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APPLICATION OF EXPERT SYSTEM FOR DETERMINATION OF THE MOST BENEFICIAL SUPPLIERS IN SINGLE PRODUCTION

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Preliminary notes

Today's business life tempo is faster than ever, so the management of production systems has to make the proper decisions as soon as possible. Relevance of time by and reliable decisions cannot supervene from inadequate models of production management based on unreliable and unfulfilled data. Experiences from single production often show lateness, because of complex production conditions that are caused by numbers of factors, which lead to significant deviations in due dates and engagement of unplanned extra work with increased production costs. The paper aimed to show the application of expert system for determination of the most beneficial suppliers in the single and the small scale production. The proposed model which is based on expert system takes into consideration different attribute types (e.g. price, due date, discount etc.) and their values which increase the model reliability and complexity. Through the applying of expert system for determination of the most beneficial suppliers the contribution is made especially to the purchase and operational preparation departments in the single production enterprises.

Keywords: *expert system, purchase possibility, single production*

Primjena ekspertnih sustava kod određivanja najpovoljnijeg dobavljača u pojedinačnoj proizvodnji

Prethodno priopćenje

U današnje vrijeme kada je tempo života u poslovnom svijetu brži nego ikad, od rukovodstva proizvodnih sustava traži se da u što kraćem roku donese što pouzdanije odluke. Važnost donošenja pravovremenih i pravovaljanih odluka ne može proizići iz neadekvatnih modela upravljanja proizvodnjom koji se temelje na nepouzdanim i nepotpunim podacima. Iskustva iz pojedinačne proizvodnje pokazala su česta kašnjenja zbog složenih uvjeta proizvodnje na koju utječe veliki broj faktora koji dovode do značajnih odstupanja rokova isporuke, što dovodi do potrebe za neplanskim angažiranjem dodatnog rada s povećanim troškovima proizvodnje. U radu se daje mogućnost primjene ekspertnog sustava kod određivanja najpovoljnijeg dobavljača u pojedinačnoj proizvodnji. Predloženi model određivanja najpovoljnijeg dobavljača utemeljen je na ekspertnom sustavu koji uzima u obzir različite vrste atributa (npr. cijenu, rok isporuke, popust itd. i njihovih vrijednosti koje povećavaju pouzdanost i složenost modela. Primjenom ekspertnog sustava kod određivanja najpovoljnijeg dobavljača dan je prilog kako funkciji nabave tako i operativnoj pripremi u poduzećima u pojedinačne proizvodnje.

Ključne riječi: *ekspertni sustav, dobavljivost, pojedinačna proizvodnja*

1
Introduction
Uvod

Today's time life is faster than ever, so the management has to make reliable decisions as soon as possible. To get timely and right decisions is impossible from inadequate production management models that are based on unreliable and incomplete data. To survive on the market an enterprise has to have quick response according to quality, price and due dates. The mentioned criteria can be fulfilled only through enterprise restructure, using of new technologies, changing of organisation configuration and motivated employees in the decision making and realisation phases.

Experiences from single production often show lateness because of complex production conditions that are exposed to a huge number of factors which lead to significant deviations from due dates, enlargement of unplanned additional works and production costs [1].

So the main goal is to show the possibility of applying expert systems for determination of the most beneficial suppliers in the single and the small scale production. Implementation of expert systems in enterprises brings improvement to organisation structure, organisation of production preparation and production, decrease of preparation time, increase of productivity and minimisation of production costs.

Based on researching through the projects Development of ERP systems for digital factory (152-1521781-2235) and Expert systems of technology in the single production (0152014) was concluded that developed models for determination of the most beneficial suppliers are not fully applicable in single production. Some of models and methods based on expert systems and fuzzy sets are given in [2, 3, 4, 5, 6, 7, 8, 9], as well.

2
Production and operative department
Proizvodnja i operativna priprema

Price, due date, quality and customer needs set new production-technological demands before enterprises. Individualisation of customer demands in terms of different products requires new organisation structures and implementation of new technologies. Production system represents a set of technological and technical systems, and the humans work. Production system is a plant or an enterprise. It can be also defined through the system theory, where the system is divided into subsystems. Each element of a system, as well as the complete system can be limited by the system border and the input and output values.

The production represents a complex system where raw material will be transformed in final products according to required quality with the goal to satisfy customer needs [10].

According to the previously mentioned, production can be described [11] as follows:

- Production according to customer demands where product is not standardised. The product is completely designed and developed to meet customer needs.
- Production according to customer demands where product is standardised. The product can be modified toward customer needs.
- Assembly according to order where parts and assemblies will be anticipated and where customer needs will be fulfilled in final assembly.

