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# GENERALIZED NET MODEL OF A SELF-DEVELOPING EXPERT SYSTEM

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## 1. Introduction

Eleven Generalized Net (GN, see [3]) models were described in a series of papers, collected in [6]. These GN-models describe the way of functioning and the results of the work of different types of Expert Systems (ESs, see, e.g., [1, 5, 11, 12]). Some types of these ESs are introduced for a first type as possible extensions of the ESs, which extensions can be described by the GNs and which can obtain real applications. The first four from the nine GN-models describe ordinary ESs; the fifth and seventh - ESs with priorities of their Data base (DB) facts and Knowledge Base (KB) rules, so, the separate facts and/or rules can be changed at the time of the ES functioning. Sixth GN-model describes an ES containing not only facts, but also metafacts, that can be represented by rules, but in the present form they are more useful and more quickly applicable. Eighth GN-model represents Intuitionistic Fuzzy ES (IFES see [2]; for the intuitionistic fuzziness see [7]). On its base the Ninth GN-model is constructed so that it represents functioning of an ES working with temporal facts and answering to the temporal questions [4]. The tenth GN-model (see [8]) represents extension to the later ES. In [9] is described GN-model of ESs with Frame-Type Data Bases. In last nine from the ten GN-models the DBs and in last eight from the ten GN-models the KBs are represented by tokens. In all cases the question for the form of these tokens is not discussed in details. The new hierarchical GN-operator, introduced in [10] gives possibility to change the tokens, corresponding to DBs and/or KBs by whole GNs.

Let every fact $A$ of the ES's DB has the form

$$\langle A, p_A, \mu_A, \nu_A \rangle,$$

where:
$p_A$ is a natural number which corresponds to the priority of $A$ (as it is in the Fifth GN-model from [6]),
$\mu_A$ and $\nu_A$ are the real numbers (as it is in the Eighth GN-model from [6]), for which $\mu_A, \nu_A \in [0, 1]$ and $\mu_A + \nu_A \leq 1$. They corresponds to the IF-degrees of validity (correctness)

and non-validity (incorrectness) of the fact $A$.

Let a new fact $B$ with parameters $p_B$, $\mu_B$, $\nu_B$ be generated in some way at a certain time-moment of the ES functioning. If both facts $A$ and $B$ are not related, then the new fact enters the DB. In the ordinary ESs, the new fact $B$ substitutes the old fact $A$ when $B$ coincides with, or contradicts $A$.

In the Eighth GN-model from [6], when the new facts $A$ and $B$ coincide, a representative of them ($A$ or $B$) remains in the DB, but with a new priority equal to $max(p_A, p_B)$, and with new IF-degrees: $max(\mu_A, \mu_B)$ and $min(\nu_A, \nu_B)$.

On the other hand, the fact with the greater priority among $p_A$ and $p_B$ remains in the DB when the facts $A$ and $B$ contradict each other and obtains the IF-degrees $min(\mu_A, \mu_B)$ and $max(\nu_A, \nu_B)$.

In this paper is proposed a GN-model of an ES, during the work of which new facts are introduced. If there is/are fact(s) coinciding with the generated one, then it should be considered true. Its degree of truth can be determined on the basis of either the old one or the new information. The calculation of IF-degrees $\langle \mu, \nu \rangle$ for the fact can be done with various algorithms, using, e.g., functions:

- $\varphi_1$ – maximal possible value,
- $\varphi_2$ – average possible value,

etc.

## 2. A GN-model

The present GN-model is shown on Fig. 1.

