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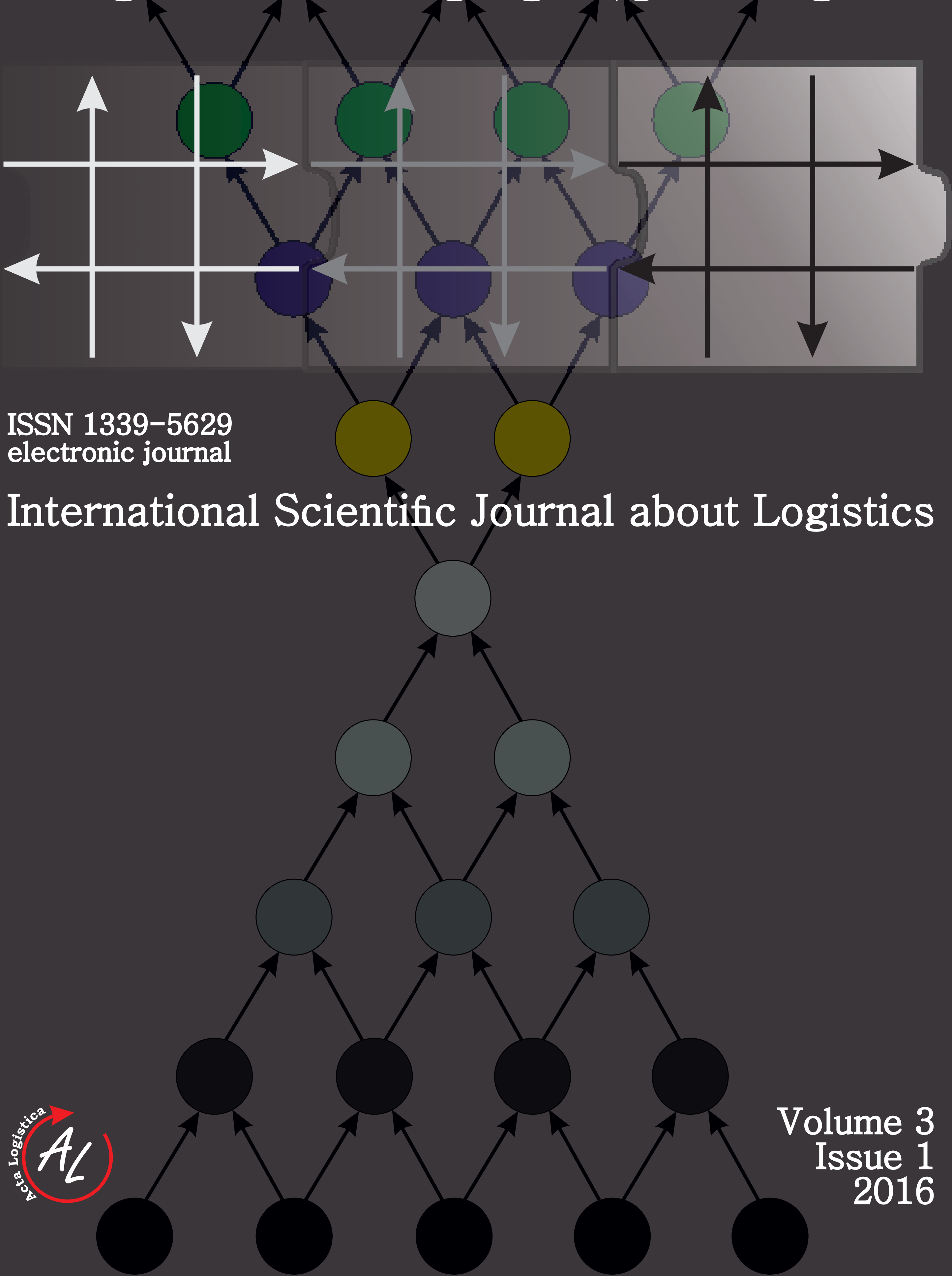

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CONTENTS

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LOGISTICS AS A PART OF INNOVATION PROCESS

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Keywords: innovation process, logistics, innovation
Abstract: The paper deals with the importance of logistics in innovation process. The issue is focused on management of different logistic processes building on the innovation and on innovation process. However, logistics is an essential part of this process. The results describe logistics chain within innovation process for the satisfaction of customers´ demand and fulfilment of customers' requests on the innovation. This approach involves "7S of logistics" which means: "create proper innovation, in the proper quality, for the right place and in the right time, as well as, with the proper price and package".

1 Introduction

At the present time, there is a high level of competition as well as fast changes on markets and only companies oriented on customers [1], [2] within open system of innovations could be successful [3].

For the innovations success in the market it is necessary to generate them in the way, that they represent an added value for customers, as well as environmental output and product quality. To accomplish the above mentioned requests as an innovation for a company, it is necessary to implement all innovations´ activities effective and originally. In this way logistics plays an essential role for a company.

2 Process Management with Respect to the Innovation

If companies want to implement a new product they need to define a process where output will be some desired innovation. In this case company has to implement new elements to the organization process. Davenport defines process as a structured complex of a sophisticated set of activities. These activities are designed to produce a specific output for specific customers or markets [4].

Activities in the process are interconnected and have a clear structure. The process is characterized by a grouping of work activities across time and space, beginning, end, clearly defined inputs and outputs. They are closely linked to the management system planning, synchronization, realization and control of internal and external material and information flow from point of origin to point of consumption aim of which is to satisfy customers´ requirements [5].

The process is simply structured, sophisticated set of interrelated activities, which has a beginning and an end. However, these processes change one or more inputs to the outputs with values for the internal or external customers. It is very important to understand the business processes and procedures for their management with respect to the innovation. It is necessary to know more than the general principle of the operation. In case that company try to introduce a procedural approach it should be able to recognize who is the customer for a specific process. After that company has to manage process which customer requires as an output - innovation. Obviously, it is also important where the process starts and ends. Due to that fact it is important to understand the basic attributes of the process and origin of customers. The customers can come from outside of the company (external customers), or even from their own company. Business processes can be correctly set and they can work properly, if we are able to understand the requirements of both above mentioned customers groups [6].

According to Štefko and Rákoš any company will not survive in the developed market economy, if it cannot satisfy customers´ requirements. These requirements can be known as model "7S of Logistics":

- proper product - innovation,
- the proper quality,
- in the proper amount,
- at the right place,
- at the right time,
- at the right price,
- proper packaging [5].

All the components of the “7S of logistics” are closely linked with the whole process of the innovation implementation because throughout the process we have to monitor the implementation of these components (Figure 1).

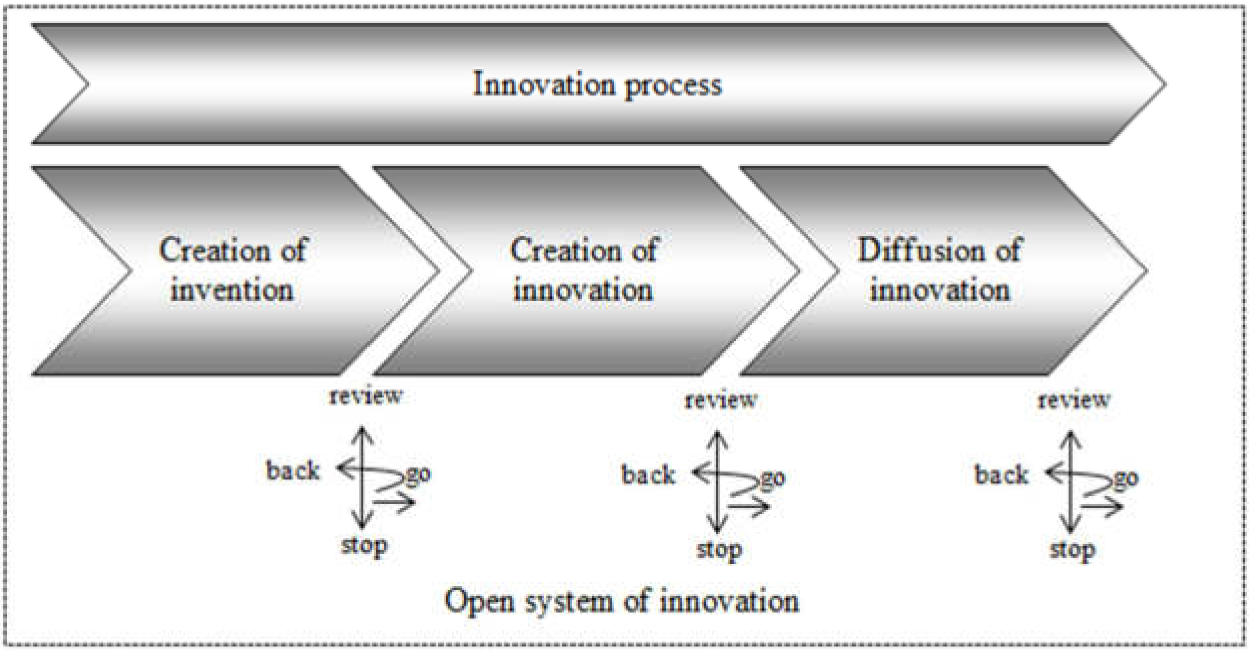

Figure 1 Process innovation management

Following the implementation of any part of the innovation process, the currently reviewed criteria for innovation are reducing the risk of failure in terms of changes in the customer requirements during the time of its implementation in the innovation process.

