SOFTWARE SUPPORT FOR MATERIAL FLOW MANAGEMENT

STRACHOTOVÁ Dana[1], ZEMANOVÁ Petra[1], BOTEK Marek[1]

[1]*University of Chemistry and Technology Prague, Czech Republic, EU*
dana.strachotova@vscht.cz, petra.zemanova@vscht.cz, marek.botek@vscht.cz

Abstract

The contemporary logistic systems are very complex and their control requires multidisciplinary range of expertise. Dynamic simulation is a tool allowing the decision maker to compare many possible scenarios and helps to find the optimal solution. It finds application in planning, designing, and optimization of production and logistic systems, including the allocation of material flows. Dynamic simulation represents the process of creating a mathematical and logical model of a system on a computer. Experimenting with the model enables user to discover logical connections among the processes and to evaluate the performance of many different structures in a relatively short time. Nowadays the market offers wide choice of simulation software. Part of the paper is devoted to describing the Witness simulation environment. Applications based on Witness dynamic simulation enable to configure optimal solution for material handling in warehouses and production plants. It leads to optimal utilization of resources and smooth material flow focused on customer, and so are satisfy his individual requirements.

Keywords: Dynamic Simulation, Witness, Warehouse, Material Flow

1. INTRODUCTION

In today's global competitive market, companies must innovate and get the most from its resources to succeed. Companies have to face the turbulent changes on the market and customer's raising requirements on the product. Firms try to supply demands of everyone at present profit formation that means each company tries to economize costs, to effective material flow control in the company as well as in all supply chain.

Many companies are creating innovation initiatives and funding programs to develop innovation processes. This requires enabling its employees, business partners, and users with the platforms and collaboration tools that promote innovation. Cloud computing (CC) infrastructures are next generation platforms that can provide tremendous value to companies of any size. This type of innovation platform enables innovation by putting a structure around the innovation process and providing tools for innovators and early adopters to publish, experiment, provide feedback, and enhance innovations. [1] They help companies achieve more efficient use of their information technology hardware and software investments and provide means to accelerate the adoption of innovations. CC increases profitability by improving resource utilization. Costs are driven down by delivering appropriate resources only for the time those resources are needed. CC has enabled teams and organizations to streamline lengthy procurement processes.

In this paper cloud application suitable for material handling system design and optimisation in supply chains is presented. This application based on Witness dynamic simulation enables to configure optimal solution for material handling in warehouses and production plants leading to optimal utilization of resources and smooth material flow. Basic structure and logical framework of simulation, input data requirements and outputs supporting decisions about investments for example to handling equipment are described.

2. METHODOLOGICAL BASES

The pressure on the company's competitiveness is constantly increasing domestic and international markets. The management tries to reach the top in its branch and to keep on the position in the future. One of the essential preconditions for achieving the objectives mentioned above is to know precisely the material and information flows in the company and to be able to manage them effectively.

Supply chain can be defined as the network of organizations that are involved, through upstream and downstream linkages, in different processes and activities that produce value in the form of products and services delivered to the ultimate consumer. [2] It consists of multiple firms, both upstream (i.e., supply) and downstream (i.e., distribution), and the ultimate consumer. [3]

Supply chain management (SCM) is the management of physical, logical, and financial flows in networks of intra- and inter-organizational relationships jointly adding value and achieving customer satisfaction. [4] From a process-oriented or cross-functional perspective, SCM comprises planning, sourcing, production, and distribution logistics but is not exclusively focused on one of these areas. [5]

Management of material flow in the supplier chain requires the knowledge of all inputs and outputs in individual elements of the chains. At present, supply chains are very extensive as they are required to fulfil the needs of any customer with different requirements for the final products. For this reason, use of computer simulations - namely the dynamic ones - brings great benefits in current turbulent environment. Computer simulation is the process of creation of a logical/mathematical model of a real-world object or system defined within the model, or of a decision-making process or implementation of a large number of experiments with such object [6]. Simulation is a method that allows you to predict the behaviour of a real-world system under changing internal or external conditions. In terms of the capability to simulate the operation of a complex real-world system, the use of business process simulation is quite broad and diverse [7]. Computer simulation can be most often encountered in the following cases:

- Optimization of material flow and handling equipment
- Production planning and management, including staffing and maintenance
- Determining the optimum amount and location of stock
- Minimization of shipping costs etc.

