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DEVELOPED PETRI NETWORK APPLIED TO THE FLEXIBLE TECHNOLOGICAL SYSTEM MODELLING

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ABSTRACT

Petri Network, as a graphical tool offers a unified method for discrete events system designing from the hierarchy description so far to the real solution to be carried out. The Developed Petri Networks offers a great number of the advantages in the manufacturing centres by the multiple tasks, which are solved. An example of the application of the developed Petri Networks to a flexible technological system is presented.

1. GENERAL

By comparing with another presented method in the literature, the developed Petri Network from this paper has the following advantages in the modelling of the manufacturing system:

- The easiest modelling of the SED and SFP characteristics: concurrency, asinchronism, conflict, mutual exclusion, procedure relations, no determinism and system lock;
- A very good visualising of the system interdependency; concentration of all the information needed for the controller implementation; the designing method of the models from the top to the bottom (the refining technique step by step);
- Ability to verify the undesired properties of the system, such as: locks, instability and to validate the generated sequence by computerized mathematical analysis - saving time for simulation of the many cases;
- Performances analysing without simulation. Estimation of the production capacity, using the resources, stability, performance degree, all of these could be easy evaluate.
- Simulation of the discrete events which could be managed vu the model;
- Information about the monitoring in real time;
- The Petri Networks contain the precedence relations as well as the performances restrictions of the system.

2. THE TASKS OF THE DEVELOPED PETRI NETS

The developed Petri Network carries out the modelling, analysing, validation, verifying, simulation, the organising and the evaluation of the performances - from the project to the manufacturing, when the net is transformed in control and monitoring tool.

The manufacturing system could be considered as an activities group and finally, this assembly is called product. The activities are fabrication processes including manufacturing, material manipulation a performing of the information. There are human resources, machines, the working materials needed to carry out these activities.

The process planning specifies the activities and the resources in detail.

The plan includes the precedence relations and the parallelism between the activities by purchasing the necessary resources. The technological planning could define more precisely some alternative resources for any activity and could purchase priorities to any important resource.

The Petri Net defined in graphical or analytical mode has not a physical meaning. The modeller must solve and interpretation by labelling the positions and the transitions. Generally, the positions represent the conditions and the transition represents the events.

The following rules are used in the developed Petri Networks:

1. A position represents a state of one resource or an operation; if the position is a resource, the initial number of the token could be a constant value e.g. machine numbers, or a variable e.g. the tokens are represented by the pallets existing in the system.
2. If a position represents the resource state, one or more tokens from the position show that the resource is unavailable.

The transition represents the starting or the ending point of an events or executing process.
The next example is presented for showing the definitions and interpretation of the developed Petri Network.

3. THE DEVELOPED PETRI NETS APPLIED TO A FLEXIBLE TECHNOLOGICAL SYSTEM

It is considered a transfer solution shown in figure 2.1. This station is composed of an AGV (automated guided vehicle), which transfers two kinds of pieces (1 and 2) produced by two manufacturing centre. If the transfer starts cannot be stopped.
Immediately after a transfer is finished, another piece is available to be transported by the AGV.