3 Logistics in the Innovation Process

The innovation requires more than simply coming up with a new idea – an invention is a process of finalization ideas into a practical use. The innovation process is a process which involves activities from a research, through the application of results to a commercial use. Many authors [7, 8, and 9] devote the innovation process into three basic parts: a creation of an invention, an innovation and diffusion of innovation. Each of these parts can be divided into phases, which include several activities. Therefore, different parts and stages of the innovation process could continuously follow each other. It is essential to use different logistic principles to ensure the flow of information, material or the other (Figure 2).

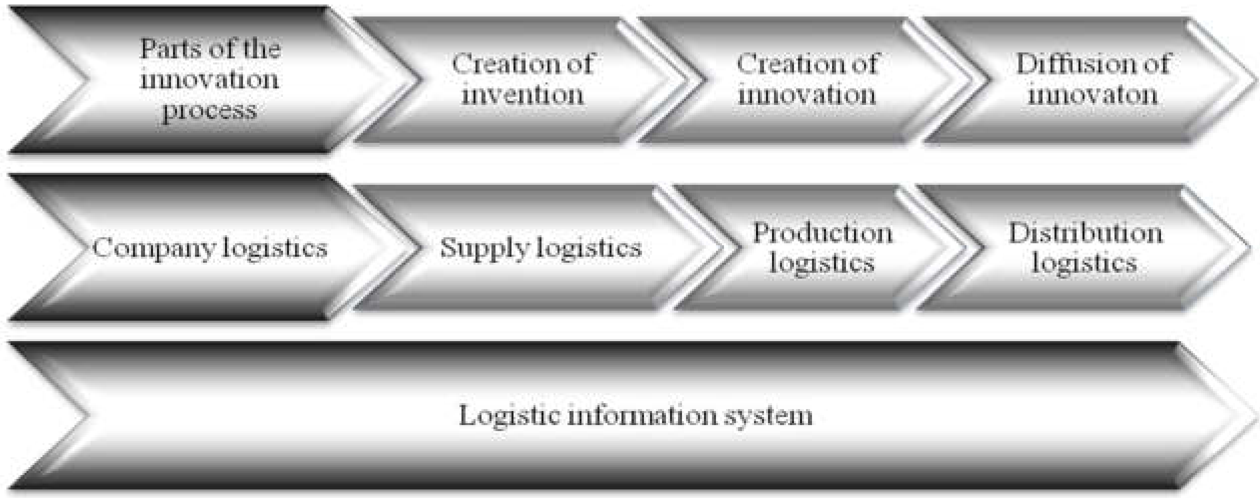

Figure 2 Management of the logistics chain in the innovation process

As already outlined, in the different stages of the innovation process it is necessary to continuously monitor market changes and adapt the innovation to implement the 7 S of logistics. This approach can be provided by logistic information system [10, 11]. We can consider it as a modular system connected with information about sales, purchase, supply, production, maintenance, quality management, etc. This system provides a flow of information during the implementation of the innovation process.

Furthermore, it is necessary to implement enterprise logistics including production and distribution logistics. The supply logistics provides resources for the innovation process. These may be materials, semi-products or services that are necessary for the following production of a prototype or they are necessary for the production of the innovation itself. On the other hand, intangible resources are even more important before the production, when they represent information for inventions and a feasibility study of these inventions. Consequently these new inventions are drawn to new innovative projects.

In addition, different areas of logistics present activities related to the physical and administrative handling of these resources, such as receiving and controlling, storage, protection etc. The production logistics plays a key role in the production of prototypes and their innovation. Logistics represent management intra-movement of material, prototypes and products from suppliers to the enterprise, to the individual workplaces. Finally, this movement is connected with the distribution logistics for final consumers. In that way it ensures a bargain and sale, as well as, reliable and rapid transfer of innovations to the customer.

Conclusions

Based on the above mentioned issues we can conclude that logistics is currently effective instrument of the innovation process management. Well-organized logistic chains in the innovation process represent a high chance for successful innovations implementation. This approach can decrease costs and increase profits with respect to all dimensions of the corporate social responsibility. Companies will provide a high chance of the success on the market if they manage the logistic chain in the innovation process.

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USAGE OF RFID TECHNOLOGY FOR THE NEEDS OF LOGISTICS OF SERVICES

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Keywords: RFID, system, simulation, information system, logstics of services
Abstract: RFID technology is common available technology, that is capable to bring new and innovative view of customer services of logistics of services. RFID technology in logistics of services is able to improve the information, financial and material flows in order to ensure better customer services. RFID is a modern technology, which currently provides a wide range of logistics of services to the users. Logistics of services deal with the management of material, information and financial flows in order to ensure quality of services at the time, in current location and necessary costs.

1 Introduction

RFID is a modern technology, which currently provides a wide range of logistics of services to the users. Logistics of services deal with the management of material, information and financial flows in order to ensure quality of services at the time, in current location and necessary costs.

For the needs of logistic of services has been selected a catering unit as a company, where can be used RFID system for rendered services. A system analysis of the restaurant was made. Based on the analysis it was designed a new information system thath uses RFID technology [1].

2 The proposal of information system

The new information system will use the latest technology in the field of RFID, in the management of the flow of materials, information and finances. Introduction of a suitable information system will shorten times of operations (order time, preperation time etc.), that will increase productivity of the restaurant and the information system will increase interests in the restaurant and attract new customers. The proposal of information system will consists of three modules: module orders, module cash desk and module server [2], [3].

2.1 Module orders

Module orders is dependent on data received from the control unit. Control unit of module orders is Raspberry Pi. The control unit is equipped with touch screen, USB interface, power supplies for the control unit and connector RJ-45 for connecting to LAN. To the control unit is connected a RFID reader via USB.

Description of the running application: Application is waiting to attach RFID card to RFID reader. From the card it reads the unique identifiaction number, under which the aplication can recognize individual customers. After applying RFID card to reader the application will decide, if there is an open bill in central personal computer, if not then it will create new bill. The customer chooses from the menu that is stored in the control unit. Confirms his order and then the data writes to a specific bill and account in central personal computer based on RFID card data. A waitress can entry in this process and edit an order on herself [4], [5].

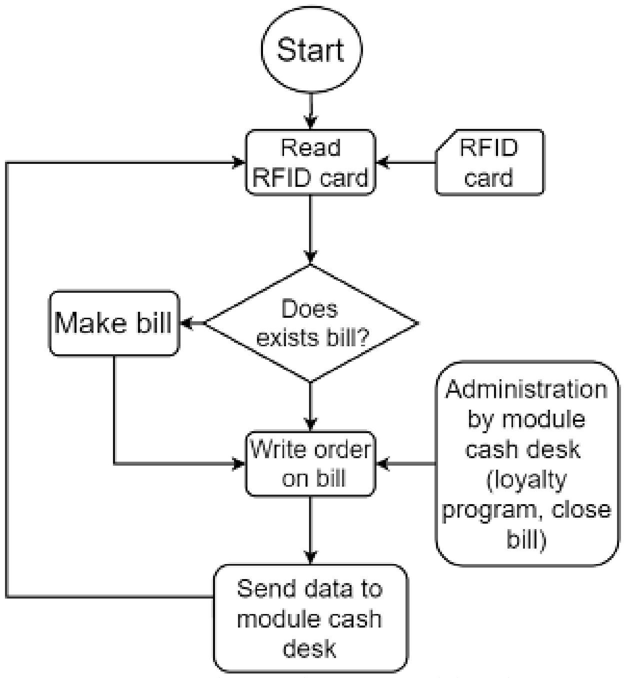

Figure 1 Application diagram – module orders

2.2 Module cash desk

Module cash desk is the main part of the whole information system. It consits of a central personal computer. On this computer is deployed the information system. To the central computer is connected RFID reader that is used to log in to the information system and for the needs of the loyalty program.

Description of the running application: After receiving order from the customers will on the central computer record a custumer order. After writing on the bill data will be send to the central computer with the information about bill on the server, where the data based on RFID card account are stored. At the same time as writing on central customer bill, the application has to decide if the order obtains also a meal. If so, the kitchen has portable printer and the order is printed for the kitchen and the order also shows on the monitor, which is also in the kitchen. Otherwise is the order displayed on the screen of central computer at the bar. Upon delivering the order for customers waitress confirm delivery. Then it is able for the customer to make a new order and the algorithm will repeat. If the customer no longer wishes to order, he pays his order. After entering into the system, the information about the payment sends central computer to the module server. The central bill will be closed, then will be printed a receipt for the customer and the central bill is deleted in the central computer and then is waiting to receive another order.