Simply speaking, we can say that the simulation allows resolution of complex processes (such as supply chains), for which classical analytical methods are not appropriate. It allows the study of system behaviour in real time as well as in slow and accelerated motion, which brings great advantages when designing changes [8]. In the simulation, these changes and their effects on the behaviour of the system as a whole system are immediately visible. This allows the examination of various options and drawing the final consequences from them.

There is a large number of simulation programs (such as Witness, Simul8, Arena, ProModel etc.); this paper describes the simulation program Witness developed by the British company Lanner Group Ltd. It is a very effective tool for management and determination of optimum solutions for production, service and logistics systems. To create a simulation model, you have to define the elements, which can then be Displayed, Detailed and assigned logical relationships. The basic elements for material flow management include (according to the Witness manual):

- Parts

Parts represent everything that moves between physical elements. They can be small microchips as well as a car transport containers. Parts are drawn into the model passively from the outside world, or enter actively as per the predefined rules.

- Machine

Machine is an element which can change a condition of a part to another condition. Depending on the number of parts the machine is capable of changing, different machine types can be defined: single, assembly, batch, generally etc.

- Buffer

A buffer has certain predefined capacity, which allows storage of individual parts for a certain period of time. There are various output methods for exiting the buffer (FIFO, LIFO).

- Vehicle

Vehicle is an element that transports parts within the system model. For this element, we can define capacity, speed and loading/unloading times. Vehicle can refer e.g. to a forklift truck, car or lorry, crane or trolleys with automatic control system. Vehicles necessarily require the presence of Tracks elements to be functional.

- Tracks

A track is an element which defines the physical position of a vehicle, forming its overall path. Tracks allow easy identification of the locations for loading, unloading and parking of vehicles.

Our experience with many real projects shows that Witness belongs to the most powerful tool in the optimisation of processes occurring in logistics such as manufacturing, storing and distribution. It suits perfectly as a core to our cloud application developed for material handling system design and optimisation. A cloud is an on-demand computing model composed of autonomous, networked hardware and/or software resources. [8] Cloud computing is the result of evolution and adoption of existing technologies and paradigms. The goal of cloud computing is to allow users to take benefit from all of these technologies, without the need for deep knowledge about or expertise with each one of them. Cloud computing aims to cut costs, and helps the users focus on their core business. [9]

3. EXPERIMENTAL PART

Simulation model of material handling system is proposed in Witness simulation software environment. It works with the assumption that material flow through for example production plant or warehouse can be divided into finite number of movements. A movement is characterised with a point of start, point of finish and a resource necessary to carry out this movement. Resources represent workers and handling equipment such as forklifts, tow trucks etc. Imagine for example material flow of palettes through intake area to a warehouse equipped with very narrow isle storage racks and forklifts. Palettes incoming in carriers has to be unloaded to intake area at first (movement 1), then these palettes are transported in front of storage racks (movement 2) and finally these palettes are placed in storage racks positions (movement 3). Point of start to point of finish distances are summarized in the matrix of distances and can be recalculated to a time of movement using speed of resources. [10] These distances are derived from a layout of modelled system usually with help of algorithms searching for the shortest paths in a graph (i.e. Dijkstra's algorithm).

3.1. Dynamic Simulation of Material Handling System

The architecture of simulation can be divided into three levels. All three levels represent Witness elements Machines and Variables. Although there are usually many different material handling units flowing through modelled system, simulation works only with one Part initializing and proceeding movements and generating and recording them to variables.

