the complexity of a huge logistic network with several independent players to a relatively simple local problem.

Because the complexity of the local problem is by orders of magnitude lower than a global optimization approach we are able to model the logistic problem at a much more fine grained level. As such we can give entities quite some reasoning power for themselves. This includes the ability to identify and assess possible risks such as being late (and having to pay a penalty), to rot or thaw, or to be damaged by improper handling.

The box of fish mentioned in our example would notice the slow raise of temperature and predict a time to go without severe damage. In coordination with the vessels route planning algorithm it will than decide, that it cannot reach its final destination (B) intact. So it will decide to take the lower price it can achieve in C as the minor risk compared to the possibility of reaching B in a no marketable condition.

To identify risks in a given environment, a great deal of information is required. Whenever we want to fully or partially automate this task in a multiagent environment, we need to incorporate some notion of "risk consciousness" into an agents reasoning capabilities.

As every agent in the applied BDI approach has to have some sort of planning capabilities it comes quite natural to plug the goal oriented risk model described above into the planning mechanism to derive potential risks as everything that potentially conflicts with the steps of a plan.

This view on risk allows us to handle risks using a conflict resolution algorithm. One such algorithm has been developed in []. The cobac (conflict based agent control) approach identifies 8 different strategies to handle conflicts in an agents goals. By introducing identified risks as valuation criterion for intentions generated by an actual plan we can generate new conflicts between alternatives in a plan and such use the conflict resolution scheme of cobac to handle those risks.

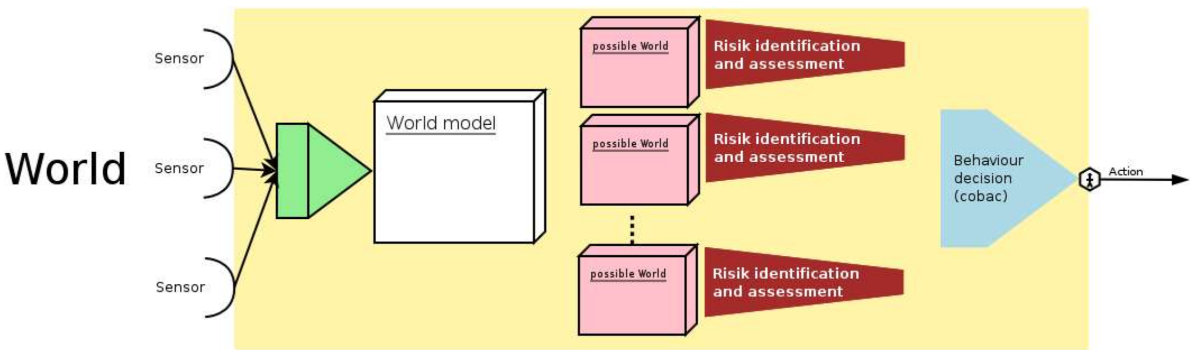

Figure 3: World Model

Figure 3 shows the abstract model of a decision process within one risk aware agent. The agent perceives its environment through sensors and integrates this sensor data into its world model (beliefs in the BDI nomenclature). Than it calculates a set of possible future world states and plans its course of action based on those. Next the risk identification and assessment assigns a value to each identified risk and to the corresponding step in the plan accordingly. The entirety of plans is finally passed to the conflict resolution which generates an action decision for the next step to be made.

CONCLUSION AND OUTLOOK

To enable local autonomous decision making in logistics each entity can be equipped with its own reasoning capabilities including a notion of risk and the ability to reason, make plans and communicate with other entities. In this paper we described the basic risk concept and outlined a technical realisation of a local RM system.

Research on methodical concepts of risk analysis in the context of autonomous systems in agent based environments and related applications will be the next step in realisation. The development of procedures and an approach of a RM system will be done afterwards. The ascertained requirements of RM for robust logistic processes will be conversed in the agent based system and checked with respect to their effectiveness and efficiency. This RM system will be enhanced by methods for recognition of plans and intention on competing logistic processes.

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