BUSINESS PROCESS MANAGEMENT IN GENETIC APPROACH CONTEXT

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Abstract: *Need of business process management becomes a necessary condition for improving company´s effectiveness. Nowadays, business processes are more complex and contain growing amount of parameters and variables. As a result, business process optimization is getting hardly solvable. Therefore, new approaches are being sought to prove the goal in short time and at low costs. The work shows the possibility of the utilization of business process management, mainly business process planning, with usage of genetic algorithm and genetic programming. The conclusions based on described solutions are then considered due to newly established needs in modern companies.*

Keywords: *Business Process Management, Process Planning, Scheduling, Genetic Algorithm, Genetic Programming.*

1. Introduction

Despite initial failure, there is a rapid development of discipline named business process management (BPM). Historically, there has been a perceived disconnection between organizational structure and processes. Organizations have had to focus on their production efficiency due to raising competitive pressures and globalization. Therefore, new approaches for management, controlling and planning were sought. BPM became a way out of this situation like a customer oriented approach with obvious added value identification. Basic ideas of BPM were introduced by Hammer and Champy [1], who emphasized key factor of information technology which forces companies to pursue improving their business processes.

The organizations look for new procedures of better organization, management, resource planning and controlling in all business processes because of permanent pressure on company efficiency. There are a lot of rapid changing variables in many running processes in today traditional process oriented company. Business process definition interprets process as a collection of related, structured activities or tasks using people and tools to transform set of inputs into collection of outputs for customers or other processes [2].

New methods and procedures are sought in consequence of complexity, quantity and cohesion of business processes. Genetic algorithms and genetic programming are particular class of evolutionary algorithms that use techniques inspired by evolutionary biology such as inheritance, mutation, selection, and crossover. Genetic algorithm and genetic programming are techniques used in computing to find optimal (or close to optimal) solution from entire range of possible solutions (the searched space). The techniques are categorized as global search heuristics [15]. Therefore, genetic algorithms and genetic programming are implemented in many different disciplines.

2. Business processes in genetic approach context – process planning

Process planning or production planning was one of the first revealed areas of BPM where a need of business process optimization occured. Manufacturing company realises desicions relating to its products before entering the market and for the whole time of its activities. If a company wants to be succesful, it should focus on such a product which can be well sold. Manufacturing of such a product is then business process consisting of exactly described activities that are done in a given order, time and production costs. Company has to know all parametrs and variables entering production process, then company may work up process planning or usage of the tool which enables process planning.

Genetic algorithms and genetic programming benefit from consideration of feasible solution regarding active constraint and variables that are represented e.g. workplace occupancy or resource allocation (human factor, input of products and processing machines). Simply said, chosen solution has to be actually feasible. Such a solution cannot be found in any method planning theory of constraints or MRP systems (MRP calculates with unlimited capability) or other methods which do not consider business processes [3]. Studied business process planning tool has to allow to create updated solution whenever business process variables and parameters are altered. Genetic principle application is able to consider feasible solution set from whole searched space in dynamic terms of business planning processes. Finally, genetic principle is a suitable choice for solving those complex problems [12].

