PETRI NET BASED APPROACHES TO MANUFACTURING SYSTEMS

Mihaela Elisabeta CIORTEA, PhD Candidate
Department of Mathematics and Computer Science,
University "1 Decembrie 1918"
Alba Iulia, România

ABSTRACT

This paper describes the planning in manufacturing systems. The skeleton and the functionality of a Petri Net Toolbox, embedded in the Matlab environment, are briefly presented, as offering a collection of instruments devoted to simulation, analysis and synthesis of discrete event systems.

Timed Petri Nets are used to model operational and routing in production systems. A generalized multi productive machine modules is defined, adapter to system feature, repeated and connected to compose the TPN models of production systems with different levels of routing and operation.

The present paper approaches the stochastic medium considered to be fundamental in describing the changes and the aleatory variations during the desertion process of machines and blocking times in the processing activity. We intend to present a simulated model according to which we can establish the time variation and the outputs process in a simple production system.

Keywords: Petri Nets, discrete event, manufacturing systems.

Transport represents the logistic activity that assures the link among the different levels of a system covering the distance between supplies and distribution. The transport operation plays a very important role within a flexible technological system, especially in the optimization process. We can analyze the concept "transport" without having into account the operations required.

Talking into consideration the fact that the report between production and processing is a full type one, one can say that production includes processing.

The organization and the managing subsystem within the production system of goods, consists of:

- logistic subsystem
- processing subsystem
- transport subsystem
- stocking subsystem
- control subsystem.

This represents a component of the processing (manufacturing).

The logistic subsystem: within the system there is the action of materials and pieces influence. We must realize operations of positional and time transfer over the components of the manufacturing system. These operations will be done according to the coordination logistic necessary for the good functioning of the system, on the one side, and to the transfer operations logistics, on the other side. This system actions over the materials flux though the energy flux: in this way it modifies the flux parameters according to the information related to the positions and locations that have to be occupied, at different moments, by the materials flux components.

The manufacturing system has a special position, as the stress laps on the shape of a product and on the material configuration as result of a manufacturing process. Production consists of other activities such as transport, stocking and other services.

In this case, the transport subsystem has effect changing the position of the piece or of the material, before starting the manufacturing step, during manufacturing operations and after that.

The stocking subsystem, as a component of the manufacturing system, has the role of accumulating pieces in time between, and or after different processing operations. This function is necessary for preserving some active states in the working subsystem.

The control subsystem consists of a partial system which has the role of determining the values of the parameters that define the quality level; another important aspect is related to establishing the errors and transmitting information over toward a command system.

The command system is another component of the system which has as task the transformation and the distribution of the informational working inputs so that the general function of the manufacturing system we will mention a few types of manipulation system, such as:

- linear transfer for automatically lines in flux,
- conveyors,
- palette transfer on processing centers,
- industrial robots for materials manipulation.

The manipulation function of materials is used for stocking materials, the raw materials reception, tools, denies etc. the manipulation system have to be secure, efficient, have to take into account the established time and do not hope to lead to errors.

The characteristics of materials to be transported determine the type of equipment used for operation. The factors that influence the construction of the material operation system are:

- *Quantity of transported material,* large or small, continuous or discontinuous.
- *The rhythm imposed by the material flux* is determined by the quantity in time and is a very important factor in designing.
- *The scheme of material flux directions* refers to the distribution, management and dispatching of transported materials.
- *Transportation itineraries* of the material flux refer to the exact definition of each transportation/operation direction, which includes the transportation distance and the due time.

The calculus of transportation means necessary must consider the following aspects:

- production volume;
- transportation capacity of the chosen transportation means;
- duration and speed of a transporter between two locations and the number of necessary runs.

The average transportation distance in the enterprise can be calculated in two ways:

- as simple arithmetic mean of average transportation distances for every objective:

$$D_m = \frac{\sum_{i=1}^{N_{md}} d_{mi}}{N_{md}}, \text{ where } d_{mi},$$

are average transportation distances between sections or between actions and storehouses, N_{md}, is the number of average distances;

- as ponderated arithmetic mean, where the ponderation is represented by the transportation quantity or the average transportation distance:

$$D_m = \frac{\sum_{i=1}^{n} q_i \cdot d_i}{\sum_{i=1}^{n} q_i}, \text{ where } q_i,$$

is the quantity of material to be transported, d_i, is the average distance of material transportation.

The average transportation capacity for each group of transportation equipment is calculated through the formula:

$C_{mt} = N_u \cdot q \cdot N_{mc} \cdot D_m \cdot k_s \cdot N_z$, where N_u, is the number of transportation means, q, is the unitary transportation capacity, k_s, is the exchange coefficient, N_z, is the number of days for the period for which production capacity is calculated.

The average number of transportation cycles in a shift is calculated as such:

$$N_{mc} = \frac{480 \cdot K}{T_m} \text{ where } K,$$

is the coefficient for transportation means use, a number that increases to a higher integer, keeping into account certain dysfunctions that may accidentally occur during transportation.