2.3 Module server

Module server provides a backup of all data. On the server is a database of customers. Using the web interface, customers can see the statistics how many they consumed, what is the current status of the loyalty program. In addition, an administrator can log in to the web interface to obtain actual information about the number of customers and how many orders where made. Based on these data, he is able to prepare accurately orders to the supplier, and thus ensure the smooth running of the bussiness and reduce costs. By using this information system can the company reduce supply of food and beverages and that leads to reduce storage costs. Module server communicates via Internet directly with the module cash desk, which is main source of information for the module server. Module server uses cloud services.

Description of the running application: Module cash desk sends the informations to the module server about customers and the order. After receiving information will update data about customer and account. After restoring data that are adjusted to loyalty program, module server sends the updated information to the module cash deck.

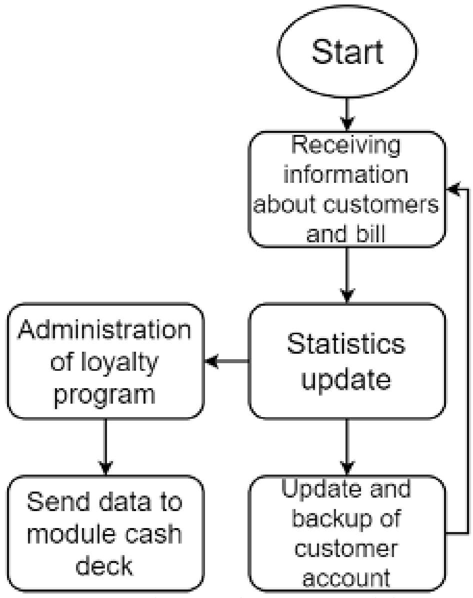

Figure 2 Application diagram – module server

RFID reader

For the information system was chosen RFID reader that connects to the control unit via USB port.

RFID card

For the needs of information system will be purchased RFID cards. These RFID cards are already pre-programmed and have read-only-memory (ROM), so it is possible only to read data (Unique Identification Number) from them. Every card has their own UID under which the application of the information system can pair RFID card with customer account.

2.4 Use case diagram

In term of application of the information system may recognize three levels of users with different access to the information system.

A customer can only place an order. Waitress is receiving the order from the customer, it is able to create a new record of the order and she can change the order made by the customer. Admin can handle the overall system administration.

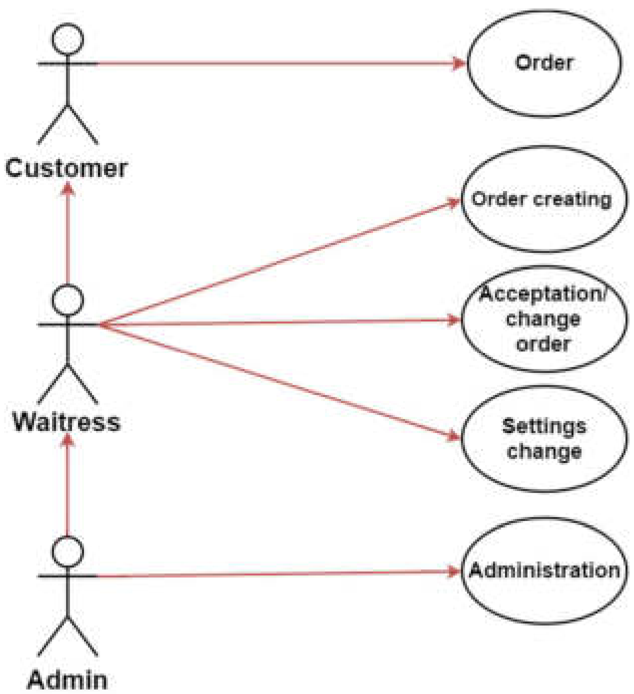

Figure 3 Use case diagram

2.5 Web interface

With the launch of the new information system will be created a website. The new service for customers, where the customers can see various statistics associated with the use of RFID cards. The customer can pick up the RFID card at waitress. This card contains UID. On the website the customer will create an account with unique login and password, after signing in to the web interface of the information system. Within the web interface the customer can track his orders statistics as well as the level of the loyalty program.

2.6 Terminal for the waitress

Waitress will have a terminal for ordering. It is a portable device for example a tablet, which is attached to the application of the information system. Waitress receives an order from the customer. She select from the list the number of the table and assing an order. Terminal behaviour is based on module orders. Terminal sends data about the order using WiFi to the central personal computer, where the order processes the module cash desk.

2.7 Implemetnation diagram

Implementation diagram indicates how the information system will be pull into practice. Deals with all the particullars necessaries for the implementation of the information sytem and how each part of the information system works together.

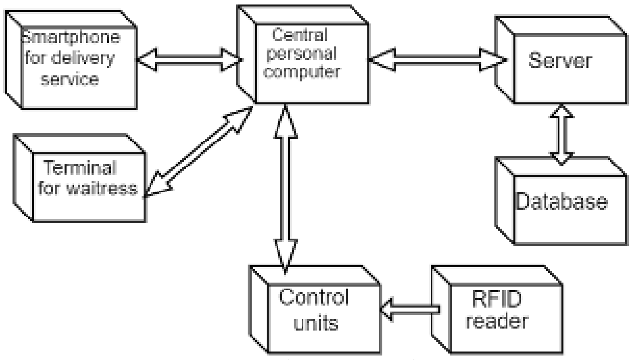

Figure 4 Implementation diagram

2.8 Simulation model

To create a simulation model of the restaurant was used program Tecnomatix Plant Simulation. Based on the data obtainted in the analysis of the arrival of customers and customer delay in restaurant was made simulation model. The mode reflects incoming customers and time that spend in the restaurant.

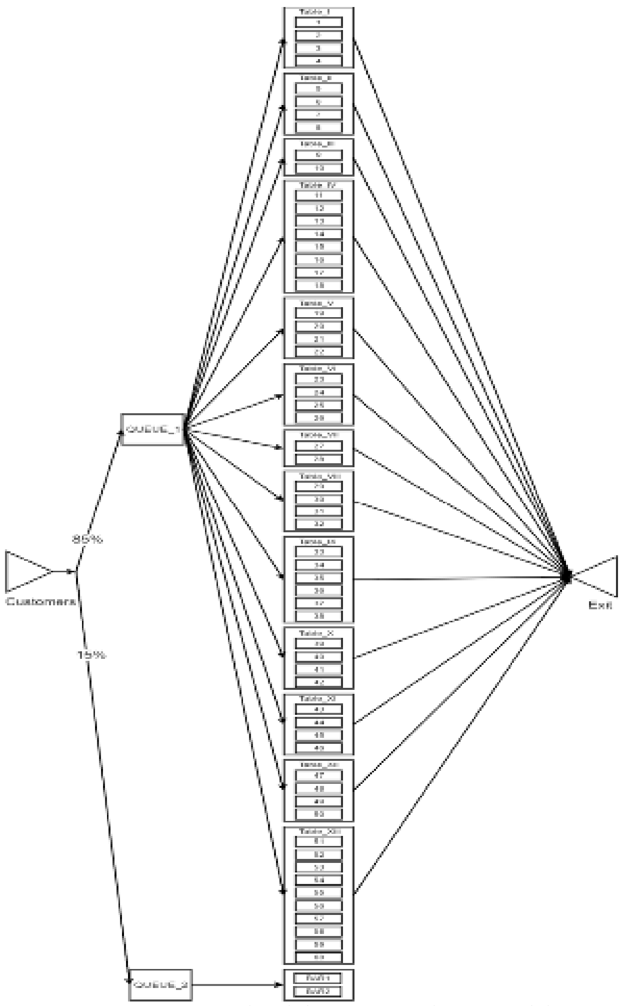

Figure 5 Formalized diagram simulation model

The result of the simulation is a statistic that reflects the percentage avaibility of each multi-channel devices during open hours of the restaurant. From that simulation it is possible to determine, if there is a free capacity to increase production.

Conclusions

By applying new information system to the restaurant, web interface and the loyalty program for streamlining the management of the restaurant there are two views on system how it works. In the first case the customer owns RFID card for the needs of the loyalty program, in other case the customer doesn't own RFID card.

