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Creating a knowledge base to support the concept of lean logistics using expert system NEST

[Radim Dolák]

***Abstract*— Article deals with lean logistics principles and its model. It describes basic principles, metrics and rules for creating lean logistics knowledge base. The case study included in this paper deals with creating of a knowledge base that supports an implementation of the concept of lean logistics. The knowledge base could be used for identification of waste in each level of logistics processes. The knowledge base also can be used for a recommendation of appropriate methods and tools of industrial engineering to reduce the waste. The knowledge base is build using the expert system NEST and was testing using fictitious and real data.**

***Keywords*— lean company, lean logistics, expert systems, knowledge base**

I. Introduction

The concept of lean logistics is generally much less known and less specific than the concept of lean manufacturing. Both of these concepts are part of the philosophy of Lean Enterprise. The issue of lean enterprise should be considered as a complex issue. There is a more complex concept of Lean Enterprise, which includes these lean concepts: lean manufacturing, lean logistics, lean administration and lean development. Getting a competitive advantage in logistics processes is very important for the survival of firms in the global market environment nowadays. Principles of lean logistics concept seek to eliminate all unnecessary processes and activities that do not bring value to the customer and profit for the company. This article deals with possibility of using knowledge base of expert system for support implementing of lean logistics concept. I suppose that with expert system should be significantly accelerate the process of implementing lean logistics concept. Attention will be focused on basic information about the NEST expert system, which includes general information about the system, its structure, knowledge representation, knowledge base syntax and the rules of inference (inference mechanism). The case study deals with creating of knowledge base for supporting implementing of lean logistics concept. The knowledge base will be used for identification wasting (losses in production efficiency) in each level of logistics processes and then there will be recommended appropriate methods and tools of industrial engineering to reduce this wasting. Knowledge base will be edited in expert system NEST, which is an empty expert system for diagnostic applications based on rules.

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II. Lean Logistics

Henry Ford was in 1913 the first who defined the waste in logistics but concept of lean logistics was introduced as a part of Lean Company concept at Toyota in 50-60 of the 20th century. The main basic of lean logistic concept is the lean philosophy. The lean philosophy is based on a single principle: all forms of wasting should be identified and eliminated. This seems simplistic, but it is not because recognizing true areas of waste is difficult. [8] It is necessary focus on the intent of the process. Eliminate all the parts of the process which do not contribute to meeting the intent, all those that do not contribute to value. Then look at each remaining part and work continually to lower its cost, make it timelier, and improve the quality of results. This focus on eliminating all wasteful effort, the fat that did not contribute to achieving the desired outcome, resulted in Toyota´s lean production system. [6] Just-in-time (JIT) is very important method which was also used in Toyota production system (TPS). Just-in-time is a method, which organizes the logistics flows so as to minimize transport and storage costs. Myerson discusses the need to apply some of the important techniques for cost reduction, including JIT and illustrates how beneficial they are for achieving leanness. [9]

The objectives of lean logistics can therefore be stated according to Baudin as follows: [2]

- delivering the materials needed, when needed in the exact quantity needed, and conveniently presented, to production for inbound logistics and to customers for outbound logistics,
- without degrading delivery, pursue the elimination of waste in the logistics process.

Lean logistics can be achieved for example according to [10] through established by follows 5 steps, which are presented in the figure called How to achieve lean logistics.

Figure 1. How to achieve lean logistics.

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First, I will need to focus on process management in the form of standardization and balance logistics activities. There will also useful ergonomics elimination of unproductive movements. The following step is production control reducing the spatial intensity of production, minimizing transports and material movement. Simulation allows analysis and design principle of supply centres. Different time analysis (REFA, MTM, UAS etc.) are used to verify the correct design in the final step.

Benefits from the introduction of the principles of the lean company can be divided into a number of the following groups: operational, administrative and strategic. The most important are operational benefits as follows: uniquely determined by the time needed for various logistics activities, data for capacity planning with high information content, basis for efficient remuneration of workers. Strategic benefits are for example standardized logistics activities and identification of loss.

III. Case study: creating a knowledge base to support the concept of lean logistics

This case study deals with using knowledge base of expert system to support implementation of lean logistics concept. There are many sources and literature for example [1], [3] or [5] which provides a detailed overview about experts systems and building knowledge base of expert system.

The analysis of lean logistics principles and measurement of these principles is usually consulted with the experts. It is also possible to use expert system for this analysis. Using expert system should be faster and less expensive way how to provide managers necessary information for making decision in process of lean logistics implementation.

The main objectives of the case study is creation of a knowledge base for assessing the state of the introduction of the concept of lean logistics using expert system and evaluation using the knowledge base on data from selected companies in each level of waste production areas and then finally recommend appropriate methods and tools of industrial engineering to reduce this waste. The aim is therefore to help provide recommendations for the implementation of lean logistics in an enterprise.