The average time for a transportation cycle is calculated:

$T_m = t_i + t_d + t_c = t_i + t_d + \frac{2 \cdot D_m}{v_m}$, where $t_{i,d}$, is the loading, respectively the unloading time for the transportation means, t_c, is the time for a transportation run.

Having in view all the previous analyzed aspects, we intend to refer to the transport system concerning shoes making.

In using the untemporized and auxiliar times Petri model, the transport flux was split in sections, following that these sections to be analized succesivly.

Because of the system's complexity and the big volume of calculus needed for a possible analyze of the system as an entire unit.

The first trying of modelling a system as an entire unit lead to a system bloking during the simulation because of the big times of processing.

The medium ***PN Toolbox*** (fig.1, fig.2) stokes all the valide transactions in a MATLAB system, but the tranzactions are realized one at the time, the function that realize the the tranzaction follows to executed is determined by the priorities or the probabilities for the tranzactions in conflict thruogh the command ***Modeling / Conflicting Transitions*** *(fig.3, fig.4)*.

Using the instruments Scope and Diary it is not relevant for this type of Petri networks.

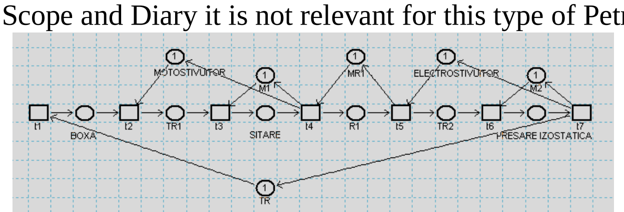
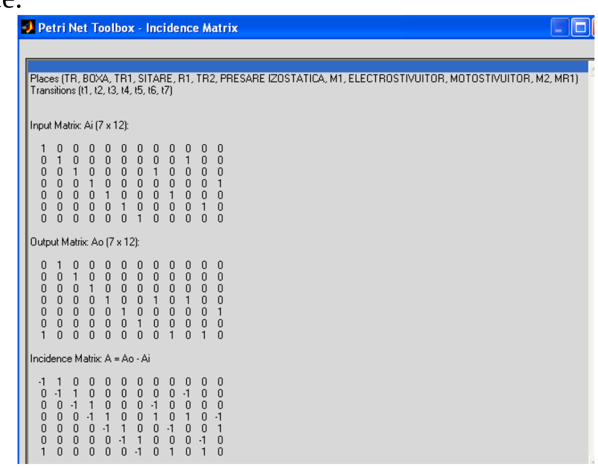


Fig. 1: Petri network for section I

1. Incidence matrice:



Petri Net Toolbox - Incidence Matrix

Places (TR, BOXA, TR1, SITARE, R1, TR2, PRESARE IZOSTATICA, M1, ELECTROSTIVUITOR, MOTOSTIVUITOR, M2, MR1)
Transitions (t1, t2, t3, t4, t5, t6, t7)

Input Matrix: Ai (7 x 12):

1	0	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	1	0	0
0	0	1	0	0	0	0	1	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0	1
0	0	0	0	1	0	0	0	1	0	0	0
0	0	0	0	0	1	0	0	0	0	1	0
0	0	0	0	0	0	1	0	0	0	0	0

Output Matrix: Ao (7 x 12):

0	1	0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	1	0	1	0	0
0	0	0	0	0	1	0	0	0	0	0	1
0	0	0	0	0	0	1	0	0	0	0	0
1	0	0	0	0	0	0	0	1	0	1	0

Incidence Matrix: A = Ao - Ai

-1	1	0	0	0	0	0	0	0	0	0	0
0	-1	1	0	0	0	0	0	0	-1	0	0
0	0	-1	1	0	0	0	-1	0	0	0	0
0	0	0	-1	1	0	0	1	0	1	0	-1
0	0	0	0	-1	1	0	0	-1	0	0	1
0	0	0	0	0	-1	1	0	0	0	-1	0
1	0	0	0	0	0	-1	0	1	0	1	0

