

OF PRODUCTION DEVELOPMENT OF DIGITAL PROTOTYPE PROJECT

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Customer clustering of an IT company is an important problem in marketing and detailed and realistic representation of the expected system. This process helps to evaluate the product before starting real production [1]. Digital computer prototyping tools allow you to visually see the experiments performed on the model of the control object and monitor the results.

CPN Tools is a software-instrumental system that can simulate the control object. Here, certain attributes can be assigned to various structural elements [2]. CPN Tools uses Petri net (PN) techniques, which are used for dynamic, connected and parallel modeling.

The PN is mathematically defined as a set $N = (P, T, F, H, \mu^0)$ [3]. Here $P = \{p_1, p_2, \dots, p_n\}$, $n > 0$ – a non-empty finite set of positions; $T = \{t_1, t_2, \dots, t_m\}$, $m > 0$ – a non-empty finite set of transitions; $F: P \times T \rightarrow \{0, 1, 2, \dots\}$ and $H: T \times P \rightarrow \{0, 1, 2, \dots\}$ – are the incidence functions of the sets of positions and transitions, respectively; $\mu_0: P \rightarrow \{0, 1, 2, \dots\}$ – is the initial marking of the network.

The graphical representation of the PN consists of circular vertices representing positions, rectangular vertices representing transitions, and edges connecting them.

The control object under consideration is a typical mechanical machining center consisting of an industrial robot (IR), a personal input keeper (IK), two identical devices (D1 and D2) performing the same operation on different identical workpieces, and a personal output keeper (OK).

The IR places the raw product from the individual input holder at the input of the 1st or 2nd free device and after the operation is completed, it places the part in the output holder. When both devices are free, a conflict situation arises between them. The conflict is resolved by selecting one of the devices based on the appropriate parameters and partially parallelizing and queuing it. When the operation is completed, the IR takes the part from the output of the device and places it in the output holder.

The states are described as the positions of the PN, and the possible events are described as the transitions of the PN. In the simulation model built with the help of the colored PN (Fig. 1), the states of the processing center module are described by the following positions:

P_1 – IR is free; P_2 – There are workpieces in IK; P_3 – IR has taken the workpiece; P_4 – D1 is free; P_5 – D2 is free; P_6 – the workpiece is in the working area of D1; P_7 – the workpiece is in the working area of D2; P_8 – D1 is machining the workpiece; P_9 – D2 is machining the workpiece; P_{10} – the workpiece has been machined in D1; P_{11} – the workpiece has been machined in D2; P_{12} – IR has taken the part; P_{13} – the part is in the OK.

The possible events in the machining center module are described by the following transitions:

t_1 – IR takes the workpiece from the IK; t_2 – IR places the workpiece in D1; t_3 – IR places the workpiece in D2; t_4 – machining of the workpiece begins in D1; t_5 – machining of the workpiece begins in D2; t_6 – machining of the workpiece ends in D1; t_7 – machining of the workpiece ends in D2; t_8 – IR takes the finished part from D1; t_9 – IR takes the finished part from D2; t_{10} – IR places the part in the OK.

The visualization of the model was carried out in the CPN Tools system (Fig. 1).

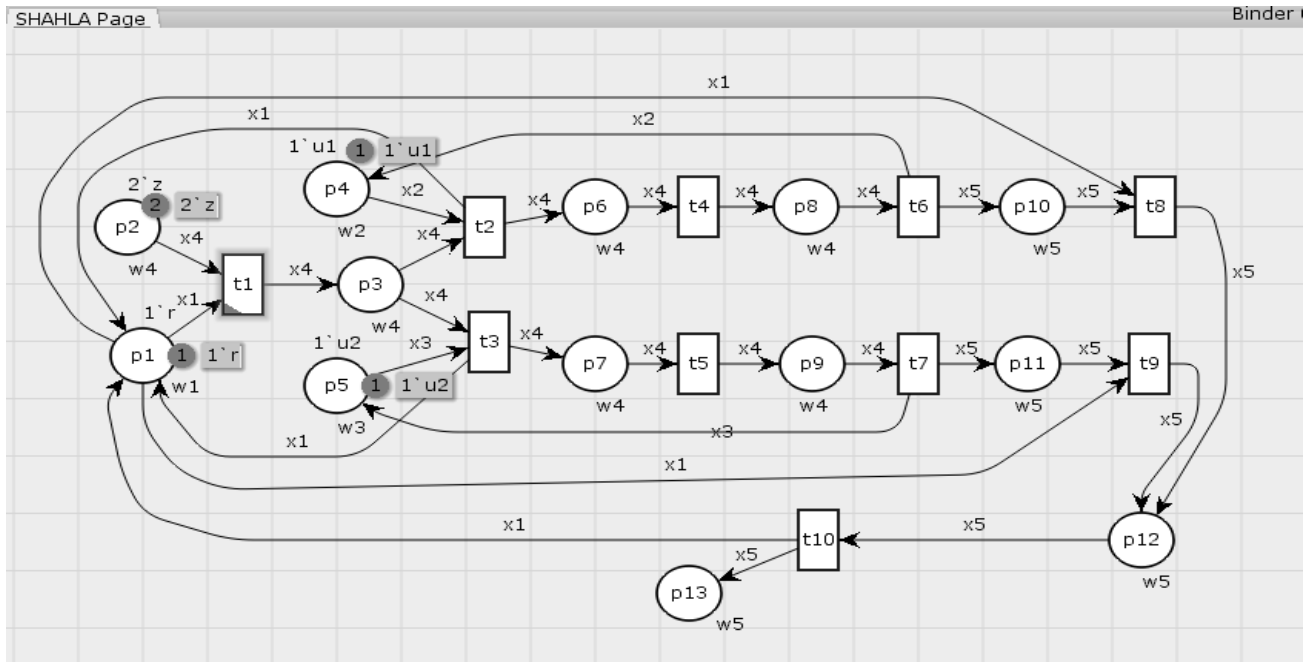


Fig. 1. Graph model of a machining center module in an manufacturing system.

During the simulation, an optimal trajectory was selected that eliminated random delays. As a result, it can be said that the created digital prototype allows you to save time and costs before operation by identifying errors at the initial stages of design.

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