3. Genetic algorithm and genetic programming as business process modelling optimization method

3.1 Optimal Process Product Management

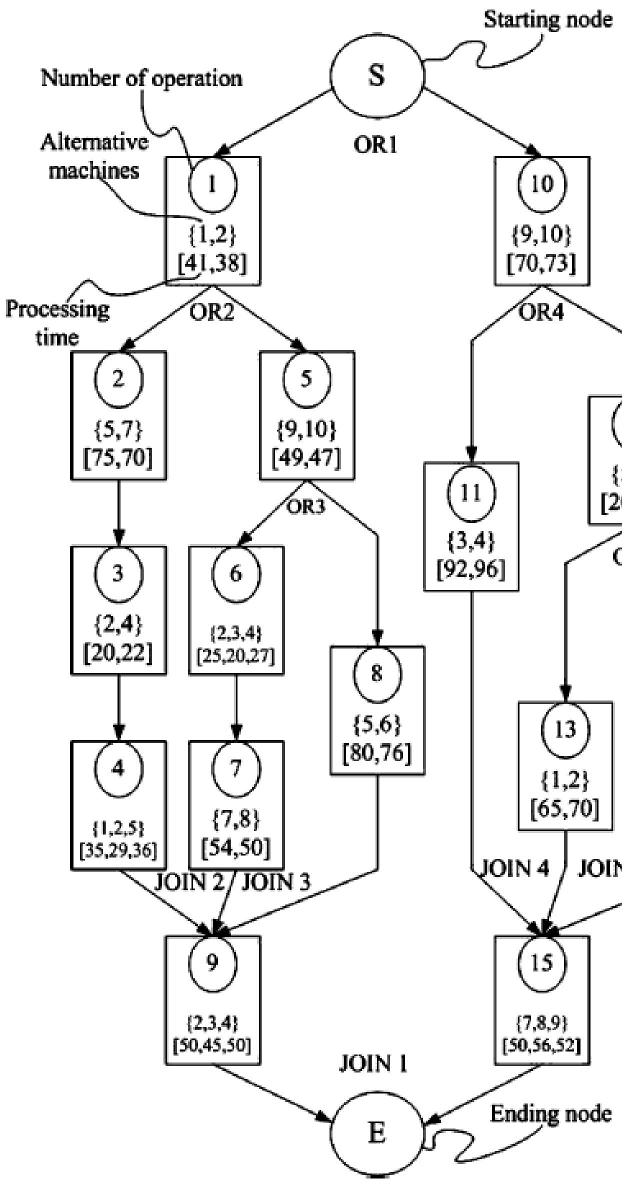
Takeuchi, Yazu and Sakuma [4] introduced process planning method TEMS-AGA (Total Environmental Management System using A Genetic Algorithm) for optimazition process product management. TEMS-AGA takes into account the possible effects on the environment together with other management concerns such as quality, lead-time, and costs. In TEMS-AGA, a problem is modelled by a AND-OR type tree-structure in its structural aspects and by a list of symbolic expressions in its quantitative aspects. TEMS-AGA evaluates the activity (policy, project) using a symbolic manipulation technique. Genetic algorithm is used to search a compromising better solution. Proposed model for optimization inputs satisfies initial conditions and becomes a useful tool for finding efficient solution.

3.2 Flexible Process Planning

In this section, flexible process planning (FPP) is explained in detail. Generally, there are many process plans achieving final product. Hutchinson and Pflughoeft define three classes of process plan flexibility [7]:

- *Sequence flexibility* occurs when an operation can have more than one predecessor or successor.
- *Process flexibility* provides alternative paths for the completion of the plan.
- *Machine tool flexibility* provides a choice of machine tool type to perform the operation rather than dictating a specific machine tool.

Li, Shao and Gao presented all three classes of process plan flexibility in their work [5] featuring technological output where it is necessary to realize three manufacturing features to accomplish the product. In context of three types of flexibility it is possible to execute one operation on alternative machines, with distinct processing time and costs. It is also possible to interchange the sequence of the required operations. Fig. 1 shows flexible process plan represented by network where paths are described by OR-links. There are three types of network nodes: starting, intermediate and ending. Starting and ending node determines start and finishing of the process. Operations interpreting intermediate nodes are described by alternative machines and time necessary to execute this operation. OR-links between nodes ensure flexibility of process; whatever path from starting to ending node can be implemented. Finally, JOIN node is a node with two or more inputs.