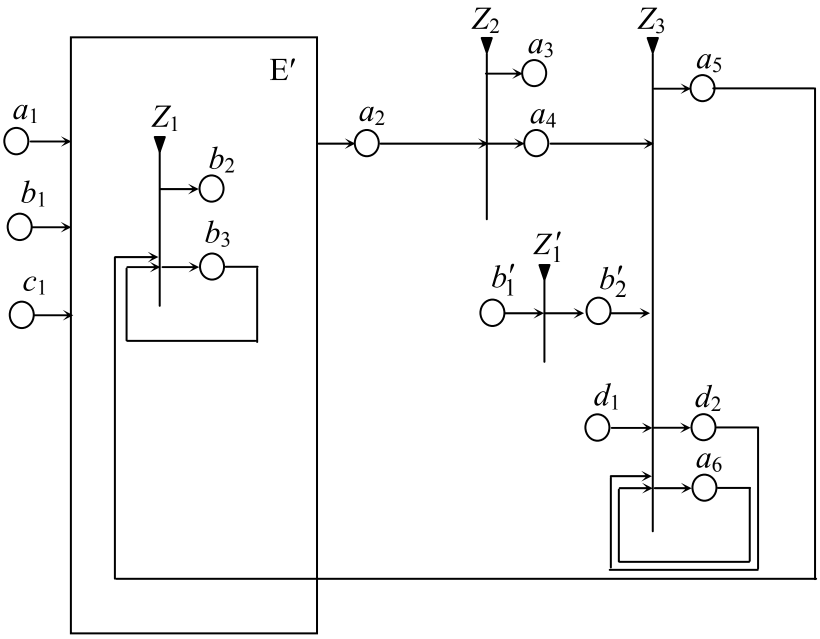


Fig. 1: GN-model of a self-developing ES

In this paper we construct a new GN which represent the functioning and results of the work of a Intuitionistic Fuzzy ES (IFESs) with the IF degrees of validity and non-validity of the new facts and new rules.

For clarity the places are marked by three different symbols: *a*, *b* and *c*, such that:

- the token $\alpha$ together with its descendants of all generations obtained after splitting will go to the *a*-places;
- the token β will go on *b*-places;
- the token γ will go on *c*-places;
- the token δ will go on *d*-places;

Below, the tokens characteristics will be ordered tuples whose first component is in turn a vector with components natural numbers. At every step where tokens will split, they will be marked with the number of the current split, keeping the previous numeration, i. e., if the first component of a token characteristic is $\langle s_1, s_2, \ldots, s_{k-1}\rangle$ ($k \geq 0$, $s_1, s_2, \ldots, s_{k-1}$ - natural numbers), then its next characteristic will be $\langle s_1, s_2, \ldots, s_{k-1}, s_k\rangle$, where the natural number $s_k$ will correspond to the number of the tokens's current splitting.

Let current $\alpha$-token ($\alpha_p$) enters place $a_1$ of the GN with an initial characteristic

$$x_0^{\alpha} = \text{“}H, p, *, *\text{”},$$

where $H$ is a hypothesis, $p$ its priority and symbols “*, *” denote the absence of $\mu$– and $\nu$– components of the initial $\alpha$-characteristic.

Let a token $\beta$ enter place $b_1$ with an initial characteristic

$$x_0^{\beta} = \text{“}\Delta\text{”},$$

where the Δ is the DB of a given ES.

Let the token γ enter the place $c_1$ with an initial characteristic

$$x_0^{\gamma} = \text{“R”},$$

where $R = \{R_1, \ldots, R_n\}$ is the list of the rules. Each rule $R_i$ has the form ($1 \leq i \leq$ n):

$$R_i = \langle C_i; A_{i,1}, \ldots, A_{i,t_i} ;\ p_i^R ; \mu_i^R ; \nu_i^R \rangle,$$

where $C_i$ is the consequent and $A_{i,1}, \ldots, A_{i,t_i}$ are the elements of the conjunction which forms the antecedent, $p_i^R$ is the $R_1$‘s priority, $\mu_i^R$ and $\nu_i^R$ are its IF-degrees of validity and non-validity, as we mentioned above.