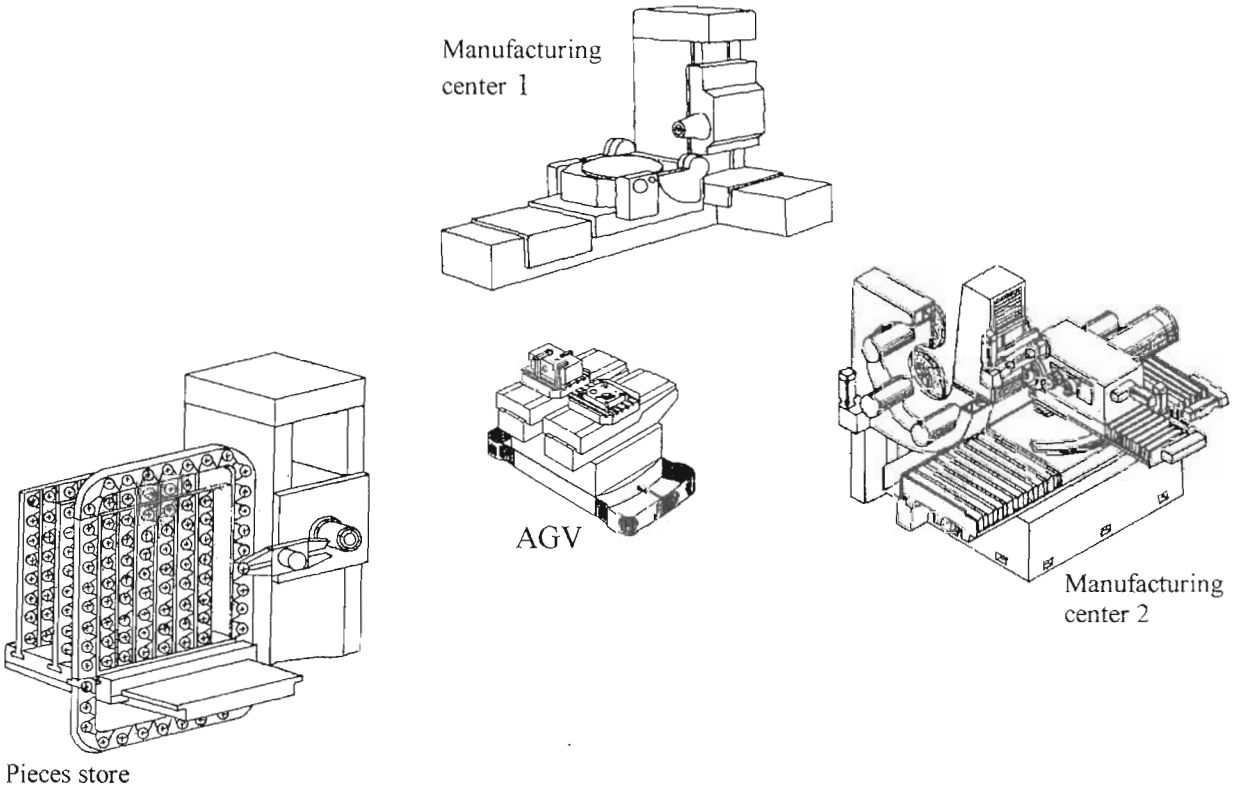

Figure 1 - Flexible cell for transfer of the pieces. The Petri Network, which models the functioning of the transfer, is presented in figure 2.

The positions and the transitions have the following interpretation:
P_{v01} - shows that a piece of the type 1 is available when the position is marked by a token (is not available when P_{v01} is not marked).
P_{v02}, in the case of a token, shows the property to be available the piece 2; the number of the token represents the pieces number and when is not marked shows that the AGV is available to transfer a piece.
The marked positions P_{v01} and P_{v02} represents the necessary constrains which must be satisfied before the initialising of the transfer activity of the AGV for the piece 1.
The same requests must be carried on in the case of the positions P_{v02} and P_{v01} comparing with the preconditions for the transfer activity of the piece 2.
P_{o01} and P_{o02} model the transfer activity state, when a marking shows that a transfer activity of the piece 1 and 2, respectively, is produced by the AGV.
t_{o01} and t_{o02} represents the start / end events for the transfer activity of the piece 1, while t_{o02} and t_{o04} represent the same events for the transfer activity of the piece number 2.

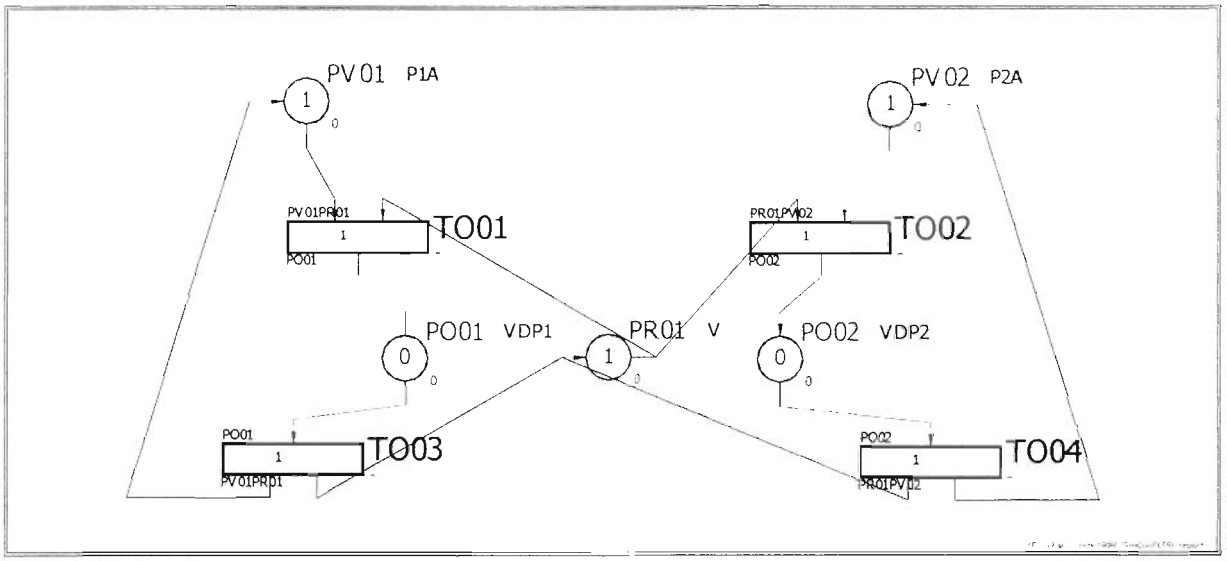

Figure 2. Petri Network Model for a transfer station (P1A/P2A - piece of the type 1/2 available; VD1P/VDP2 - AGV moves the piece of the type 1/2; V 0 AGV)