Zdroj: [5]

Fig. 1: Flexible process plan network

Furthermore, mathematic model of FPP is created with following assumptions:

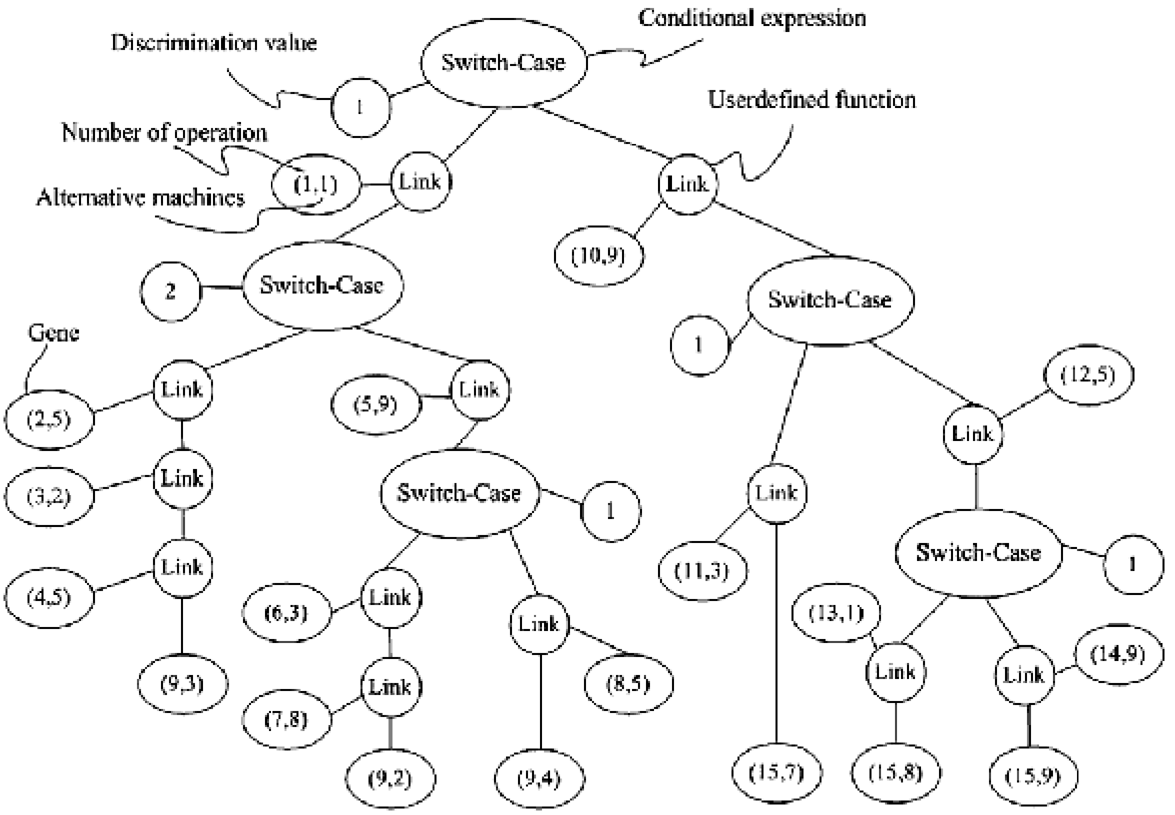
1. Each machine can handle only one job at a time.
2. All machines are available at time zero.
3. After a job is processed on a machine, it is immediately transported to the next machine on its process, and the transmission time among machines is constant.

4. The different operations of one job can not be processed simultaneously.

Genetic programming introduced by Koza [8] was chosen as optimization method in current work. Genetic programming evolves computer programs, traditionally represented in memory as a tree structure. Trees can be easily evaluated in a recursive manner. Each tree node has an operator function and each terminal node has an operand, making mathematical expressions easy to evolve and evaluate.

With knowledge of genetic programming approach, it is inevitable to transform network in Fig. 1 to tree structure. First, the intermediate JOIN nodes are splited into each branch. Because ending nodes are ignored completely, branch is determined by its final executed operation.

As shown in Fig. 2, each tree of each individual is generetad by the function set F={switch-case, link} and terminal set T={discrimination value, gene}. Switch-case is the conditional expression; and link, which connects the nodes together, is user-defined function, and its output is a list. The discrimination value encodes OR-connectors as the decimal integer. It is in concert with the switch-case function to decide which OR-link will be chosen. A gene is a structure and made up of two parts – the first is the operations of job and the other one is alternative machine. The encoding scheme of a tree is a list having two parts: part I is made up of genes, and part II is made up of discrimination values. The sequence of the program is from top to bottom. In the above encoding example, the operation sequence together with the correspodng machine sequence is (1,1)-(5,9)-(6,3)-(7,8)-(9,2).