Customer comes to the restaurant and want to order. If the customer owns the card, he attaches it to the RFID reader of control unit. UID is readed from the RFID card. Based on UID of the card, is the card paired with account made on the web site. The customer makes an order. The control unit is on every table in the restaurant. In the control unit is stored the whole menu. By simply clicking on the screen of the control unit customer chooses what he wants and confirms his order. On the base of the order it will be in central personal computer opened a new bill for a particular table. Waitress confirms the order in the central computer and all ordered items, too. All ordered item will be write on the open bill in central computer. The order will be prepared and waitress brings the order to the customer at the place where he sits. Customer consumes his order and if he want still to order something, he put his RFID card on the RFID reader and the process will repeated all over again. If the customer don't want to order something else, but he wants to pay his order. The customer clicks on the control unit on word "PAY", so he let know the waitress, that he wants to pay his order and want to leave. After paying he puts his RFID card on the RFID reader, where the waitress confirms that the orders has been paid and the customer will have the loyalty points credited to his account. After writing loyalty points to his account, the customer leaves the restaurant.

If the customer does not own the RFID card, he can get it from the restaurant staff. He creates an account with unique login on website of the information system and then is RFID card assigned to the loyalty program. Next the customer can place an order using RFID card.

If the customer doesn't wish RFID card of the loyalty program, he makes order without card via control unit with the difference, that the customer doesn't receive loyalty points.

By applying the information system using RFID technology, the loyalty program will significantly reduce the length and time of operations for the preparation of orders.

The application uses a modern method of communication between the individual modules based on LAN and Internet. The proposed information system eliminates errors that can make waitress, reduces times of orders. An important aspect of the information system is the introducing of the loyalty program to the customers, that with regular visiting of the restaurant will receive loyalty points, which can be spent for buying some food or to achieve discount on the whole bill.

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METHODS OF DISTRIBUTION, LAYOUT AND HUNGARIAN METHOD

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Keywords: distribution, lay-out, allocation, transportation problems
Abstract: The article analyzes and describes theoretical basics of various methods used for lay-out, allocation or solving various types of transportation problems. Lay-out and allocation represent two of the very important decisions which is made by macrologistics management. Nowadays we know several types of solving these problems so it is very important to be able to chose the right way and solve these problems as optimally as it is possible. This article is going to describe some of them.

1 Layout

Layout, as the layout of production, non-production and storage capacities in the company is undoubtedly one of the most important tasks because it has a direct impact not only on the company economy but also affects safety at work and social environment of the company.

Layout design is usually one-off task. The usual case is also the gradual creation of layout, where the company objects are filled with manufacturing equipment and storage areas in the longer term with advancing other processes, respectively. increasing the capacity of existing processes. The last case is to design the ideal layout with a finite number of machines, equipment and storage areas in a given area [1].

We know several ways how to solve the layout problems, for example the quadratic assignment problem, linear assignment problem, loop layout design, value stream mapping, group technology, etc. and now we describe some of them.

1.1 Loop layout design

A common layout for flexible manufacturing systems is a loop network with machines arranged in a cycle and materials transported in only one direction around the cycle. Traffic congestion is usually used as the measure for evaluating a loop layout, which is defined as the number of times a part traverses the loop before its processing is completed.

The essence of the problem is how to determine the order of machines around the loop subject to a set of part-route constraints so as to optimize some measures. A hybrid approach of genetic algorithms and neighborhood search is developed for solving the problem. The proposed method is tested on hypothetical problems. Computational results demonstrate that genetic algorithms can be a promising approach for loop layout design in flexible manufacturing systems.

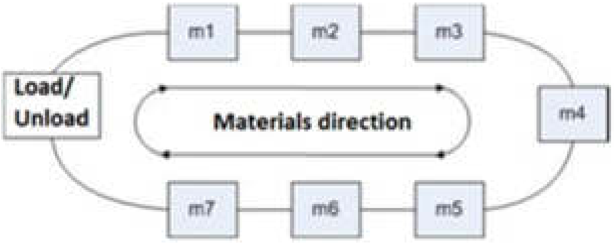

Figure 1 Scheme of the loop layout design [1]

Following Afentukis, we consider a system in which machines are arranged in a loop and materials arc transported in one direction around the loop (Figure 1). There is one loading/unloading station where parts enter and leave the system. Suppose that there are n machines in the system, *M = {0, I, 2,. . - ,n}*, where 0 denotes the loading/unloading station. A loop layout design can be represented as s permutation of machines *(m1, m2,.. . , m,)* with s prefix of loading/unloading station 0. Each part is characterised by its part-route, the sequence of machines it must visit to complete its processing. For s given part, suppose that processing on machine *j* immediately follows processing on machine *i*. If the position of machine *j* is lower than that of machine *i*, then the part must cross the loading/unloading station, which is called s reload. The number of reloads necessary to complete the processing for a part is defined as the measure of traffic congestion. The problem is to find out the best layout (or machines permutation) by optimising some measure of performances subject to a set of part-route constraints.

There are two measures commonly used in evaluating such loop layout: *minsum* and *minmax*. The *minsum* measure attempts to find out the permutation of machines which minimises the total number of reloads for all parts and seeks n more balanced congestion among parts; while the *minmax* measure attempts to find out the permutation of machines which minimises the maximum reload among *n* family of parts and tries to reduce the aggregate congestion of the system.

1.2 Quadratic assignment problem

The quadratic assignment problem (QAP) was introduced by Koopmans and Beckmann in 1957 as a mathematical model for the location of a set of indivisible economical activities. Consider the problem of allocating a set of facilities to a set of locations, with the cost being a function of the distance and flow between the facilities, plus costs associated with a facility being placed at a certain location (Figure 2). The objective is to assign each facility to a location such that the total cost is minimized. Specifically, we are given three $n \times n$ input matrices with real elements $F = (f_{ij})$, $D = (d_{kl})$ and $B = (b_{ik})$, where f_{ij} is the flow between the facility i and facility j, d_{kl} is the distance between the location k and location l, and b_{ik} is the cost of placing facility i at location k.

The Koopmans-Beckmann version of the QAP (1) can be formulated as follows: Let n be the number of facilities and locations and denote by N the set $N = \{1,2,...,n\}$.

$$min_{\varphi \in S_n} \sum_{i=1}^{n} \sum_{j=1}^{n} f_{ij} d_{\varphi(i)\varphi(j)} + \sum_{i=1}^{n} b_{i\varphi(i)} \quad (1)$$

where S_n is the set of all permutations $\varphi : N \rightarrow N$. Each individual product $f_{ij} d\varphi(i)\varphi(j)$ is the cost of assigning facility to location $\varphi(i)$ and facility j to location $\varphi(j)$. In the context of facility location the matrices F and D are symmetric with zeros in the diagonal, and all the matrices are nonnegative. An instance of a QAP with input matrices F,D and B will be denoted by QAP (F,D,B), while we will denote an instance by QAP (F,D), if there is no linear term (i.e., $B= 0$). A more general version of the QAP was introduced by Lawler. In this version (2) we are given a four-dimensional array $C = (c_{ijkl})$ of coefficients instead of the two matrices F and D and the problem can be stated as

$$min_{\varphi \in S_n} \sum_{i=1}^{n} \sum_{j=1}^{n} c_{ij\varphi(i)\varphi(j)} + \sum_{i=1}^{n} b_{i\varphi(i)} \quad (2)$$

Clearly, a Koopmans-Beckmann problem QAP (F,D,B) can be formulated as a Lawler QAP by setting $c_{ijkl} := f_{ij} d_{kl}$ for all i,j,k,l with $i \neq j$ or $k \neq l$ and $c_{iikk} := f_{ii} d_{kk} + b_{ik}$, otherwise. Although extensive research has been done for more than three decades, the QAP, in contrast with its linear counterpart the linear assignment problem (LAP), remains one of the hardest optimization problems and no exact algorithm can solve problems of size n >20 in reasonable computational time. In fact, Sahni and Gonzalez have shown that the QAP is NP-hard and that even finding an approximate solution within some constant factor from the optimal solution cannot be done in polynomial time unless P=NP. These results hold even for the Koopmans-Beckmann QAP with coefficient matrices fulfilling the triangle inequality. So far only for a very special case of the Koopmans-Beckmann QAP, the dense linear arrangement problem a polynomial time approximation scheme has been found , due to Arora, Frieze, and Kaplan. In addition to facility layout problems, the QAP appears in applications such as backboard wiring, computer manufacturing, scheduling, process communications, turbine balancing, and many others.

One of the earlier applications goes back to Steinberg and concerns backboard wiring. Different devices such as controls and displays have to be placed on a panel, where they have to be connected to each other by wires. The problem is to find a positioning of the devices so as to minimize the total wire length. Let n be the number of devices to be placed and let d_{kl} denote the wire length from position k to position l. The flow matrix $F= (f_{ij})$ is given by

$$f_{ij} = \begin{cases} 1 \text{ if device } i \text{ is connected to device } j \\ 0 \text{ otherwise.} \end{cases}$$

Then the solution to the corresponding QAP will minimize the total wire length.