- Production for warehouse. The product is well-known, customer needs will be satisfied from the warehouse. Product variants are limited.
- Implementation of new organisation concepts (simultaneous engineering, business process reengineering etc.)
- Implementation of new methods in production management, planning and scheduling
- Improvement of quality
- Flexibility.

To achieve production it is necessity to provide communication between system and environment through the material, human, energy and information flows. Through the proper managing, planning and scheduling system and according to chosen production type it is possible to reduce production flow, stocks and costs, to realise required quality and fulfil customer demands [10].

According to production type production can be divided into small scale, mass and process or continuous.

Small scale production is based on advanced specific quantity of products which is defined by structure tree or recipe. Production capacities are individual with applicability of production lines or flexible production systems. Technology procedures are defined for each product element and requirements are defined by structure tree [1].

Production capacities are calculated according to available working time of each capacity or in produced pieces of products. Production monitoring will be done according to the number of produced pieces in particular technological operations.

Small scale production can be divided into [11]:

- Single
- Batch
- Serial.

Single production is a type of production where product is defined through technical demands, drawings or patterns. Structure tree, technology, requirements and tools will be defined after the contract is signed. Calculation is done through the prediction of necessary materials and works.

Characteristics of single production are [1]:

- Structure tree is unknown and will be developed along with technical documentation
- Revisions of technical documentation are usual
- Technology is defined according to experience and prediction of time
- There is no balance between required and available capacities. Workers have to have knowledge how to work on different machines
- Changing necessity for cooperation
- Usually, there is no enough time for tools design, fabrication and probation.

After the market analysis, prediction of possible future production and products it is necessary to provide preparation activities for realisation of future production. Designing and technological processes, production planning and preparation make technical and operative production preparation.

Operative preparation has to provide planning and scheduling of all parts and assemblies in the way that due date can be fulfilled according to basic plan. Preparation and assurance of required resources and documentation per working places have to be done, as well [12].

Operative planning can be divided into four categories [1]:

- Scheduling and composition of operative production plans
- Launching of operation, providing of materials and tools
- Elimination of obstacles and detection of solutions for fulfilment of planning tasks according to dates and quantities
- Monitoring and evidence of finished tasks from production plan.

To do such kinds of jobs different methods are useful from hand-made till programme packages and management information systems which are able to do production planning and monitoring, to make different plan variants, to simulate production and to make automatic plan rebalance.

The launching plan covers providing of necessary materials (raw, auxiliary, consumable materials and finished goods), standard and non-standard tools, technological documentation according to requirements of production plan and adjustment of available resources, as well. Every unfulfilled task in the launching process directly prolongs production cycle, time and costs and finally required due dates [1].

Operative preparation task where production obstacles will be eliminated is called production dispatching [12].

Production dispatching can be functional or objective. In functional dispatching a dispatcher takes care of part of production process (workshop) for all operations from the plan that belongs to workshop. In objective dispatching a dispatcher takes care of certain number of products (work orders) from lunching till transportation in warehouse, customer or on the market. Dispatcher monitors performance of operations, provides resources for each operation and organises elimination of incurred obstacles.

Dispatching covers monitoring of parts and assemblies, problem solving and organisation of internal transport.

3
Artificial intelligence and expert systems
Umjetna inteligencija i ekspertni sustavi

Notation of artificial intelligence is given to any inanimate system which shows capability to settle down in new situations. Artificial intelligence makes intelligent machines which act in the same way as people do.

The term intelligence covers many cognitive skills, including the ability to solve problems, learn and understand languages. Artificial intelligence goal is to understand intelligence by building computer programs that exhibit intelligent behaviour. It is concerned with the concepts and methods of symbolic inference, or reasoning, by a computer, and how the knowledge used to make those inferences will be represented inside the machine.

Such kinds of systems are able to learn new concepts, conclude and make proper decisions and conclusions about the environment; they are able to understand natural languages or to explain new visual scenes.

The development of artificial intelligence [13, 14, 15, 16] starts with the ancient Greeks and Aristotle and continues till today.

Expert systems are computer programs which contain human knowledge about specific domain, capable to makes decision through the reasoning process from that knowledge, justify bringing decisions and keep that

knowledge independent from the program. Knowledge is covered by know-how, selection, planning, decision strategy, rules and regulations. Expert systems use specific knowledge for problem solving in tight domain on the expert level. Expert system is computer aided system based on expert knowledge and experience and is able to provide intelligent advice or bring the intelligent decision about specific problem. They model human intelligence, reasoning, judging and decision making which can be based on reliable and unreliable facts and information. Human beings are still too slow in decision making and they are not able to memorize sufficient amount of information necessary to bring proper decision.