Part I:(1,1)-(2,5)-(3,2)-(4,5)-(9,3)-(5,9)-(6,3)-(7,8)-(9,2)-(8,5)-(9,4)-(10,9)-(11,3)-(15,7)-(12,5)-(13,1)-(15,8)-(14,9)-(15,9)
Part II:(1)-(2)-(1)-(1)-(1)

Zdroj: [5]

Fig. 2: A tree of individual

Genetic programming exploits the same way as genetic algorithms evolutionary operations as crossover, mutation and selection. In the crossover operation, subtree exchange generates feasible descendants, individuals that satisfy precedence restrictions and avoid duplications. Mutation is implemented random chosing gene from the selected individual. Then, the second element of gene is mutated by altering the machine number to another one of alternative machines at random. Consequently, the other mutation is carried out to alter the OR-link path.

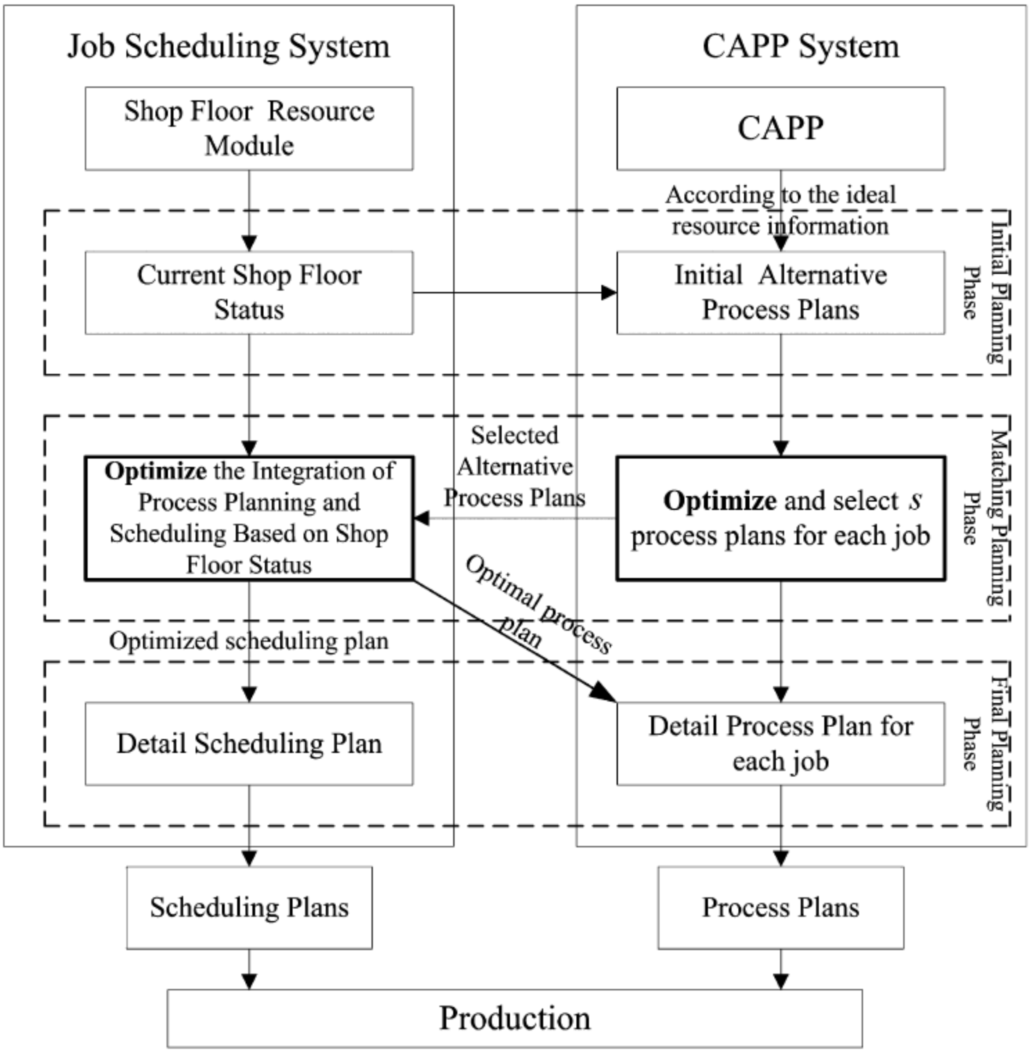
3.3 Integration of process planning and scheduling

