Title: Multiagent System for Warehouse Material Flow Control

Abstract:
Increasing sales volumes and customers demanding just-in-time and flexible deliveries result in higher requirements and complexity for logistics systems. Additional challenges are the continually changing conditions in supply chain management. Innovative warehouse management is an important part and is responsible for coordinating and synchronizing activities to improve performance.

In this work, the authors propose an approach for warehouse material flow control based on a multiagent system (MAS). A MAS consists of several intelligent agents. The main idea behind the method described here is that the individual agents act autonomously and self-interested. Such an agent would interact with other agents (e.g. conveyor belt, intersection, vehicles) to achieve its desired goal.

The developed architecture relies on every single transport unit (TPU) inside the warehouse being an agent. Furthermore, additional agents are responsible for locations, to which TPUs can move to. Using the contract net protocol (CNP), the two types of agents negotiate the transport between locations and vehicles. The TPU agents follow their own objectives, depending on the overall goal of the warehouse. Examples are the delivery of orders or storing of incoming goods. There is no overall control. Each agent acts on its own, given an objective.

The whole approach was implemented using UniWare provided by the Unitechnik Systems GmbH. Interfaces for all main entities present in the warehouse of the Netherland scenario were developed, and agents with appropriate behaviors created. The scenario features the delivery of orders for outbound TPUs and storing of inbound goods in two different classes of storage. Various vehicles are included as well.

Evaluation is done by comparing the performance of the MAS approach to UniWare using four different benchmarks in simulation. In total, the simulated runtime of the warehouse easily exceeds half a year of operation per technique. Unfortunately, the MAS style performs worse than UniWare in all benchmarks and needs further optimizations regarding the individual strategies. However, the method presented here still managed to fully operate the warehouse without any failures and features essential properties, such as flexibility, dynamic event handling, and scalability. By using the MAS approach, the logic of material flow is encapsulated within every agent's behavior. Thus allowing for better maintainability and portability.