Task of Level 1 Machines is to generate movement requirements and to record them to Level 2 Variables. These requirements initialize a flow of material. It is for example a requirement to transport one palette of finished products from a production line to a warehouse. Generating of initial requirements is described in Level 1 Variables representing production plans, order picking or production line supplying. These variables store information about frequency of movements and points of start and finish.

Level 2 Machines search for available resources required for a movement requirement stored in Level 2 Variables. In case, that resources are available the Level 2 Machines reserve resources for the movement requirement, assigns requirement to Level 3 Machine and erases it out of Level 2 Variables. Resources in the form of Variables are controlled with help of integer states ranging from 0 to number of possible movements involved in material flow. State 0 means that resource is available. States greater than 0 mean that resource is currently unavailable. Level 2 Machines repeat searching procedure in a relatively short time.

Level 3 Machines carry out movements in a way that each movement represents one Part moving through 4 machines. These 4 machines simulate decomposition of movement to procedures:

- Resources driven unloaded to point of start
- Resources manipulates at point of start
- Resources driven loaded to point of finish
- Resources manipulates at point of finish

Each procedure takes a time derived either from speed of resources and point of start to point of finish distance or from information about time of manipulation stored in Level 3 Variables. After finishing Resources manipulates at point of finish procedure, resources are again available for Level 2 Machine search (i.e. their state is set to 0) and other movement requirement is recorded to Level 2 Variables if necessary.

Input data to each level in the form of variables can be summarized as follows:

- Level 1 Variables - plan of manufacturing; plan of order picking; plan of manufacturing supplying; plan of dispatch; plan of warehouse replenishment etc.
- Level 2 Variables - number of available resources; initialize position of resources.
- Level 3 Variables - speed of resources; matrix of distances; time of manipulation during procedures Resources manipulates at point of start/finish; resources breakdown probability; times of resources refueling and charging.

3.2. Results

Outputs obtained from simulation are:

- Utilization of available resources evaluated from observations of time spent in current state during simulation.
- Utilization of available resources evaluated from observations of time spent in current procedure during simulation.
- Optimal number of resources.
- Time of reaction on movement requirement evaluated as a difference between time of inception of requirement and its satisfaction.
- Space requirements in points of start/finish evaluated from queues of movement requirements during simulation run.

These outputs are transformed to graphs displayed in **Figure 1** and **Figure 2**:

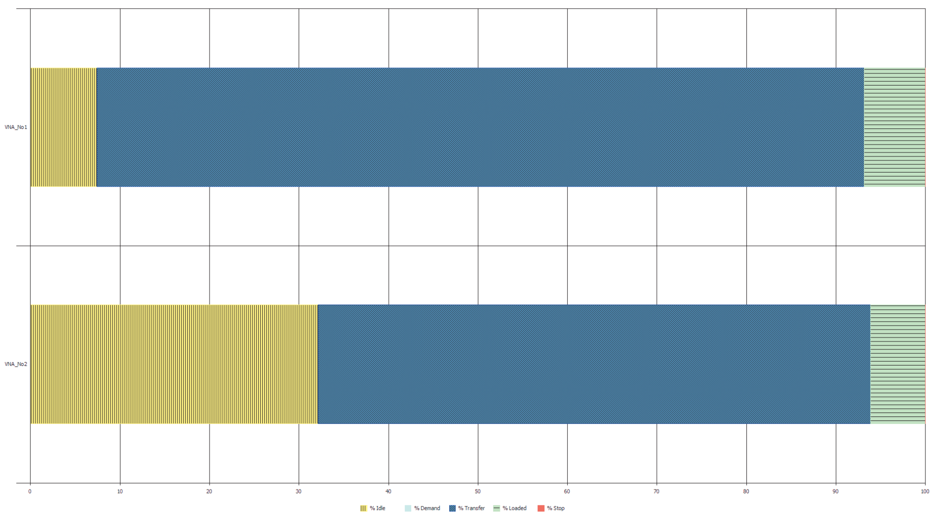

Figure 1 Utilization of very narrow aisle (VNA) forklifts evaluated from observations of time spent in current procedure during simulation