Process planning and scheduling are two of the most important sub-systems in manufacturing systems. A process plan specifies which raw materials or components are needed to produce a product and what processes and operations are necessary to transform those raw materials into the final product. Process planning is the bridge of the product design and manufacturing. By contrast, scheduling plans receive process plans as their input and their task is to schedule the operations on the machines while satisfying the precedence relations given in the process plans. It is the link of the two production steps preparing processes and putting them into action [16]. Although there is a strong relationship between process planning and scheduling, the integration of them is still challenge in both research and applications.

Traditionally, process planning and scheduling were carried out sequentially, where scheduling was done separately after the process plan had been generated. This approach has become an obstacle to enhance the productivity and responsiveness of manufacturing systems. Even if, in the planning phase, process planners consider the current resources on the shop floor, the constraints considered in the process planning phase may have already changed greatly because of the time delay between planning phase and execution phase. Investigations have shown that 20-30 % of the total production plans in a given period have to be modified to adapt to the dynamic changing of production environment [9].

In manufacturing companies without the integration of process planning system (IPPS), a true computer integrated manufacturing system (CIMS), which strives to integrate the various phases of manufacturing in a single comprehensive system, may not be effectively realized [10]. In this section, integration model based on the engineering principle where the computer aided process planning (CAPP) [11] and scheduling systems are working simultaneously. The detailed working steps of the integration model are given as follows [6] as shown in Fig. 3:

1. CAPP system is working, based on the ideal shop floor resources. CAPP generates all the initial alternative process plans for each job.
2. Shop floor resource module provides the current shop floor status to the CAPP system. Consequently CAPP system optimizes all alternatives process plans for each job. Because of combinatorial-explosion CAPP ignores poor process plans without affecting the flexibility of the model very much.
3. The integration of process planning (using the selected process plans) and scheduling is optimized, based on the current shop floor status. For each job from the selected process plan is generated the optimal scheduling plan and selected one optimal process plan.
4. CAPP system is used to generate the detailed process plan for each job, and scheduling system is used to generate the detailed scheduling plan.



Zdroj: [6]

Fig. 3: Integration model of process planning and scheduling

As in section 3.2 above , process plans are represented by networks except of splitting and merging nodes which are separated into standalone OR and JOIN nodes as shown in Fig. 4. Premises and mathematical model are similar to work presented in section 3.2, where genetic programming is optimization method. Finally, genetic algorithm is used in integration model of process planning and scheduling.

Genetic algorithm representation of alternative process plans displayed in Fig. 4 is needed. Each chromosome in process planning population consists of two parts with different lenghts as shown in Fig. 5. The first part of chromosome is the process plan string, and is made up of gene. Gene is a structure containing two numbers. The first number is the operation. The second number represents alternative machine. The second part of chromosome defines OR string, and is made up of discrimination values. Discrimination value decides which OR-link is chosen. Fig. 5 shows an example of individual job 1 (see Fig. 4), where first gene is described by operation with number 1 and alternative machine with number 2. Totally chromosome includes 9 genes of part one and two discriminition values of part two.