Sub-objective of the case study is to define a model for area of the lean logistics and convert model of lean logistics in the form of rules of the knowledge base for expert system NEST.

A. *Expert system NEST*

NEST is an empty expert system which includes inference mechanism. NEST was developed at the University of Economics in Prague, Czech Republic. The program provides a graphical user interface (GUI) for: creating, editing and loading knowledge bases, setting the access processing of uncertainty, consultations, the target evaluation and recommendation statement with an explanation of the findings. NEST is the program designed primarily for the academic purposes, which puts emphasis not only on the appearance, but also on the functionality of the program aimed at creating a knowledge base, comparing the results of consultation in the selection of various types of work with uncertainty. [5] Knowledge base of NEST is represented by attributes and propositions, rules, contexts and integrity constraints.

B. *Acquisition of knowledge for building knowledge base about lean logistics concept*

The most important factor for the quality of each expert system is a good knowledge base including knowledge expressed by the different types of rules. Very important is good cooperation between an expert and knowledge engineer or to study relevant issues to acquire the knowledge. There are many sources and literature for example [2], [4], [7] or [9] which provide a detailed overview about lean logistics principles and about methods and tools of industrial engineering, specifying the characteristics and benefits of the various methods and instruments. There will be mention two important groups of necessary information and knowledge for building knowledge base in the expert system: criteria for lean logistics and methods and tools of industrial engineering to support lean logistics implementation.

C. *Criteria for lean logistics*

There are many criteria for lean logistics, but the basic idea is to reduce the basic types of waste in logistics processes. The types of waste in different areas of logistics processes can be divided into these 8 different categories:

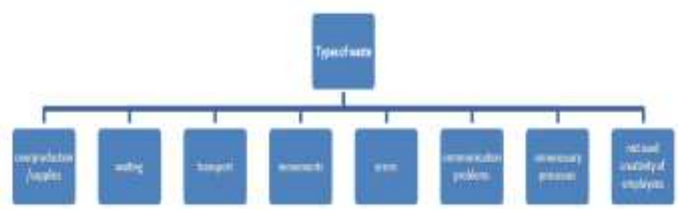

Figure 2. The basic model of types of waste in logistics.

We can define appropriate criteria for lean logistics according to the specific type of waste. To identify the rate of the level of waste in lean logistics concept, we need at first to define some key elements for lean logistics which are describes for example in [7].

We can use some numerical criteria relating to lean logistics process as for example follows: index value of inventories, value of inventory turnover etc. We can also use various questions that can be answered by selecting predetermined scales.

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D. *Criteria for lean logistics*

Industrial engineering is an important tool to achieve higher business productivity. Implementation of industrial engineering methods is the responsibility of the industrial engineers who are trying to implement appropriate methods to achieve higher productivity and to avoid excessive wastage in the enterprise.

Methods and tools of industrial engineering are final statements of created knowledge base. Inference mechanism will recommend appropriate methods and tools of industrial engineering according to rules in knowledge base and input information about situation in logistics processes. Inference mechanism can recommend these methods and tools of industrial engineering such as: JIT, planning, 5S, standard layout, milkrun, pull system, process layout, team working or workshops.

E. *Building knowledge base in the expert system NEST*

There were set out basic criteria that will be used for creating rules in knowledge base in the previous section. Knowledge base is created by the NEST editor and saved in XML file. Knowledge base of expert system NEST is using XML version 1.0 and coding windows - 1250 and has the following basic structure of the elements:

- global properties,
- attributes and propositions,
- contexts,
- rules: apriori rules, logical rules, compositional rules,
- integrity constraints.

First step in process of building knowledge base is to enter the global parameters. Important settings include specifying the range of weights, the threshold of a global context and condition. It is possible to define a type inference mechanism (standard logic, neural network or hybrid). It is also possible to add the name of an expert and knowledge engineer, including a description of the knowledge base.

Knowledge base has the following hierarchical structure:

- queries,
- intermediate statements,
- final statements.

The structure of the knowledge base "lean logistics" is shown in the following figure as a viewport of knowledge base for lean logistics and specifically in the area of waste of overproduction/supplies".

Figure 3. Part of the designed knowledge base focused on overproduction/supplies in lean logistics.

The types of rules which we used to create the knowledge base can be systematically classified into the following groups:

- evaluation (basic) rules,
- recommending rules
- specific rules,
- direct rules.

Evaluation (basic) rules represent the part of the rules that can be used to derive the types of waste directly from the basic questions (input data obtained from the questionnaire survey). Recommendation rules are provided in its intermediate questions (types of waste) and at the conclusion of the rule are industrial engineering methods that can be applied to eliminate the waste. Specific rules combine in its assumption intermediate inquiries and basic questions and recommend the choice of specific methods of industrial engineering. Direct application of the rules is used to significant questions that lead directly to the specific recommendation methods of industrial engineering.