Expert system has to contain the following [17]:

- Full detail knowledge from the problem domain
- Research techniques
- Support of heuristic analyse
- Capability of creating new knowledge based on existing
- Symbolic processing
- Capability of comment of conclusions.

Expert systems are adequate tools for problem solving when knowledge is not reliable and when it can be shown by equitation procedures and so on. Such kind of knowledge is based on experience where experts frequently use the tries and mistakes method in the problem solving because there is no unambiguous procedure off problem solving.

The goals of expert system are to generate plans automatically through the application of knowledge about plan from the expert system knowledge database and to bring decisions automatically. Today, expert systems are applicable in many areas such as science, industry, geology, military purposes, medicine etc.

4
Proposal model for determination of the most beneficial supplier
Prijedlog modela za određivanje najpovoljnijeg dobavljača

The suggested model has to show possibility of applying expert systems for determination of the most beneficial suppliers in single and small scale production according to defined attributes.

To make proper model it is necessary to find relevant attributes. According to performed analysis of manifestations in the process of determination of the most beneficial suppliers in single and small scale production the attributes have been chosen. Some of them are simple, and some others are complex and depend on some other values. The following attributes are taken into consideration: price, due date, payment delay, lateness in delivery, claims and substitute material. Solution of the model will be decision tree where expert system alone chose the basic attribute. Decision tree consists of nodes, leaves and null-leaves. Node represents events and each leaf possible solutions. Null-leaves is solution without solution apropos there is no solution for given conditions.

Attributes and their behaviour will be shown for mentioned model. The first attribute is price which depends on analysed values.

Attribute: Price = f (purchased quantity, carriage-paid, discount)

Based on possible combinations the quantitative or qualitative values can be set. Table 1 shows some of values (other values can be given by the combination of influence factors). The values' range is between 1 and 10 (10 for the best and 1 for the worst). Higher values mean advanced significance and privilege of that supplier according to some other. Higher values will be bound according to purchased quantity, franco and discount.

Table 1 *Attribute: Price*
Tablica 1. *Atribut: Cijena*

Price	Purchased quantity	Franko	Discount
10	High	Supplier	High
6	Medium	Customer	Small
1	Small	Customer	Small

Other attributes will be shown in Table 2.

- Due dates - each supplier is expected to have delivery time as short as possible
- Payment delay - longer payment delay enables multiple use of funds
- Lateness in delivery - desirable not exist but it exists it is desirable to be as short as possible
- Claims - are not welcome and indicate supplier's reliability
- Substitute material - it is a desirable attribute which enables production continuity in the case of insufficient basic material.

Table 2 *Other attributes*
Tablica 2. *Ostali atributi*

Attributes	Attribute values
Due dates	Short Very short Medium Long Very long
Payment delay	30 days 60 days 90 days 120 days
Lateness in delivery	Was Was not
Claims	Were Were not
Substitute material	Yes No

5
Example of determination of the most beneficial suppliers through applying of expert system
Primjer određivanje najpovoljnijeg dobavljača primjenom ekspertnog sustava

Expert system is structured as project [18, 19] (Figure 1). Each module consists of objects – attributes, procedures, user interface and reports, variables and optimisation tools, Firstly, attributes and theirs values have to be defined. If the attribute is complex (it consists of other attributes) the chaining process will be used (attribute Price is example).

Figure 2 shows a case table for determination of the most beneficial suppliers. There are more than 1100 rows and that is only a part of the possible combination of the mentioned problem. How huge is the problem best represented by the decision tree that can be shown at once in

full scale but only part by part. The short version of decision tree is shown in Figure 3.

Through the number of dialogue boxes (some of them are shown in Figures 4 and 5) values will be specified and according to these values the final mark of the supplier will be set.

Given output values are sorted in categories which as final result markes the most beneficial suppliers (Figure 6).