Another application in the context of location theory is a campus planning problem due to Dickey and Hopkins. The problem consists of planning the sites of n buildings in a campus, where d_{kl} is the distance from site k to site l, and f_{ij} is the traffic intensity between building i and building j. The objective is to minimize the total walking distance between the buildings.

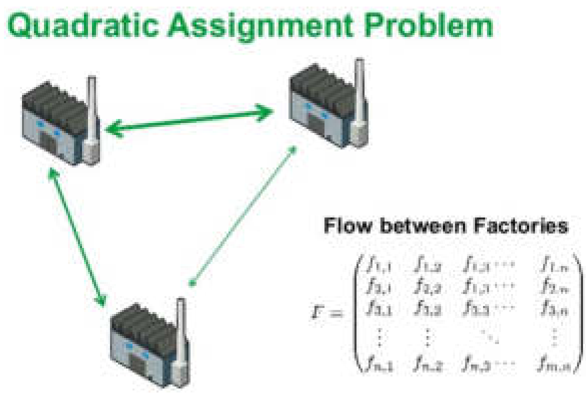

Figure 2 Scheme of the quadratic assignment problem [2]

In the field of ergonomics Burkard and Offermann showed that QAPs can be applied to typewriter keyboard design. The problem is to arrange the keys in a keyboard such as to minimize the time needed to write some text. Let the set of integers $N = \{1, 2, ... n\}$ denote the set of symbols to be arranged. Then f_{ij} denotes the frequency of the appearance of the pair of symbols i and j. The entries of the distance matrix $D = d_{kl}$ are the times needed to press the key in position l after pressing the key in position k for all the keys to be assigned. Then a permutation $\varphi \in S_n$ describes an assignment of symbols to keys. An optimal solution $\varphi *$ for the QAP minimizes the average time for writing a text.

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A similar application related to ergonomic design, is the development of control boards in order to minimize eye fatigue by McCormick. There are also numerous other applications of the QAP in different fields e.g. hospital lay-out (Elshafei), ranking of archeological data (Krarup and Pruzan), ranking of a team in a relay race (Heffley), scheduling parallel production lines (Geoffrion and Graves), and analyzing chemical reactions for organic compounds (Ugi, Bauer, Friedrich, Gasteiger, Jochum, and Schubert) [1].

2 Transportation problems

The transportation problem is concerned with finding the minimum cost of transporting a single commodity from a given number of sources (e.g. factories) to a given number of destinations (e.g. warehouses). These types of problems can be solved by general network methods, but here we use a specific transportation algorithm.

The data of the model include:

1. The level of supply at each source and the amount of demand at each destination.

2. The unit transportation cost of the commodity from each source to each destination.

Since there is only one commodity, a destination can receive its demand from more than one source. The objective is to determine how much should be shipped from each source to each destination so as to minimize the transportation cost.

In the following picture (Figure 3) we can see a model with m sources and n destinations. The amount of supply available at source i is a_i and the demand required at destination j is b_j. X_{ij} represents the quantity of supply transported from source i to destination j and the cost associated with this movement is represented by c_{ij}.

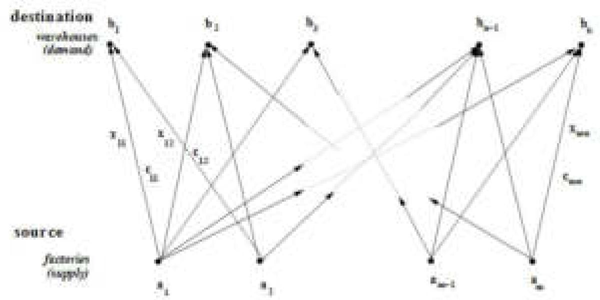

Figure 3 Scheme of the transportation problem [3]

According to this the total cost (3) of transporting the commodity from all the sources to all the destinations is

$$Total\ cost = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij} \qquad (3)$$

And the main goal is to minimise (4) this total costs, so the following problem must be solved

$$\min z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij} \qquad (4)$$

While

$$\sum_{j=1}^{n} x_{ij} \le a_i \ for\ i = 1, \dots, m$$
$$\sum_{j=1}^{m} x_{ij} \ge b_j \ for\ i = 1, \dots, n$$
$$x_{ij} \ge 0 \ for\ all\ i\ and\ j$$

When the total supply is equal to the total demand then the transportation model is said to be balanced. A transportation model in which the total supply and total demand are unequal is called unbalanced. It is always possible to balance an unbalanced transportation problem.

If the transportation model is unbalanced we introduce a dummy source (fictitious factory/warehouse) which helps us to balance the capacities or the demands in the transportation model. Since the source doesn´t exist, no shipping from the source will occur, so the unit transportation cost can be set to zero.

2.1 *The North-West Corner Method*

Consider the problem represented by the following transportation table (Table 1). The number in the bottom right of cell (*i; j*) is c_{ij}, the cost of transporting 1 unit from source *i* to destination *j*. Values of *xij*, the quantity actually transported from source *i* to destination *j*, will be entered in the top left of each cell. Note that there are 3 factories and 4 warehouses and so *m= 3, n= 4* [4].

Table 1 Transportation table [3]

	W_1	W_2	W_3	W_4	Supply
F_1	10	0	20	11	20
F_2	12	7	9	20	25
F_3	0	14	16	18	15
Demand	10	15	15	20	

The north-west corner method generates an initial allocation according to the following procedure:

1. Allocate the maximum amount allowable by the supply and demand constraints to the variable x_{11} (i.e. the cell in the top left corner of the transportation tableau).
2. If a column (or row) is satisfied, cross it out. The remaining decision variables in that column (or row) are non-basic and are set equal to zero. If a row and column are satisfied simultaneously, cross only one out (it does not matter which).
3. Adjust supply and demand for the non-crossed out rows and columns.

4. Allocate the maximum feasible amount to the first available non-crossed out element in the next column (or row).
5. When exactly one row or column is left, all the remaining variables are basic and are assigned the only feasible allocation.

2.2 The Least-Cost Method

This method usually provides a better initial basic feasible solution than the North-West Corner method since it takes into account the cost variables in the problem:

1. Assign as much as possible to the cell with the smallest unit cost in the entire tableau. If there is a tie then choose arbitrarily.
2. Cross out the row or column which has satisfied supply or demand. If a row and column are both satisfied then cross out only one of them.
3. Adjust the supply and demand for those rows and columns which are not crossed out.
4. When exactly one row or column is left, all the remaining variables are basic and are assigned the only feasible allocation.

3 The Hungarian method

The assignment problem deals with assigning machines to tasks, workers to jobs, soccer players to positions, and so on. The goal is to determine the optimum assignment that, for example, minimizes the total cost or maximizes the team effectiveness. The assignment problem is a fundamental problem in the area of combinatorial optimization.

With one of the most effective methods for solving the assignment problems came Kuhn. Preparing of his algorithm was based on the work of the Hungarian mathematician Egerváry. Kuhn generalized Egerváry´s method, calling it " The Hungarian method" (in some literature is also referred to as "KUHN algorithm").

The Hungarian method does not respond to the degeneration of the solution that is the weak point of other algorithms and requires no initial solution obtained by another (approximate) method. If we continue to mention the initial solutions, it will be a specific case of baseline, which is part of the creation of the Hungarian algorithm itself.

The basic process of the solution (in case of the balanced transportation problem) can be described as follows:

First we create an initial solution, which does not suits to restriction of our transportation problem. From some sources are not transported all the material and not all consumer demands are satisfied. For this solution can be written these restrictive conditions (5), (6):

$$\sum_{j=1}^{n} x(i,j) \leq a \quad (i) \quad \text{for } i \in \{1,2, ..., m\} \qquad (5)$$

$$\sum_{i=1}^{m} x(i,j) \leq b \quad (j) \quad \text{for } j \in \{1,2, ..., n\} \qquad (6)$$

We improve the initial solution until in the previous relations don´t apply only conditions of equality. With that we fullfill the restrictive conditions. All material resources are assigned to all consumers and all consumer demands are satisfied. In this case, the algorithm ends and the result is optimal. The whole algorithm of The Hungarian method consists of four stages. A schematic illustration of a follow-up stages is shown in the following algorithm (Figure 4) [5].