It was necessary to make some corrections after testing knowledge base on real data from 35 companies when was the knowledge base finished. There was important to make consultation with industrial engineer and make some corrections. There were subsequently modified some rules for deriving the final recommendations in the form of appropriate methods and tools of industrial engineering to reduce waste in logistics according to consultation with industrial engineer.

Statistics of the total number of attributes, propositions and rules used to establish the knowledge base "lean logistics" shows the following figure.

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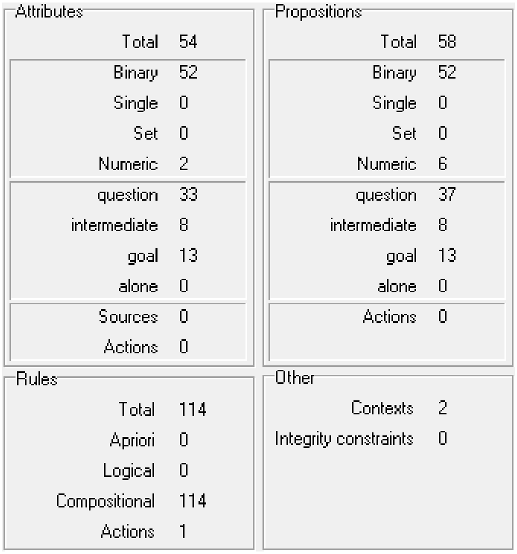

Figure 4. Knowledge base “lean logistics”.

IV. Case study: testing of a knowledge base to support the concept of lean logistics

We can start consultation process in the NEST expert system after the knowledge base is created. The consultation process is based on acquiring data from the user. There are 31 queries about situation in logistics processes. There are derived final results (goal statements) by inference mechanism that works with the knowledge base that contains knowledge in the form of rules and with input data which are based on the responses to questions during consultation process.

A. Testing of a knowledge base using fictitious data

Knowledge base for lean logistics was tested on the basis of fictitious data for basic functionality of recommended methods and tolls of industrial engineering and for analysing types of waste in logistics.

Testing on fictitious data revealed the need to distinguish finer scales recommended methods and tools of industrial engineering and also the necessity of introducing contexts. The resulting weights for recommended methods and tools of industrial engineering were finely distinguished by adding direct and specific rules in the knowledge base.

B. Testing of a knowledge base using real data

I got 35 datasets from Czech manufacturing companies with logistics processes for testing our knowledge base. Data sets include information for consultation process using created knowledge base.

There is an example of results of consultation process using data about logistics processes from one real Czech manufacturing company: figure 5 shows the most recommended methods and tools of industrial engineering to reduce waste and following figure 6 shows identified rate of each type of waste in logistics. We can see minimal and maximal weight values for propositions from the interval [-3; 3].

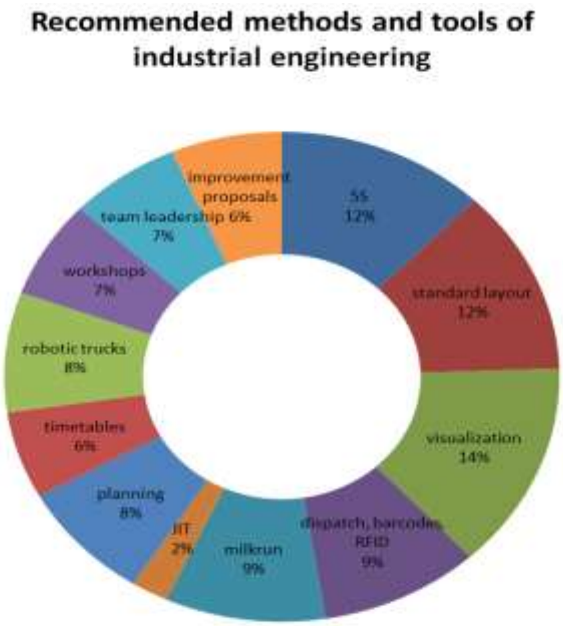

Figure 5. Recommended methods and tools of industrial engineering to reduce waste.

Figure 6. Identified rate of each type of waste in logistics.

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V. Conclusion

The case study describes the building process of a knowledge base in the expert system NEST that can be used for identification of the losses in production efficiency and lean logistics concept implementation. Knowledge base can be used for identification wasting in each level of logistics processes and for recommendation appropriate methods and tools of industrial engineering to reduce this wasting.

I have tested the knowledge base using real data from Czech companies. I want to improve the knowledge base by adding more rules and I want also test knowledge base in a real industrial setting in the future. I hope that knowledge base of expert system will be useful for supporting decision making about lean logistics concept implementation.

Acknowledgment

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