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Principle generalized net models of the activity of a petrochemical combine

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The Generalized nets (GNs), Intuitionistic Fuzzy GNs of type 1 (IFGN1s) and Intuitionistic Fuzzy GNs of type 2 IFS2s (see, e.g., [1]) are convenient tools for designing complex objects featured by a large scale of various real-time parallel processes. In the general case, it is impossible to show analytical formulas for the description of these processes. A variety of simulation methods are used for their modelling. Petri nets are one of these (new) basic methods. GNs can also be used as a means for simulating such (real) processes, but (in contrast with the Petri nets and by virtue of their transition condition predicates and characteristic functions) they can also comprise elements of analytical modelling techniques. For example, some characteristic functions can assign to a given token a value that is calculated by analytical functions.

LUKoil Petrochemical Combine (LPC) in Bourgas is one of the integrated industrial enterprises in Bulgaria which exerts a strong influence upon the dynamic development of the State Industrial Chemical Corporation and the economy of the country. We will use it as an example for our models.

Some of the processes in LPC are described in [2] by GNs (in particular, by IFGN2s). Now, we shall extend the ideas from [2], constructing two principle GN-models.

The constructed models can be used for simulation of the processes in the combine. The models are investigated following the ideas of hierarchical models and models based on the union and composition of simpler GN-models.

The modelling starts with the construction of a simplified global model of the combine as a whole. It has the form shown on Fig. 1. As we noted, the GN can be an IFGN2, i.e. so a token ("quantity") enters place l_1 and this action represents the quantity of feedstock (oil) received. This place represents the Petrochemical Sea Port (Terminal) where distribution of feedstock through the basic types of units is made: chemical unit (l_4) and refinery. The second one has the following two components: "Catalytic Reforming" (l_5) and "fuel output" (l_6). A part of the production from l_5 is directed to l_7 and together with the production from l_4, is going (according to some pre-set conditions) to l_{10} (for production of plastics,

fibres and rubber), or to l_{11} (for production of petrochemicals in petrochemical units). A part of the "quantity" (token) is going from the last place to place l_{12} (for production of solvents), and another part returns through place l_{13} to the "catalytic cracking unit" and there takes part, together with newly entered "qualities", in the production of fuels (l_8) and other products (l_9). The tokens (qualities) from places l_6, l_8, l_9, l_{10}, l_{12} go to place l_{15} and that represents the outgoing of the finished product from the LPC.

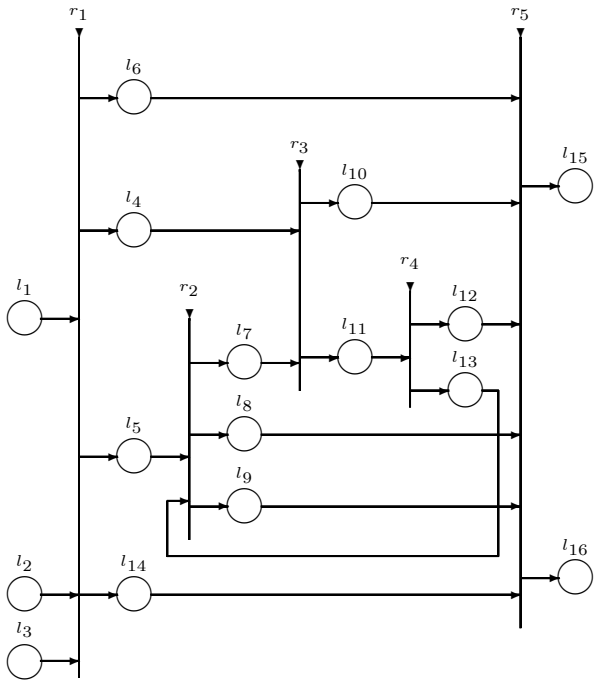

Fig. 1.

The general movement of fuels, petrochemicals and plastics, produced and processed in LPC can be observed by this part of the GN.

Besides, the GN has two other (not differentiated separately) parts.

The first one symbolizes the entry of information of the demand of fuels, petrochemicals and plastics (place l_2), workout of this information (orders) (place l_{14}) and report on the orders (place l_{16}) - whether they are satisfied or not.

The second one (place l_3) represents the influence of: 1) the global and local- area marketing situation, 2) the recent Customs and tax regulations in national and European legislations and 3) the dynamics of crude-oil prices, on the other side.

Based on the pursuit of optimal load of the available equipment and relatively constant feed-stock volumes, the last item influences most of all the balance of outcoming by-products in general. On the other side, the new-entered part influences the circumstances and ratios of fuels', petrochemicals' and plastics' demand and the level of customers' satisfaction. As far as LPC is a significant local-area and global market participant it is important that the new token keeps an eye on and effects the marketing response as a result of LPC' economic activity.

The tokens ("quantities") that go into l_1 have as initial characteristics the type of feedstock, and during their movement in the GN they receive the following characteristics:

"the kind and quantities of processed intermediate fractions" and "the kind and quantity of the final product" depending on the type of places they enter. In the end, in place l_{15} these tokens ("quantities") obtain the final characteristic "working costs" and other characteristics specified by the model's users.

