

Generalized Nets: Theory and Applications

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The Generalized Nets (GNs, [1-5]) are defined as extensions of the ordinary Petri Nets (PNs) and their modifications, but in a way that is in principle different from the ways of defining the other types of PNs. The additional components in the GN-definition give more and better modelling capabilities and determine the place of GNs among the separate types of PNs, similar to the place of the Turing machine among the finite automata.

By analogy with the PNs, GNs contain places, transitions and tokens, but their transitions have essentially more complex structure. Besides the input and output places, the GN-transitions contain moment of activation, by analogy with Time PNs; duration of the active state, by analogy with e-nets; index matrix with predicates that determine whether a token from i -th input place can go to the j -th output place; index matrix with natural numbers that determine the capacities of the arc between i -th input and j -th output place; and a special condition, by analogy with the PRO-nets, that determine whether the transition can be activated. GN-tokens enter the net with initial characteristics, that include as a very partial case the idea for colours with which the tokens of the Coloured PNs are coloured and for the symbols, with which the tokens of the Predicate-Transition Nets are marked. Entering a new place, the GN-tokens obtain new characteristics. In contrast to the Coloured PNs and the Predicate-Transition Nets, GN-tokens can keep all their characteristics and they can be used for evaluation of the truth-values of the transition condition predicates. Also in contrast to the remaining types of PNs, the GNs contain global temporal scale.

The GNs have more than 20 conservative extensions (i.e., extensions for which their functioning and the results of their work can be represented by an ordinary GN). The most important of them are:

- four types of intuitionistic fuzzy GNs
- Colour GNs
- GNs with global memory
- GNs with optimization components
- GNs with additional clocks
- GNs with stop-conditions
- GNs with volumetric tokens
- GNs with complex transition type
- GNs with characteristic functions of the places and arcs
- GNs with 3-dimensional structure.

Some of these GN- extensions have many real-world applications. For example, the intuitionistic fuzzy GNs of different types are used for models in chemical and, specifically, in petrochemical industry. Some of these models contain additional clock and/or stop-conditions. They are suitable, e.g., for the models of rectification columns in a petrochemical refinery. The GNs with optimization components can be used for describing of decision making and control processes, and for some more theoretical GN-models, e.g., for ant-colony optimization and genetic algorithms. The GNs with volumetric tokens are used for models of Internet processes, while GNs with place characteristics in some medical and ecological models. The GNs with 3-dimensional structure, the colour GNs and the GNs with complex transition type provide better visualization of the modeled processes.

The GNs theory contains some aspects:

- algebraic aspect: different operations and relations are defined both over the transitions, and over GNs in general. The operations, defined over GNs –“union”, “intersection”, “composition” and “iteration” do not exist anywhere else in the PN theory. They can be transferred to virtually all other types of PNs (obviously with some modifications).
- topological aspect: to each GN a graph is juxtaposed and its properties can be used for searching the GN-properties.
- logical aspect: the logical conditions for reachability of the output places from the input places are studied.
- operator aspect: six types of operators are defined in its framework. Every operator assigns to a given GN a new GN with some desired properties. The comprised groups of operators are from global, local, hierarchical, reducing, extending and dynamic types.

During the last 30 years, the GNs have found applications in the areas of Artificial Intelligence (AI) and Data Mining (DM), medicine, biology and ecology, chemistry and economics, university administration processes and many others.

The GNs are object of intensive research and applications in different countries in the world: Australia, Bulgaria, Poland, Portugal, South Korea, Spain, UK, USA and others.

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