6 Conclusion
Zaključak

The article gives a short review of production emphasised by operative preparation. Operative preparation department has to make different decisions and one of them is the decision about the most beneficial supplier. Single production problems are analysed theoretically and in real enterprise life. As a result of the analysis the model that is based on expert system has been

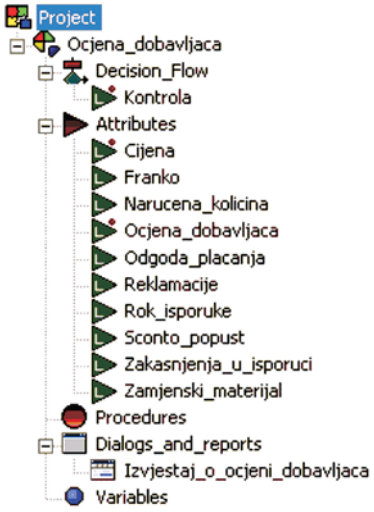

Figure 1 *Project review for the problem of the most beneficial suppliers' determination*
Slika 1. *Izgled projekta za problem određivanja najpovoljnijeg dobavljača*

	Cijena	Odgoda_placanja	Reklamacije	Rok_isporuke	Zakasnjenja_u_isporuci	Zamjenski_materijal	Ocjena_dobavlja
1	10	30	Bilo	Kratak	Bilo	Ima	33
2	9	30	Bilo	Kratak	Bilo	Ima	32
3	8	30	Bilo	Kratak	Bilo	Ima	31
4	7	30	Bilo	Kratak	Bilo	Ima	30
5	6	30	Bilo	Kratak	Bilo	Ima	29
6	5	30	Bilo	Kratak	Bilo	Ima	28
7	4	30	Bilo	Kratak	Bilo	Ima	27
8	3	30	Bilo	Kratak	Bilo	Ima	26
9	2	30	Bilo	Kratak	Bilo	Ima	25
10	1	30	Bilo	Kratak	Bilo	Ima	24
11	10	30	Bilo	Srednje kratak	Bilo	Ima	31
12	9	30	Bilo	Srednje kratak	Bilo	Ima	30
13	8	30	Bilo	Srednje kratak	Bilo	Ima	29
14	7	30	Bilo	Srednje kratak	Bilo	Ima	28
15	6	30	Bilo	Srednje kratak	Bilo	Ima	27
16	5	30	Bilo	Srednje kratak	Bilo	Ima	26
17	4	30	Bilo	Srednje kratak	Bilo	Ima	25
18	3	30	Bilo	Srednje kratak	Bilo	Ima	24
19	2	30	Bilo	Srednje kratak	Bilo	Ima	23
20	1	30	Bilo	Srednje kratak	Bilo	Ima	22
21	10	30	Bilo	Srednji	Bilo	Ima	29
22	9	30	Bilo	Srednji	Bilo	Ima	28
23	8	30	Bilo	Srednji	Bilo	Ima	27
24	7	30	Bilo	Srednji	Bilo	Ima	26
25	6	30	Bilo	Srednji	Bilo	Ima	25
26	5	30	Bilo	Srednji	Bilo	Ima	24
27	4	30	Bilo	Srednji	Bilo	Ima	23
28	3	30	Bilo	Srednji	Bilo	Ima	22
29	2	30	Bilo	Srednji	Bilo	Ima	21
30	1	30	Bilo	Srednji	Bilo	Ima	20
31	10	30	Bilo	Srednje dug	Bilo	Ima	27

Figure 2 *Part of case table for problem of the most beneficial suppliers' determination*
Slika 2. *Dio tablice slučajeva kod problema određivanja najpovoljnijeg dobavljača*

suggested. The artificial intelligence and expert systems are described shortly, as well.

For researching the problem a model is suggested that enables the attribute selection. Attributes and their values have been described. The decision tree has been created for the model and the expert system has been tested with the implemented model. The article gives examples of actions that have to be done with the expert system.

Realised results given by the implemented model can be divided in practical and theoretical way. Theoretical result is achieved through the making of model for determination of the most beneficial supplier in the single and the small scale production. Practical results are realised through a shorter period of time for decision making and the possible implementation of suggested model in Management Information System as a support to scheduling. Further improvement steps are to incorporate other attributes that can have influence in the process of determination of beneficial suppliers (which are not included in this article) and enlargement of existing attributes with new values and criteria through the operational research methods.