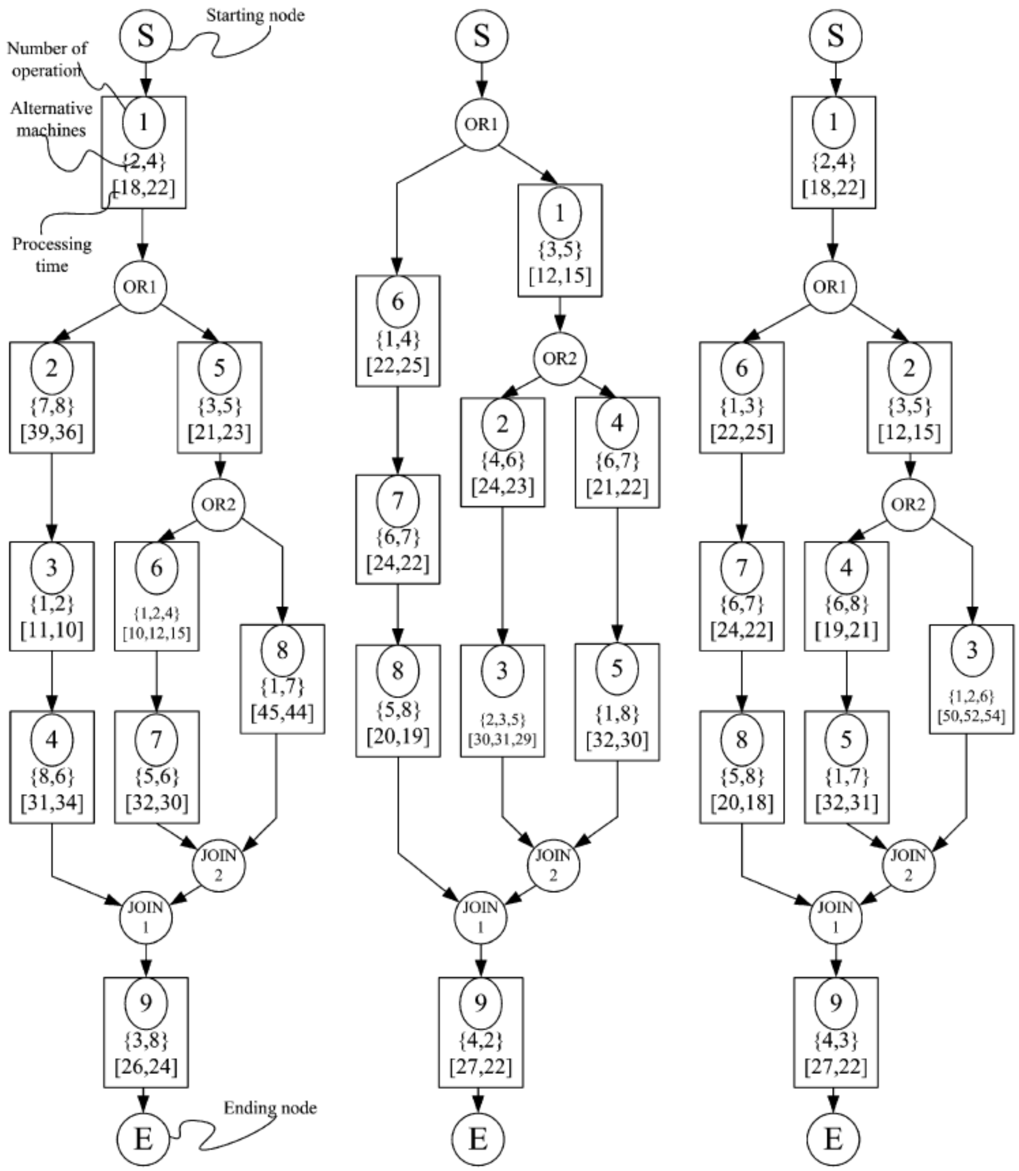


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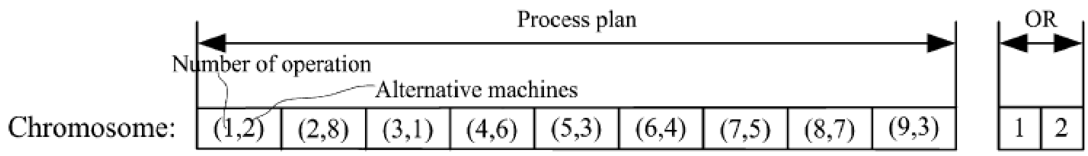
Fig. 4: Alternative process plans networks



