EWGT 2012
15th EDITION OF THE EURO WORKING GROUP ON TRANSPORTATION
INTERNATIONAL SCIENTIFIC CONFERENCE
ENERGY EFFICIENT TRANSPORTATION NETWORKS
10 13 SEPTEMBER 2012 PARIS MARNE-LA-VALLEE

Compendium of Papers

Improving Resource Management of Large Logistics Facilities

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Abstract

Resulting from an increase of shipment quantities many logistics facilities such as terminals, distribution centers, or production sites reached the limit of their performance ability and thus become a bottleneck in supply-chains. In order to strengthen the productivity of logistic facilities scientific methods can be applied in order to increase the capacity utilization. Referring to the operator's requirements, the aim of the project "Efficiency in Logistics Facilities" is to develop prototypical software so-called "EcoSiteManager ESM". The ESM will be a modular software tool for the control of large logistics facilities or factory sites.

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Keywords: Logistics Facilities; Efficiency; Mathematical Optimization; Logistics Management

1. Introduction

Next to Paris and London the Ruhr metropolis is the third biggest population centre in Europe with approximately 5.2 million inhabitants [1]. With an accessibility of approximately 20 million people within a two hours travel the Ruhr metropolis and its adjacent regions represents a unique consumer region and thus a centre for work and consumption in Germany and in Europe. Due to its geographical location in Europe the Ruhr metropolis has a central role in the global goods stream during the past decades. 20% of the federal freight haulage is generated in North Rhine-Westphalia and a majority of it in the metropolis Ruhr [2]. As a result a high number of logistics facilities established in the Ruhr metropolis to supply the population in urban regions and resident enterprises.

However, in recent years the performance and quality requirements affecting logistic facilities grew constantly. Resulting from an increase of shipment quantities many logistics facilities such as terminals, distribution centres, or production sites reached the limit of their performance ability and thus become a bottleneck in supply-chains. They turn into an endangerment for defined cost and service goals in superordinate transport, procurement or distribution nets. Solving the problem by building new facilities seems to be obvious. Though, additional surface and financial investments for facility enhancements is not always obtainable. An efficient operation of existing logistic facilities is essential for the development of metropolitan regions. Regarding the economic power and the global commodity flows of the region and in addition against the tightening of space for logistic facilities innovative control and steering mechanisms are needed.

Various unused potentials exist for increasing efficiency of logistic facilities instead of enhancing through building operations [3]. For example, processes and procedures have to be intelligently steered and indistinct or decentralized information can be made transparently and available. In order to strengthen the productivity of logistic facilities (i.e. quantity, speed and quality by the same amount of resources) first of all the general survey of existing resources has to be enhanced. Thereafter, scientific methods can be applied in order to increase the capacity utilization.

2. Situation

To describe the basic situation of large logistics facilities the major influencing factors have to be pointed out in the following:

- Vehicle control and manual handling of resources:

A focus of the joint research project lies on the problem-based modelling and in finding an appropriate solution for deployed handling resources in yards or in large factory sites. Previous approaches do not take into account of several practical constraints such as limited time windows for finding a fast solution for large data sets. Most of the existing solutions require long processing times and contain a small size of solvable instances [4], [5]. They do not yet meet the practical requirements of previously existing approaches. Therefore, a combined examination of route planning requirements and the loading processes under consideration of real-time information has to be solved in a single solution.

- Loading point planning:

The flexibility of existing algorithms regarding the dissolution rate and the change of design rules is a missing element of current research. Currently, most of existing research is focussing on cargo systems, and therefore especially on manual guided cargo-handling equipment. An additional requirement is that the solution finding process is implemented in a user-guided software tool and therefore, a maximum duration of the loading point planning may not be exceeded. A knowledge transfer on the organization for loading of other logistical facilities for increasing their efficiency is one of the research objectives.

- Master control center:

The major challenge in the development of an overarching logistics control center is to build an unified and flexible model for information exchange. It must contain information processes, services, personnel, and tasks of the various organisations. The performance increase of logistics facilities requires a detailed modeling of complex business processes. A common understanding of relevant processes and their connections are the fundamental basis for an overarching process model.

- Information and resource control:

From a technical perspective, there is a research gap that addresses the acquisition of the properties of shipments and its subsequent use to increase efficiency. This information on specific features of forwarders is experience and knowledge of the employees is not available across processes. The basis of modern distribution and sorting processes are automated identification systems. The related data must be detected automatically, quickly and accurately. Furthermore, a permanent knowledge of shipment must be ensured in the system [6].