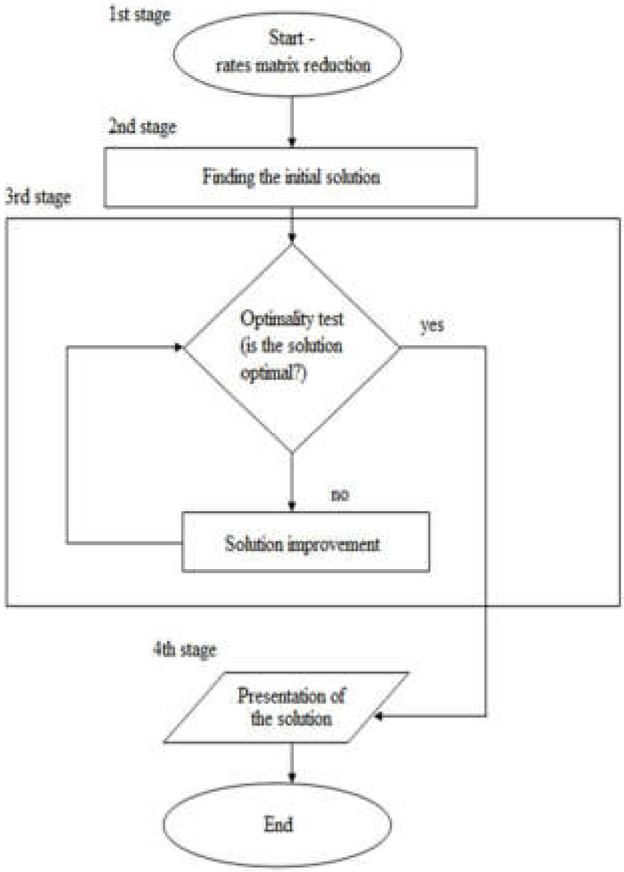

Figure 4 The Hungarian method algorithm

In the actual solution it means that the first two steps are executed once, while Steps 3 and 4 are repeated until an optimal assignment is found. The input of the algorithm is an *n* by *n* square matrix with only nonnegative elements.

Step 1: Subtract row minima

For each row, find the lowest element and subtract it from each element in that row.

Step 2: Subtract column minima

Similarly, for each column, find the lowest element and subtract it from each element in that column.

Step 3: Cover all zeros with a minimum number of lines

Cover all zeros in the resulting matrix using a minimum number of horizontal and vertical lines. If *n* lines are required, an optimal assignment exists among the zeros. The algorithm stops.

If less than *n* lines are required, continue with Step 4.

Step 4: Create additional zeros

Find the smallest element (call it *k*) that is not covered by a line in Step 3. Subtract *k* from all uncovered elements, and add *k* to all elements that are covered twice [6].

Conclusion

Decisions about the layout and allocation are very sensitive and delicate because they are made usually just once, when the corporation is building a new objects. Wrong allocation or layout of the productional and non-productional subjects, storage areas or distribution centres of the corporation can later cause huge problems.

As we can see there are plenty of ways how to solve these different problems of transportation, layout or allocation and it´s just our call which one we are going to use for solving these types of problems. It´s also important to know, that every single case has usually it´s own variables which are different from other cases. That means there can be different optimal method for every case.We have to choose the correct method according these variables and achieve as optimal result as we can.

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Review process

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FMEA (FAILURE MODE AND EFFECTS ANALYSIS) AND PROPOSAL OF RISK MINIMIZING IN STORAGE PROCESSES FOR AUTOMOTIVE CLIENT

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Keywords: failure mode and effect analysis, FMEA, storage processes, automotive industry, outsourcing
Abstract: There are several quality tools that support achievement of goals and ensure primary basis for promoting quality in enterprises. FMEA is a quantitative inductive method, which was created for the recognizing and evaluating of products and processes failures, with considering that risks are categorized according selected criterias. Identifying and removing risks prevents the formation of dangerous consequences. It is possible to define any eventual system failure by the method reviewing. The documentation process is a key activity in addressing of structural changes FMEA. In automotive industry is requested to observe quality, production and marketing standards on high levels which contain more specialized norms and certificated programs as well. The articel is focused on risks minimizing in goods and orders receipt and goods outgoing.

1 Introduction

It has been long known that logistics is not just a matter of one class and one process. Logistics covers all industries and processes in which come to organization, secure and management of material, information and financial flow. The largest rate of Slovak industry is in automotive, up to 44%, and at the same time is Slovak republic leader in number of produced automobiles per 1000 inhabitants, up to 184pcs [1]. Acceleration in automotive industry does not accelerating legislative only, but social changes and challenges in automotive supply chain as well. Necessity of reviewing tool FMEA, and proof of detection risks in company members of the automotive supply chain is implemented in programs of customer audits, automotive standards and controlling processes.

Maintenance terminology according to EN 13306 defines the fault as the termination of the ability of required function in object performation. Elimination of defects and repair times shortening is a challenge for every business in every time. By minimizing of defects is necessary to take into account the severity and consequences of the defect management system. Failure management solutions should not allow the liquidating.

The process as defined by portal Business Dictionary is a sequence of interdependent and linked procedures which at every stage consume one or more resources (employee, time, energy, machine, money) to convert inputs (data, material, parts, etc.) into outputs. These outputs then serve as inputs for next stage until a known goal or end result is reached.

Storage is a process which main task is to placement material goods, products, raw materials on time and at the same time prepare the transport units according to customer requirements, production and transport possibilities in order to ensure continuity of material flows, to satisfy the demands of the market and the effectiviness of follow-up activities, such as loading, unloading, transport, distribution and preparation of the accompanying documents. Other reasons include storage buffer feature that compensates the various material flow and material requirements in quantitative and timing terms. Storage also provides coverage to the fluctuating needs of sales and supply markets, fulfills the function of speculation arising from the expected growth of prices on the market and make a wide range according to the needs of individual plants, so-called a completion function. The qualitative changes in the product range storage (drying, aging, fermentation, etc.) performs a processing function but there would be a so-called. productive stores.

2 FMEA

FMEA history dates to seventies of the 20th century, when the National Aeronautics and Space Administration (NASA) has brought investigative solution to determine the reliability of the system FMEA for the project Apollo. In August 1966 was created a document with 4 chapters, which defines detailed description of the mission and methods of the FMEA toll for this project. In addition, are included the critical groups of possible errors and their consequences. The most serious consequece of the error in the above-mentioned document is considered the death of the spacecraft crew. The model of FMEA is with small modifications used until today.

In the 80s, the procedure started to be implemented FMEA in the automotive and later the nuclear industry. In Europe began with the implementation Ford as first, then Volkswagen. FMEA is currently ranked the most common used methods for assessment and evaluation of the potential risks. Tool FMEA can be applied to the process or the system, but some authors divide it also to software FMEA or design FMEA.

Process FMEA analyzes errors during manufacturing, installation, storage or other activities. In this case is by solving used the system approach. Here are analyzed errors, which are generated in the process, their mutual relations and errors entering and releasing the process. Errors and effects are ranked according to their risk and on the basis of the proposed actions to eliminate risks. Attention is focused on the suitability and safety of processes to ensure the quality and stability of the process.

System FMEA aims eliminates system errors by system designing. Analysis of system is mainly used in pre-production, run-in phases and with participants from all business units. Figure 1 shows the flow of information in the FMEA performing by Ford Handbook, which is available for its suppliers. The downward arrows represent the main stream (material, information, financial), and the upward arrows represent feedback for learned lessons. Double-sided arrow points to the interface between the FMEA and addressing the massive problem. FMEA and REDPEPR (Robustness Engineering Design and Product Enhancement Process) complement each other.

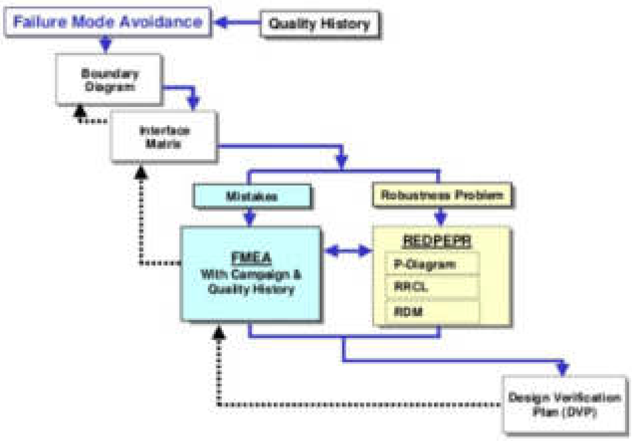

Figure 1 Information flow according Handbook Ford

Brainstorming is a key method by generating the FMEA ideas. This method promotes the creativity of the authors, allows the relaxed atmosphere and mutual inspiration in presenting proposals.

Ishikawa diagram, known as Fishbone diagram, is used to display the problems and possible causes. The main axis is a problem and the branches of the main axis are the effects that are caused of the problem. At the beginning of diagramming it is necessary that the investigators define the main possible causes of the problem (material, equipment, methods, people, nature etc.)

Pareto diagram (Figure 2) is by FMEA next significant analytical tool, that is able to identify the most important issues of the criteria. Here is applied the Pareto Principle 80/20 and to the most important issues shoud be given the most attention.