Petri net models for manufacturing systems have been widely used for the logical control validation, simulation, and performance analysis. They can also be implemented as the supervisory controllers of a system by imbedding the low- level processes into places or transitions of its Petri net model. These low-level processes can be represented as software/hardware components. The controllers are represented as control code in the computer-based environment. Such a controller is called a Petri net controller, which can be defined as a control/logical based on marked Petri net a discrete event system. The firing of transitions in a marked Petri net regulates the flow of tokens places. It is this flow of tokens, which defines the supervisory control actions. Following SimConPetri software components are different from a module or subroutine in modular programming. They have three basic features:

1. A well-defined public interface;
2. An internal implementation that is inaccessible to the user; and
3.Both the visible part and the inaccessible implementation should be separately compliable from the program components that use them.

These features allow preventing programming errors, extensive compiler error checking and increasing program reliability, and make software components plug-compatible. The software/hardware components it the extension of the software component concept to include manufacturing components like a robot, or a machine.

The basic idea is that a "compiler" can be developed such that a Petri net model is transformed into say, program to include the software/hardware components embedded in the places or transitions in the net. These components could be independently developed in advance and are used for low-level control of the system, for example, a continuous process: a robot moves an object from positions A to B. The resulting control programs and all software/hardware components will be integrated to execute the operation of an event-driven system, e.g., a manufacturing system.

Therefore, a Petri net model and its corresponding Petri net controller are equivalent in the sense that the latter can be converted from the former by using the "compiler" idea and cooperating low-level control processes. Therefore, a Petri net, a Petri net model, and a Petri net controller are considered as one unit As we later develop our Petri net synthesis method.

An event-driven system can be abstracted as a state machine in which the states change when events occur. The finite state machine or automaton model results when the total number of states in a system is finite. Finite state machines are well established as a fundamental model for computation and computing machines. However, when they are used to model in a straightforward manner, the exponential increase in the number of states makes it very difficult to implement. Graphical representation is almost impossible and thus graphical visualization cannot be easily realized.

Other models have been recently developed for modelling and control of discrete event systems. Among them are formal language based supervisory control, the theory is elegant and is independent of the models used for application. In most application, each discrete event process is assumed to be modelled by an automaton or a state, machine, and its behaviour is completely described by the language generated by the automaton. All system requirements or specifications are also assumed to be specified as

language. Therefore, a design problem for supervisory controllers of discrete event systems can be stated as follows: find an automaton which is a supervisory controller such that the combined automaton for the controlled system generates the specified language.

4. CONCLUSION

The paper presents a new type of the Petri Networks called developed Petri Networks, which gives the possibility to implement the controllers in order to manage a flexible technological system. The Developed Petri Nets is deled as a theoretical point of view; the advantage of using this type are presented and finally, those applications to a manufacturing cell is presented.

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REȚELE PETRI DEZVOLTATE APLICATE LA MODELAREA SISTEMELOR TEHNOLOGICE FLEXIBILE

(Rezumat)

Rețelele Petri, la fel ca orice metoda grafică, oferă o metodă globală pentru proiectarea sistemului cu evenimente discrete începând de la descrierea ierarhică până la generarea soluției reale. Rețelele Petri dezvoltate oferă un număr mare de avantaje în ordonanțarea proceselor în centrele de prelucrare. Este prezentat, de asemenea, un exemplu aplicativ de sistem flexibil tehnologic modelat cu rețele Petri dezvoltate.

LE RÉSEAU DÉVELOPPÉ DE PÉTRI S'EST APPLIQUÉ À MODELER TECHNOLOGIQUE FLEXIBLE DE SYSTÈME

(Résume)

Le réseau de Pétri, comme outil graphique offre une méthode unifiée pour le système discret d'événements concevant de la description de hiérarchie jusqu'ici à la vraie solution à effectuer. Les réseaux développés de Pétri offre un grand nombre d'avantages aux centres de fabrication par les tâches multiples qui sont résolues. Un exemple de l'application des réseaux développés de Pétri à un système technologique flexible est présenté.