Referring to the operator's requirements, the aim of the collaborative project "Efficiency in Logistics Facilities" is to develop a prototypical software so-called "EcoSiteManager ESM". The ESM will be a suitable modular software tool for the control of large logistics facilities or factory sites. The development of the prototype is based on three areas of innovation. These Innovations are:

- *unitCV* Storing relevant shipment information in an electronic CV and an IT-platform,
- *HugO* Application of human guided optimization methods and therefore interactive software and
- *X-Ray* Monitoring functions of all resources within the system.
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To implement these fields of innovation mathematical optimization and forecast methods are developed and used. This technology will increase the amount of available information at logistics facilities including shipments and their properties (e.g. volume, form, handling requirements) in relation to resources and their current status (e.g. use of warehouse floor space). Results will be integrated in an application-GUI that has intuitive handling and user assistance.

3. Facility Layout, Processes and Management Model

Generally speaking, a logistics facility can be understood as a terminal, a distribution or a production site [7]. In the following, Fig. 1 shows the pictured processes. These processes range from the loading ramp, shipment delivery places to the processes inside the transhipment hall or logistics buildings.

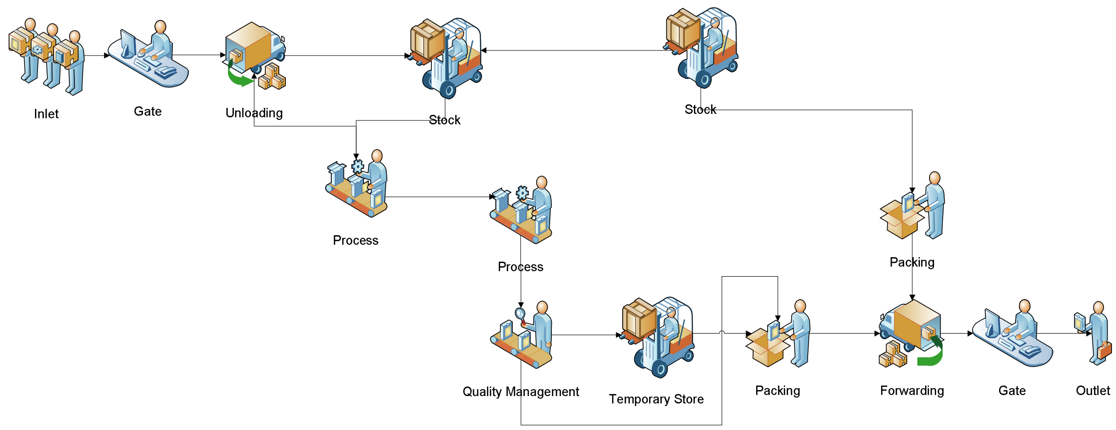

Fig. 1. Logistics Facilities Key Processes [Miodrag, 2011]

The following focuses on the necessary modules to shape a logistics facility [8]:

- **Objects** such as shipments or vehicles need to be accurate and continuously transparency sized in its characteristics (e.g. volume, form, arrival plans, and technical criteria). Objects have to be coordinated, planned and steered optimally and in a transparent way. However, often transportation characteristics are not recorded in an appropriate way.
- **Resources** instituted in logistic facilities and their current status such as filling degree, orders on forklift trucks and allocation of unloading points have to be accurately described. In general, scientific methods, e.g. mathematical optimization, material-flow simulation or effective key performance indicator systems have not reached a sufficient penetration in logistics facilities. These methods are actually not expedient due to missing real time data and a missing comprehensive fielding. Especially the results are based on hypothetical conditions of resources.
- **Human expert's decision mechanisms** are fundamental of current control and planning mechanisms for logistics facilities. In practice decisions highly depend on this human expert knowledge. The above specified scientific methods are used rarely or only in sub-sectors (e.g. picking). Here, a transmission of the expert knowledge in formalized and automated procedures in a software tool is missing. With the application of formalized expert knowledge, logistics facilities can be controlled and steered in order to increase their productivity.