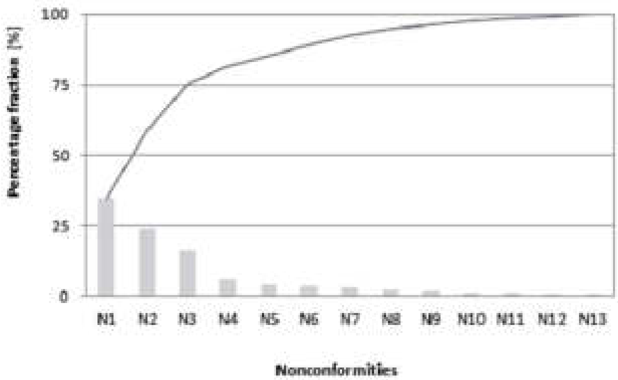

Figure 2 Pareto diagram

To use the full potencial of this method and achievig the main goal, it is necessary to identify potencial risks even before the process fails. Time, capacity and finance used in the correct reviewing of the FMEA by changing the product/ process are inversely proportional to the time, capacity and finance consumed by dealing already produced undesirable consequences.

As was mentioned above, FMEA is quantitative method as the numerical evaluation of the risk level (1) is described as the product of probability (frequency) of the negative effects occurance and consequence of the fault, i.e.:

$$R = P \ x \ D \qquad (1)$$

where R is a measure of risk, P is the probability of risks and D is the result of risk.

The risk influences of the system are mostly categorized according to the severity, safety features, environmental aspects and the duration of the idle period. An example of FMEA header is in Figure 3 and an example for ranking of severtiy criteria is in Table 1.

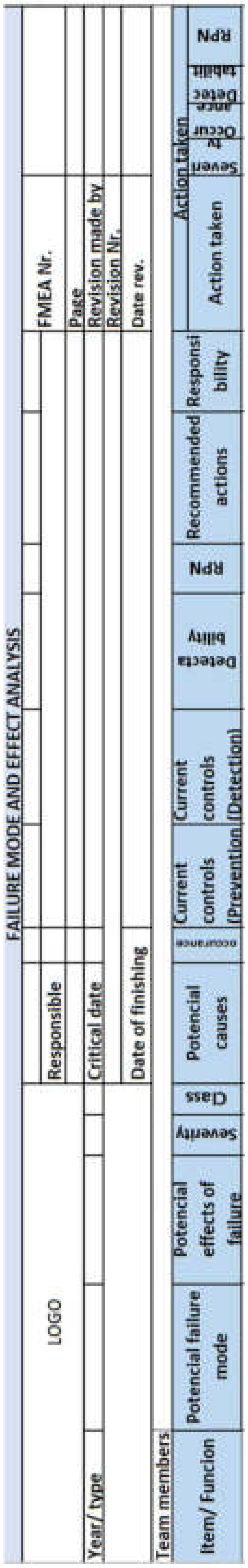

Figure 3 FMEA header

Table 1 Ranking of severity effect

Ranking	Effect	Criteria: Severity of Effect
1	None	No effect
2	Very Minor	Very minor effect on product or system performance.
3	Minor	Minor effect on product or system performance.
4	Low	Small effect on product performance. The product does not require repair.
5	Moderate	Moderate effect on product performance. The product requires repair.
6	Significant	Product performance is degraded. Comfort or convenience functions may not operate.
7	Major	Product performance is severely affected but functions. The system may not be operable.
8	Extreme	Product is inoperable with loss of primary function. The system is inoperable.
9	Serious	Failure involves hazardous outcomes and / or noncompliance with govt. regulations or standards.
10	Hazardous	Failure is hazardous, and occurs without warning. It suspends operation of the system an/or involves noncompliance with govt. regulations

Using of FMEA tool is supported by many quality standards which are worlwide valid as QS 9000, ISO TS 16949, or regional certification standards which are valid for specialized country areas, as VDA, AVSQ or EAQF. Figure 4 is describing the main focus of each mentioned norm.

Figure 4 Certification programms

3 Minimizing of failure in storage processes

In terms of storage is clear that stocks must be strictly controlled and careful monitored by physical inventories in warehouse and supported by additional processes in storage process, like appropriate storage methods, technical equipment, time management of loadings and unloadings, which are secured by appropriate information flow in standard documents forms. In the case, that stocks are not accurate, it may brings the following consequences like unwilling stockpilling, frequent ordering, when the actuall stocks are not visible for users, ineffective inventory systems, direct shopping, incorrect records, errors in input data, loss of documents, loads without proofs, discrepancies between the physical and system state, unrecorded decifit, incorrect placement, packaging, labeling, etc. Finally, all nonconformities cases the failures in customer satisfaction.

To avoid the most possible amounts of failures in the storage processes is requested to revaluate the actuall performance of processes. Preparing supportive actions for optimization of storage locations, warehouse zoning, processes for inventory performance, goods segmentation, container management, written solutions for most common system problems and motivation programs for staffs are elementary activities that support the applicable storage actions and processes.

Conclusions

From the indicators in warehouse logistics can be said, that the apllication of FMEA brings the optimizing of the parameters of productivity, efficiency and also advantages to the structural indicators. As reported by Carlson, consultant and instructor for FMEA methodology, FMEA provides effective solutions for eliminating the risk occurance by using the optimizing the storage space by 30%, then brings advantages in work load of warehouse equipment by 7% and increase the productivity of employees by 25%. This means in praxis, less demands for storage spaces, less warehouse equipment and decreases in human resources working on the processes, which are evaluated by tool FMEA.

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OPTIONS OF TRANSPORT FOR KOSICE'S SURROUNDING IN NONSTANDARD TIMES

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Keywords: public transport, nonstandard times, system of transport, planning

Abstract: The contribution deals with a design of effective way to ensure the traffic in the Kosice-surroundings district even in the nonstandard and special times. The current status is analysed by a method of system approach. The current situation in the public transport is analysed according to transport timetables; nonstandard times and time spans of transportation lines are defined. The contribution points to the options to solve and presents a design of division of transport space into three parts that would be secured by separate means of transport. Routes are not firmly defined but they will be created dynamically, according to the needs and number of passengers. Hierarchical structure of the solution of problem of the ensuring of above standard transportation for Kosice - surroundings district is created by the system access for the design itself and solution of the defined problem.

1 Introduction

Several companies provide transport in the Kosice - surroundings district, but there also exists time spans in their extensive service, when there is no connection available for transportation from the Kosice city in any village of the district Kosice-surroundings or vice versa. Individual residents of the district are aware of the inadequate transportation lines appearing on individual routes. This problem is global; the lack of transportation lines is not only on one route, but concerns all the villages of the district. Problem time intervals, at which traffic in a given area is not ensured or is ensured only at minimum, will be defined in terms of identification of empty times. These deficiencies give space for business plans. Analysis of the problem of insufficiently ensured transport in the selected area will be required for the utilization of this space. The acquired knowledge is used for the creation of design solutions that will be benefits not only for the population of the district Kosice-surroundings, but also for the company that will take the project. Under the project it is meant security of transport in the nonstandard time intervals in a given area with financial gain for a particular company.

2 Transport

Transportation is one of the oldest and basic human activities. In many fields it manifests its importance, eg. for the development of the state, economy, development of population and culture. It plays an important role in the economy and is part of material production. It provides the link between the production spheres and connects geographically separated areas.

Transport, that has personal, useful value for each person, provides certain services to the people. People appreciate the usefulness of provided services according to specific criteria e.g. speed, comfort, economy and according to the purpose, on which transport is used. Moving of persons and items is not the objective but only a mean, with the exceptions, and transport allows to the person to use and consume of a variety of material and spiritual values, which are the product of social, productive or non-productive activity, or that it is found in nature [1].

3 Analysis of the public transport in Kosice – surroundings district

Bus routes are more flexible, in contrast to the train tracks, therefore it is not necessary to fixate to the existing bus connections, but we may also think about potential new routes on the roads of the Kosice-surroundings district.

Figure 1 The structure of the road network in the Kosice – surroundings district

Figure 1 illustrates the structure of the road network in the Kosice-surroundings district. Blue points are for the better clarity - villages connected by just illustrative lines that represent real transportation links. The red point

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represents the centre of Kosice city. The red line shows the outer border of the Kosice-surroundings district.

3.1 *The time span of the public transport*

It is necessary to classified time endowment, i.e. real time in which it is necessary to ensure the transport, for needs of analysis and further processing of information. The main reason, why it is necessary to divide time endowment, is that the individual time slots are not homogeneous, they are distinguished by the different characteristics, which are caused by the external factors. The individual time slots may have different demands on ensuring of transport, on the basis of their characteristics.