Zdroj: [6]

Fig. 5: Chromosome of process plan

Tab. 1 shows encoding of alternative process for manufacturing jobs presented in Fig. 4. By step 2 of integration model, three alternative process plans are chosen for each job. As mentioned above, first number is number of operation and second one is number of alternative machine. Individual of scheduling plan contains two parts as well as individual of process plan. Length of first part (scheduling plan string) is equal to *n*q*, where *n* is count of jobs and *q* is count of the most operations among all the alternative process plans of *n* jobs. Length of second part (proces plan string) is then equal to *n*. Finally, number of gene in process plan string means ordinal number of alternative process plan.

Table 1: Alternative process plans for 3 jobs

Job	Alternative process plans
1	(1,2)-(5,3)-(8,7)-(9,8)
	(1,2)-(5,3)-(8,7)-(9,3)
	(1,4)-(5,3)-(8,7)-(9,8)
2	(1,3)-(2,6)-(3,2)-(9,2)
	(1,3)-(2,4)-(3,3)-(9,2)
	(1,3)-(4,6)-(5,1)-(9,2)
3	(1,2)-(2,3)-(3,2)-(9,3)
	(1,2)-(2,3)-(4,6)-(5,7)-(9,3)
	(1,2)-(2,3)-(3,1)-(9,3)

As shown in Tab. 1, each job has 3 alternative process plans ($n=3$). Because of maximal count of operations in all process plan is 5 (2nd process plan of 3rd job), then $q=5$. Consequently length of first part (scheduling plan string) of individual is equal to 15 ($n*q$) and length of second part (process plan string) is equal to count of jobs. Genes in second part determinate process plans which will be chosen. In example shown in Fig. 6 will be chosen the first for job 1, second for job 2 and second for job 3. The scheduling plan string is made up according to chosen process plans in process plan string and contains four 1s (because 1st process plan of job 1 has got 4 operations), four 2s (because 2nd process plan of job 2 has got also 4 operations) and five 3s (because 3rd process plan of job 3 has 5 operations). All numbers are arrayed randomly to generate a scheduling plan string. Remaining genes in scheduling plan string are arrayed by value 0.

Base on described representation of solved problem, there is a need of mathematical model definition including fitness function and genetic operators [6]. In case of individual of process plan, crossyover operation is executed by exchanging parts between two process plan strings. Mutation is realised by changing alternative machine numbers or swapping OR nodes. In case of individual of scheduling plan, new offspring is generated by mixture of parent genes. Mutation is then swapping two chosen genes or changing gene in process plan string and following change of scheduling plan string. All operations cannot break defined restrictions and have to allow such solutions which are not in jar with set of created alternative process plans.

4. Conclusion

In this work, process planning and scheduling optimization methods were introduced. Effective tools were made up in all metioned cases. The paper emphasises on characterization of solved problems, process representations and their following encoding suitable for processing and utilization in genetic algorithms and genetic programming. Networks [5], [6], AND/OR graphs [4] or Petri nets [13] are most frequently used types of process reprezentation. Therefore, choosing regular process representation type as well as finding initial statement of a problem, mathematical model determination or right usage of evolutinary methods are necessary presumtion to solve the chosen task [14].

Business process planning and scheduling approaches used in technological manufacturing processes were described in this work. In the future research of a new approach for planning and scheduling processes in companies with character of non-technical proceeding will be created. Most of manufacturing companies do not have strict defined technological procedures due to product is not created by machine manufacturing but human dependent specific working. Processes performed by people as well as machine manufacturing must have got a determined operational sequences which should be handled in supposed time and intended date. In nowadays manufacturing companies is one of the most frequent problems to finish project in time and costs agreed with customer. Therefore, new process planning and scheduling methods are sought. Suppose that tool for effective real time process planning and scheduling will be developed with using genetic approaches principles.

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