Fig. 2: Incidence matrix

2. Text model:

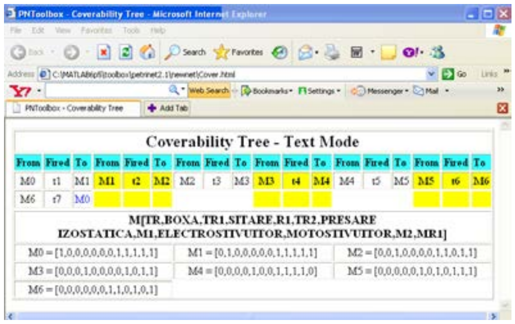


Fig. 3: Text model

3. Grafic model presented as a list:

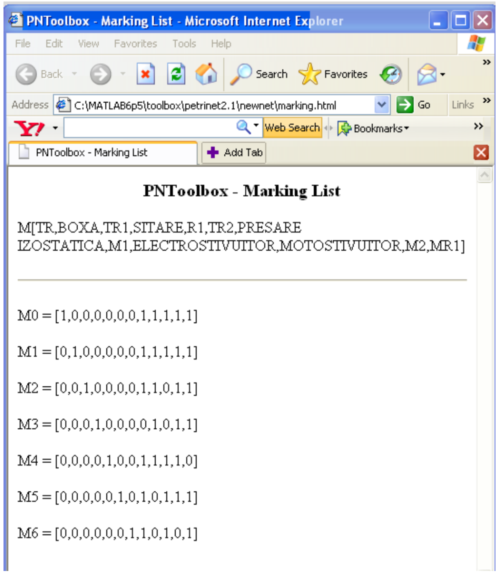


Fig. 4: List model

4. Invariances presentation:

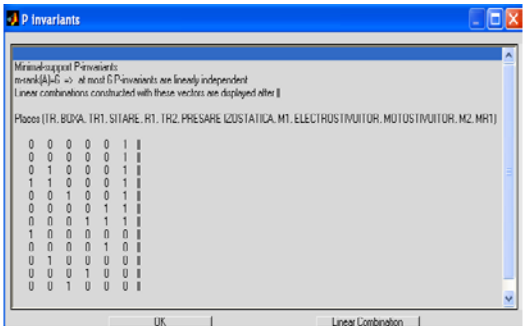


Fig. 5: Invariant of tied

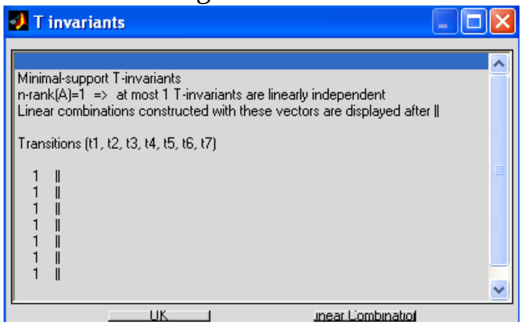


Fig. 6: Invariant of transition

The system to be analyzed has a very long processing time, which leads to system blockage. Therefore, we have opted for a division of the system into work sections.

When the untimed Petri model with auxiliary times is used, the transport flux is divided into sections, which are analyzed successively.

Because of the complex nature of the system and of the great volume of computations necessary, the system as a whole was not possible to analyze.

For place-timed Petri nets (P-timed PN), time durations can be assigned to the places; tokens are meant to spend that time as reserved in the corresponding places, immediately after their arrival (fig.5, fig.6). In simulation, all the transitions that can fire due to the current marking, fire at the same time. A transition can fire several times, in accordance with the marking of its input places and, from a theoretical point of view, an infinitesimal delay is considered to separate any two successive firings.

For stochastic PNs, only exponential type distributions can be used to assign the time durations of the transitions. For conflicting transitions, it is the shortest time duration that allows the choice of the transition to fire, without using priorities or probabilities. Multiple firing of the same transition is not permitted, even if the token content of its input places allows this; i.e. the transition fires once and after the allocated time elapses, it will fire again if the current marking is appropriate.

The Petri nets form a simple graph (fig.1) that presents discrete event systems where resource parallelism, synchronisation and sharing occur.

CONCLUSIONS

Applying product manufacturing directions and transport durations obtained through local measurements, we obtain graphical representations that highlight the average time durations of transport activities and the evolution of the average manufacturing duration depending on the transport activity durations using finite product batches as parameters.

- Stochastic Petri nets use as parameters the average value of exponential distribution assigned to the position that models transport availability. We obtain graphic representations regarding the evolution of average manufacturing time durations, the evolution of the average equipment use duration, the graphical representation of the average transport duration for each separate transporter and graphical representation of the average number of transporters in the storehouse.

As the network doesn't fit to the initial marker we can't put in practice any of the operations mentioned above. A blocking operation will appear at the second working machine. The solution required is of reducing the sewing time and the autting time also. Or, these operations should be realized on more machines with additional devices so that the objects could enter again in the manufacturing process.

The simulation of the proposed manufacturing system using timed Petri nets provides the possibility to view the manufacturing process in time.

Improvement solutions aim at aspects connected to changes in transportation means and to re-considering workstations.

Next, we present the differences that appear in the case of using the proposed model as compared to the existing one. The statistical model is shown as a table. The differences are connected to the times used for the vertices in the case of simulation and to the length of line.

The first model is applied to section 1, P-timed PN, running for 2519160 seconds for the present model and for 2506935 seconds for the proposed model, with a number of 1300 events. Further on, the fields that change their values are shown. For this section, the actual time duration for transport is of 5 min, and the transport time duration obtained after the new location is placed is of 3,5 min.

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