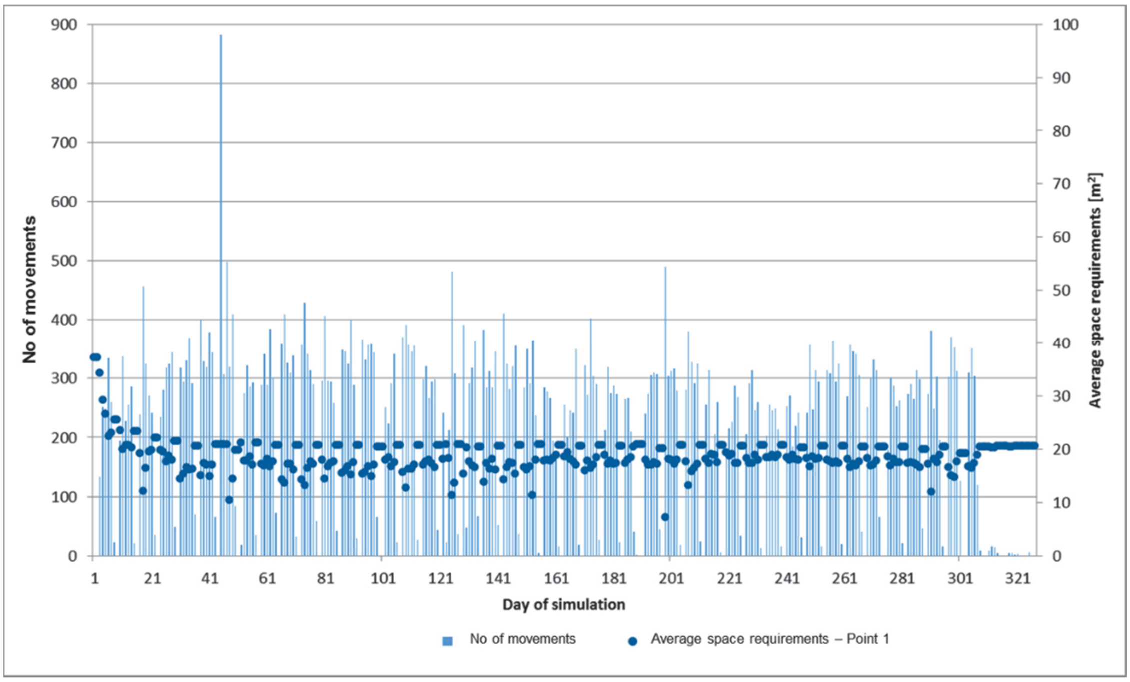

Figure 2 Space requirements in points of start/finish

4. CONCLUSION

Nowadays it is very important to effectively control material and information flows in the company, in the supply chain. One method for finding the optimal solution of real problem is simulation utilization. The principle of simulation is simple. Instead of monitoring the process behaviour or object behaviour in real time, we could observe the behaviour of its model that it is faster and easier to adapt according to specific conditions. It brings advantages. Simulation time could go much faster than real time. So we could analyse a large number of alternatives. Costs of simulation changes are not important compared to implementation of the project. The simulation program makes it possible to create a model of non-existent system and to suggest the new system.

Described solution fits perfect to tasks dealing with material handling system design and optimisation. Outputs of simulation support decisions about investments to resources such as handling equipment or warehouse management system. Cloud computing ensures high speed of calculations and therefore an opportunity to check many varieties of a system structure in a short time. [11] Furthermore, simulation is available to work with stochastic inputs that provide users with great understanding how a system works under uncertainty.

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