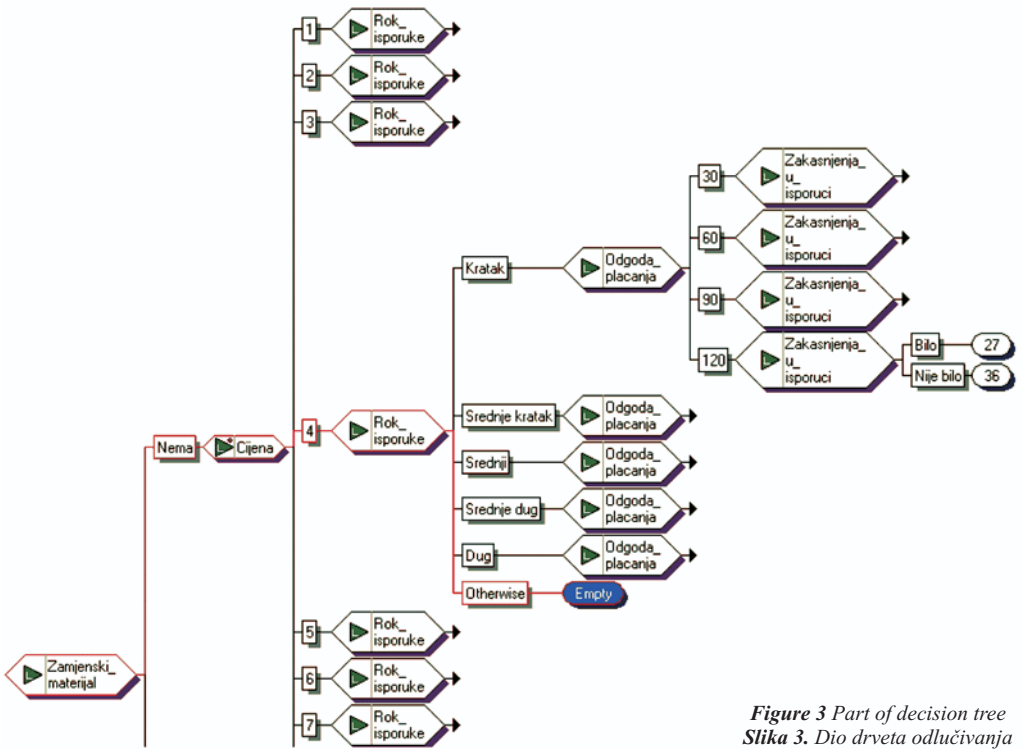

Figure 3 *Part of decision tree*
Slika 3. *Dio drveta odlučivanja*

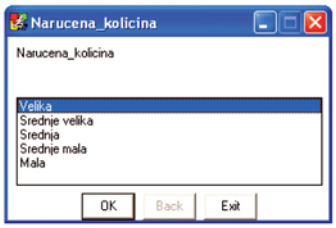

Figure 4 *Selection of value for attribute Purchased_quantity*
Slika 4. *Odabir vrijednosti atributa Narucena_kolicina*

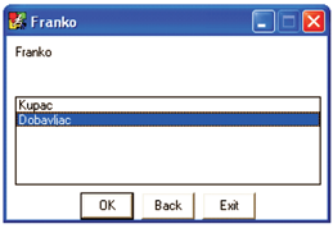

Figure 5 *Selection of value for attribute Franko*
Slika 5. *Odabir vrijednosti atributa Franko*

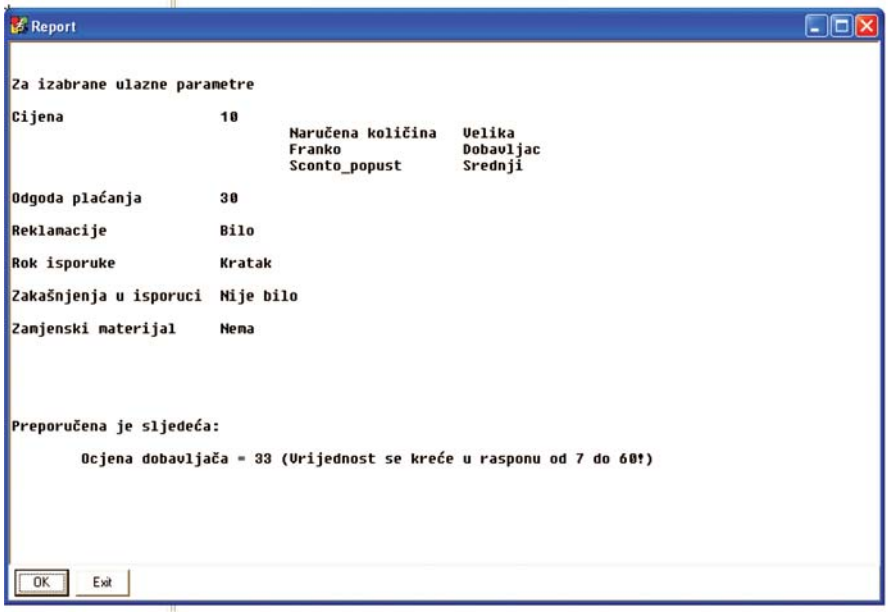

Figure 6 *Preview of given result for selected example*
Slika 6. *Prikaz dobivenog rezultata za navedeni primjer*

7
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