The primary classification is division into weekends and working days. The secondary classification is division of one day into single sections according to the needs and frequentness of transportation lines as follows:

4:00 - 6:00 early morning lines
6:00 - 8:00 morning lines
8:00 - 12:00 a.m. lines
12:00 - 14:00 lunchtime lines (school)
14:00 - 18:00 afternoon lines (modified and schools)
18:00 - 20:00 evening lines
20:00 - 22:00 late evening lines
22:00 - 23:30 late evening lines (modified)
23:30 - 4:00 night lines

3.2 *Frequentness of bus connections*

Coverage of transportation links in the daylight hours in areas of Kosice-surroundings district is quite sufficient. Slovak Bus Transport (SAD) solves the situation within the possibilities. It provides transportation for villages to such an extent that the investment costs would be covered. Villages with bigger number of residents or villages situated on main routes to nearby cities have almost ideal situation with high frequented transportation links. Smaller fringe villages, which have a limited number of lines, are worse off, because companies do not invest in ensuring of higher frequented transport for a few passengers.

There are no bus connections for the time interval between 23:30 and 4:00. SAD does not provide night transport for any of villages of the Kosice-surroundings district. Even the train transport does not compensate for the lack of bus connections. Some of the villages do not have even late evening lines after the end of work shifts or some small villages have the problem with transport even at the earlier hours, where afternoon links operates as last.

Potential travellers for the nonstandard times

The nonstandard times represent an interval between 11 PM and 4 AM, when there are no regular traffic connections between Kosice and Kosice-surroundings district. Potential travellers are the inhabitants Kosice-surroundings district, who need to be transported from Kosice to their villages and vice versa. For the defined time interval, the potential travellers are people, who want to get home from the town. The assumption of the inhabitants of Kosice-Surroundings comes from the following facts:

- afternoon shifts in industrial companies,
- night business in restaurants, bars and clubs,
- evening culture events,
- evening sport events,
- individual reasons (emergency drug store visits, late-night visits, etc.).

These factors cause, that people, who are in the town during the late-hours create the need of late-night traffic links. For the inhabitants of Kosice, there exists a night public transport secured by the Transport Company of Kosice. The only type of transport for the inhabitants of Kosice-Surroundings is secured by the taxi services, which represent an irregular and very uneconomic means of transport according to the public transport. A large number of potential travellers would prefer the economic advantages of public transport against the irregular means and if there were traffic connections, that would suit their time schedules, especially within the nonstandard times.

Besides the late-night hours, there exist other types of nonstandard times (which are not applied for the daily intervals, but for some chosen seasons throughout the year) that create more potential travellers.

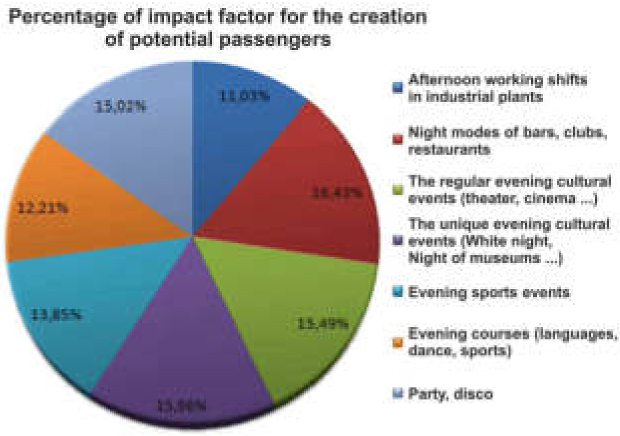

Figure 2 Effect of the factors on the creation of potential travellers

The graph (Figure 2) shows the percentage of effect of individual factors on the creation of potential travellers. From the graph applies, that the factors have rather the same effect of the creation of the potential travellers. Besides this detection, it is possible to point of one of the factors and set a significant conclusion. All of the factors besides special evening events occur regularly, therefore the traffic connections for special evening events will be treated as second-grade problems. The primary problem will be to secure the transport within the regular uncovered time intervals.

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4 Transport suggestion – section model

The main principle of the section model consists of the division of Kosice-surroundings district into smaller areas, for which the transport will be provided individually. These areas will be coupled with the means of transport of the needed capacity according to the potential of the individual areas. The times will also be fixed in order to fix the customer to a set location. In this case, there is no need to plan and manage the routes, because those will be reduced for the individual areas.

To divide the bigger units into smaller areas, there are several methods: Clarke-Wright method, closest neighbour method, method of distribution potentials, shot-beam method. For this particular case, it is necessary to choose the method that can be applied besides the giant number of villages within the area, which also represents a lot of input information for some of the methods.

The division of the Kosice-surroundings district, which consist of 112 villages and 2 towns, will be accomplished by the simplified method of distribution potentials, which is simplified for a larger number of elements [2]. The simplification of the method is based on the visual solution. Other places are not assigned to the place with the biggest potential according to the values of the attainability time – *CaDos* (time of radius - *CaDos*), but according to the visual assignment, with the help of a map. The distribution potential of the villages in the Kosice-surroundings district is set according to 2 criteria; number of inhabitants and the distance from Kosice. The distribution potential *DP* (1) is calculated flowingly:

$$DP = NI \times 1/dis \qquad (1)$$

NI – Number of Inhabitants
dis – distance from Kosice

The inverse value of the distance is used because of the character of the distance, the bigger it is, and the worse is the distribution potential. The table 1 shows 10 places with the worst distribution potential.

Table 1 10 villages of Kosice – surroundings district with the biggest distribution potential

VILLAGE	Number of inhabitants	Distance from KE [km]	potential
Valaliky	4020	11	365
Moldava nad Bodvou	10142	30,7	330
Čaňa	5195	17,5	297
Družstevná pri Hornáde	2428	11,7	208
Sady nad Torysou	1785	8,7	205
Rozhanovce	2226	11,5	194
Veľká Ida	3218	18,9	170
Kecerovce	2989	21,9	136
Kosické Oľšany	1222	9,5	129
Geča	1556	12,4	125

The villages with the biggest distribution potential are assigned with other villages visually. The criterion was the road between the two places that should be the shortest. The goal of the visual assignment was to divide the area into smaller sections, which would have the smallest average distance from Kosice and also to create sections that would have the biggest number of possible customers. The visual assignment divided the area into three sections (Figure 3).

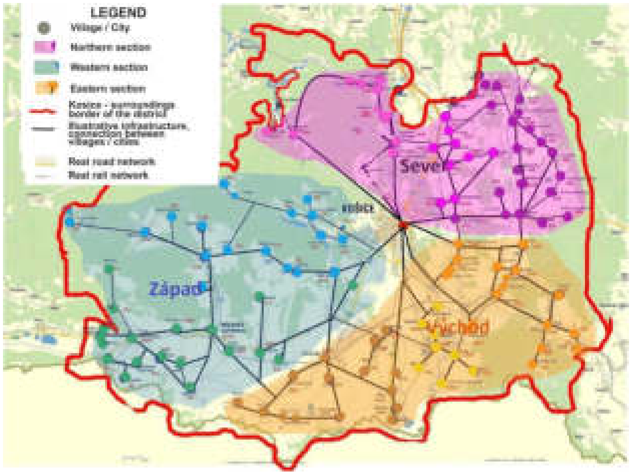

Figure 3 Sections defined by the visual assignment according to the method of distribution potentials

4.1 *Definition of the routes for the nonstandard times*

The individual sections consist of the villages with the total of 115 203 inhabitants and the average distance from Kosice is 22,8 km. The table 2 represents the basic data about the defined sections; East, West and North. Each section contains villages, which have one utility vehicle. The driver sells the ticket for individual destinations, while the destinations are automatically uploaded into the system and saved into the GPS, which sets the most appropriate route to the particular section. But, such a route will be a lot longer and will take much more time than the regular daily links, because the vehicle will turn to the villages that are not on the main route. The mileage will be individual for each route, depending on the demand.

Table 2 Characteristics of the defined sections

Sections	Number of Inhabitants	Average distance [km]	Average dist. potential	Number of potential customers	MAX km from Kosice	Number of villages within the section
West	42 158	29,4	45,3	54,2	46,8	36
East	45 397	20	67	58,3	32,6	37
North	27 648	19	48,3	35,5	29,7	41

The section model requires three large-capacity vehicles, one for each route. The bus Arway 12,8m is suitable for the sections East and West with the number of seats being 56. For the section North, the most suitable vehicle is Mercedes Picardo SLM with the capacity of 29 seats and 7 places for standing + the driver. The figure 4 shows the vehicles for the suggested section model.

Figure 4 Vehicles for the suggested section model: Arway 12,8m [3], Mercedes Picardo SLM [4]

Conclusions

The analytical part defined the times, within which the public transport is not provided. Then, it was found out, that there exists a significant interest of the public for extra transport links within the area of (Kosice-surroundings). The aim was not only to create a solution for the nonstandard times, but also to create the suggestion, that would be economically appropriate for the relevant realizing company. The suggestions contain the characteristic principles themselves, together with the suggested routes, pre-set times of transports and the possible car park. According to the unstable input parameter of the project realization, it is possible to use the interactive budget calculator that allows to us adjust the suggestions to the requirements of the company and actual market. The section model is considered to be a better variant for the solution of the problem and its practical application.

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