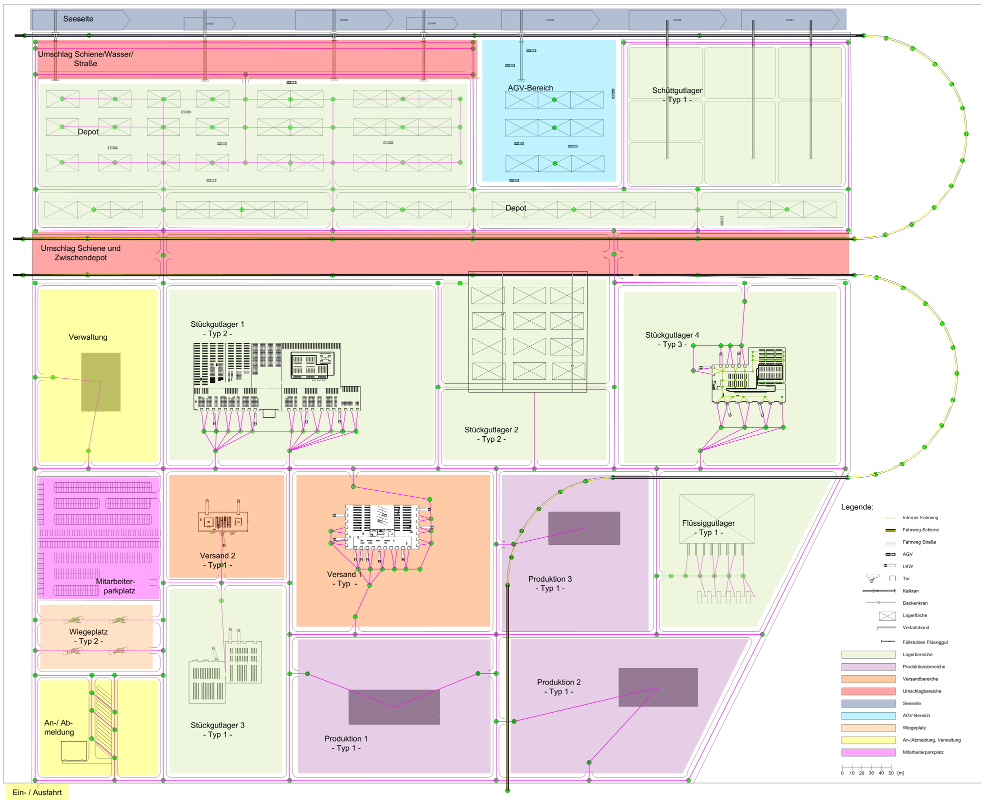

Fig. 2. Modeling a logistic facility

To model a logistics facility, the infrastructure and the operating resources has to be visualized. Therefore a universal model has been developed as shown in figure.2. The model includes:

- Dock (with various possibilities of loading)
- Rail handling and loading stations, railway gates
- Different types of Warehouses
- Conditioning areas (for various branches)
- Gates and weighting stations.

Furthermore, operational stuff e.g. trucks, forklifts, or stuff can be modelled. The overall aim is to cover 80 % of the common types of logistics facilities.

The build Software prototype improves knowledge in logistics facilities, supports the dispatcher with a decision support tool. Therefore, the ESM consist of three control levels:

The **Management Level** enables the human expert to recognize the facilities status at first sight. Therefore, a Management Cockpit has been modelled. It summarizes the necessary data and arranges the needed information in an efficient way. It contains aggregated information and is the highest control level in the planned software tool.

The **Sector Level** contains a forecast module and offers the possibility to optimize the sector utilization. Contrary to the management level, the sector level focusses on comparable stations such as weighting or loading stations.

The **Resource Level** is an operational level. The human expert has the possibility to enable or disable specific resources. In addition, he has the chance to allocate transports a higher priority, to redirect transports or to close roads.

4. Solution Approach

Regarding the mentioned sector and resource levels one approach for the loading point planning has been built as a sub algorithm. Transshipment facilities mostly consist of a fix number of unloading gates and internal areas for buffering. Whenever there are more trucks to unload than gates are available at one time a schedule can enhance the unloading procedure. Due to time sensitive shipments and different departure times of the line haul we increase the number of shipments which arrive in time at the target areas. Therefore, the numbers of available forklift trucks, the internal workload, the internal transshipment duration of each shipment and the amount of unloading gates are the most influencing factors.

Different simple types for dispatching incoming vehicles to unloading gates are developed to reflect usual strategies in practice. In figure 3 a typical layout of an existing less-than-truckload facility is shown, which consists of 7 unloading gates, 28 loading areas and 9 forklift trucks for transshipment. Each forklift truck is configured with realistic process durations for carrying pieces in the facility. For dynamic data a real set of 80 vehicle bringing 1136 pieces has been used.

First, each shipment has to be carried from the unloading gates to the unloading buffer (area 1) by the truck driver. The following transshipment is done by forklift trucks starting at the buffer, picking up one piece, driving to the destination area and returning to the unloading buffer. The main duration of the forklift's process relies on the driving time, which depends on each shipment destination. The shortest paths are pre-calculated per Dijkstra algorithm and stored into a database. Concerning the truck process on the yard we also consider the duration for registration and waiting time [9] [10].