The other type of tokens go to place l_2 with the initial characteristic "information about the demand of goods with the necessary description, quantities, parameters, etc." and are leaving the GN with the final characteristic "the order is fulfilled" or "the order is not fulfilled" (as well as other data).

More detailed processing models can report on such factors as the moment when the feedstock enters the LPC, the duration of processes, the moments when the products leave the LPC, the duration of waiting for processing feedstocks or fractions, etc.

Tokens can have their own priorities which determine the ways of the transfer. The transition condition predicates can have explicit forms. During the simulation of the LPC-processes, different situations can occur with respect to the initial characteristics of the tokens in places l_1 and l_2, and also with respect to the characteristics of the tokens which are in the net at the initial time-moment (they correspond to the available quantities in the LPC).

The described GN reflects only the most global connections existing between the different units of LPC. When more details are required, some of its places and/or transitions may be substituted by whole new GNs. These nets will describe the separate subprocesses which are included in the most global ones.

Another situation is when a new GN (a subnet of the most global one) corresponds to a part of the places and transitions of the above GN, but does not cover their contents.

The GN shown in Fig. 2 is an example illustrating this. The components of this net correspond to places l_1,l_5, l_6 and the transition Z_1 from the net from Fig. 1.

Briefly, the meanings of the places of the new net are as follows:

l_1 — Petrochemical Sea Port (Terminal),

l_2 — production of fuel oil

l_3,l_4,l_5,l_6,l_9,l_{13},l_{30} - production of other cuts

l_7 — production of oil cut

l_{10}, l_{11} — production of cut C_4

l_{12} — production of high-octane petrol

l_{16}, l_{17},..., l_{25} — tanks

l_{26} — production of cut C_5

l_{27} — production of toluene.

Finally, we will note that the above GN can be used for other purposes, too. For example, if we change the forms of the characteristic functions so that they determine the quantity of the products which go to the atmosphere, or down to the soil, then the GN can be used for modelling processes related to the ecological contamination of the environment.

In conclusion, we shall note that from economical point of view the first, basic and most important part of the first GN is the part "Global Market". The customers' orders are based on the generated by this item information. The same information determines the quantities of the crude-oil delivered (depending on its origin, of course - because the geographical origin of crude-oil determines the specific proportions of its ingredients). In near future we shall extend the first model by analogy with the second one, but in economical direction.

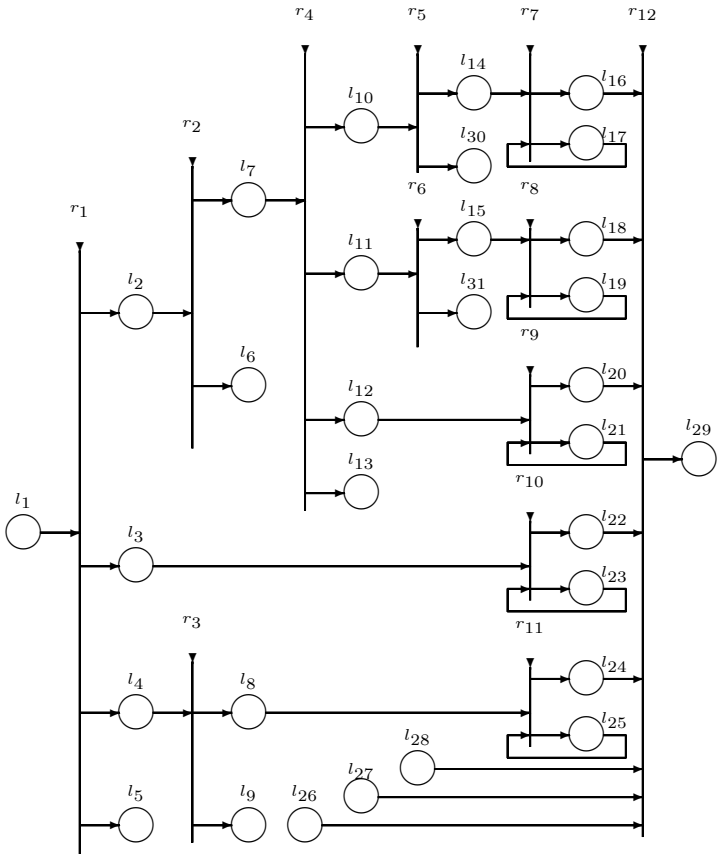

Fig. 2.

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[1] Atanassov, K. Generalized Nets. World Scientific, Singapore, 1991.

[2] Dimitrova S., L. Dimitrova, T. Kolarova, P. Petkov, K. Atanassov, R. Christov, Generalized net models of the activity of NEFTOCHIM Petrochemical Combine in Bourgas, in Applications of generalized nets, (K. Atanassov, Ed.), World Scientific Publ. Co., Singapore, 1993, 208-213.