For visualizing the calculated schedules two Gantt diagrams are produced. Seven gates with corresponding waiting and unloading durations are shown in figure 4. A vertical line marks the time of arrival at the yard. Vehicles bringing time sensitive shipments are marked in red color.

The corresponding transshipment of packages in the facility is shown in figure 5. The transshipping duration differs because of the mentioned distances to the unloading areas. Time sensitive shipments are marked in red color.

Several usual scheduling heuristics are possible to realize. Due to various constraints and generalizations heuristics concerning the processing time (LPT, SPT) are not purposeful. The trucks arriving dynamically cannot be scheduled before their arrival and the unloading time varies because of the simultaneously unloaded vehicles and because of the dynamic workload of the forklift fleet. Further heuristics that can be used for preemptive scheduling are not considered because of several experiences from practice.

The tested strategies reflect current simple operation methods of dispatching trucks. Whereas the First-Come-First-Serve (FCFS) heuristic has no impact on the incoming order, the second strategy gives unloading preference to vehicles bringing time sensitive shipments.

In both strategies the fleet of forklift trucks needs 92565 meters for transshipping 1136 packages. The most important measurements are listed in table 1.

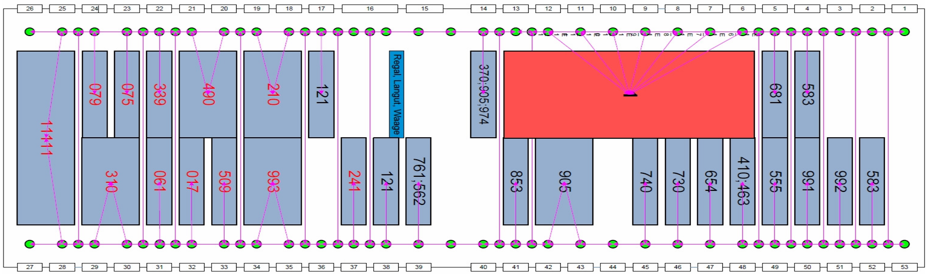

Fig.3. Less-than-truckload facility layout

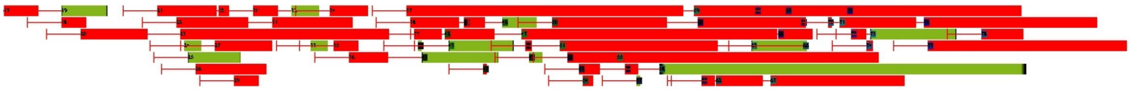

Fig. 4. Schedule of unloading gates

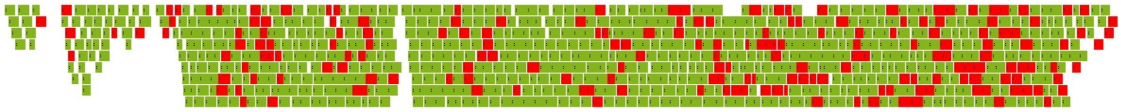

Fig. 5. Schedule of forklift trucks

Table 1. Measurements of implemented dispatching strategies

	FCFS	FCFSprio
Total waiting time prioritized vehicles	482 min	451 min
Total waiting time non-prioritized vehicles	255 min	262 min
Prioritized packages arrive on time	193	202
Prioritized packages arrive not on time	10	1

5. Conclusion & Outlook

The presented system for controlling large logistics facilities or factory sites ESM will be a modular software tool with integrated scientific methods will be applied in order to increase the capacity utilization. First results of computing complex processes like less-than-truckload transshipment show the possibility to connect several logistics issues on large sites. [11]

Although the results offer little improvement of the total unloading duration, the number of time sensitive shipments could be increased significantly. Due to the implemented fast heuristics, this sub-task is able to give exact and fast responses to the overall solution of planning trucks at factory sites. In further investigations strategies using more than one zone for unloading vehicles will be examined and implemented for daily use. Thus, there is great potential in reducing internal transshipment distances, in reducing the total resources usage and reducing the entire discharge duration.

In future, further site modules will be developed scientifically. Real test data will be taken to demonstrate the possibilities and potential of an overall traffic planning on large sites. Additionally, a dynamic tour planning of present and announced vehicles will be combined with the presented loading point planning.

Acknowledgements

The presented results are parts of the work from the research project "Efficiency in logistic facilities" within the research project "EffizienzCluster LogistikRuhr" funded by the German Federal Ministry for Science and Education (BMBF) which takes place in cooperation with the companies DB Mobility Logistics AG, ESG Elektroniksystem- und Logistik GmbH, Kühne + Nagel AG & Co. KG, Logwin Solutions Deutschland GmbH, AMETRAS nobab GmbH and TU Dortmund University.

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