Let the tokens $\beta'_1, \beta'_2, \ldots, \beta'_s$ ($s \geq 0$) enter sequentially place $b'_1$ with initial characteristics

$$x_0^{\beta'_{cu}} = \langle\text{”}new\ fact\text{”},\ p_{\beta'_{cu}}, <\mu_{\beta'_{cu}},\ \nu_{\beta'_{cu}}>\rangle,$$

where:

“*cu*” symbolizes the current number of the β′-type token which enters the GN,

$p_{\beta'_{cu}}$ is a natural number which corresponds to the priority of the fact,

$\mu_{\beta'_{cu}}$ and $\nu_{\beta'_{cu}}$ is the IF-degrees of validity and non-validity of the fact.

The transitions of the GN are the following (see Fig. 1).

$$Z_1' = \langle \{b_1'\}, \{b_2'\}, \begin{array}{c|c} & b_2' \\ \hline b_1' & W_{b_1',b_2'} \end{array}, \wedge(b_1')\rangle,$$

where

$W_{b_1',b_2'}$ = "The current procedure for verification of the hypothesis is completed".

The $\beta'$ tokens do not obtain new characteristics in place $b_2'$.

Here the Eight GN model from [6] is marked by $E'$ in Figure 1. Place $a_2$ corresponds to $E'$-output place for $\alpha$-tokens, that in [6] is marked by $a_{18}$. Following [6] we must note that the α-tokens obtain characteristic

$$x_{cu}^{\alpha} = \text{"!H, } \mu_{\alpha_{cu}}, \nu_{\alpha_{cu}}\text{" or "}\neg\text{!H, } \mu_{\alpha_{cu}}, \nu_{\alpha_{cu}}\text{"}$$

in place $a_2$,

where "!$H$" denotes that hypothesis $H$ is valid and the "¬!$H$" denotes that hypothesis $H$ is not valid.

In place $b_3$ permanently stays $\beta_0$-token with initial and current characteristic

$$x_0^{\beta_0} = \text{"}\Delta\text{".}$$

$$Z_2 = \langle \{a_2\}, \{a_3, a_4\}, \begin{array}{c|cc} & a_3 & a_4 \\ \hline a_2 & W_{a_2,a_3} & W_{a_2,a_4} \end{array}, \wedge(a_2)\rangle,$$

where

$W_{a_2,a_3}$ = "$x_{cu}^{\alpha} = \neg$!H",

$W_{a_2,a_4}$ = "$x_{cu}^{\alpha}$ =!H".

The $\alpha$-tokens do not obtain any new characteristic in places $a_3$ and $a_4$.

$\delta$-token, entering the net through place $d_1$, carries the algorithm for estimation of the degree of truth for the fact $\langle \mu_{\alpha_{cu}}, \nu_{\alpha_{cu}} \rangle$ and has a characteristic, e.g.:

$$\varphi_1(\mu(\alpha), \nu(\alpha), \mu(\beta_1'), \nu(\beta_1'), \ldots, \mu(\beta_s'), \nu(\beta_s')) =$$

$$= \left\langle \max\left(\mu(\alpha), \max_{1\le i\le s} \mu(\beta_i')\right), \min\left(\nu(\alpha), \min_{1\le i\le s} \nu(\beta_i')\right)\right\rangle,$$

or

$$\varphi_2(\mu(\alpha), \nu(\alpha), \mu(\beta_1'), \nu(\beta_1'), \ldots, \mu(\beta_s'), \nu(\beta_s'))=$$

$$= \left\langle \frac{\mu(\alpha) + \sum_{i=1}^{s} \mu(\beta'_i)}{s+1}, \frac{\nu(\alpha) + \sum_{i=1}^{s} \nu(\beta'_i)}{s+1} \right\rangle,$$

ect., where $s$ is the number of the tokens with initial characteristic $\mathrm{pr}_1\, x_0^{\alpha}$.

$$Z_3 = \langle \{a_4, a_6, b'_1, d_1, d_2\}, \{a_5, a_6, d_2\}, \begin{array}{c|ccc} & a_5 & a_6 & d_2 \\ \hline a_4 & false & W_{a_4,a_6} & false \\ a_6 & true & false & false \\ b'_2 & false & true & false \\ d_1 & false & false & true \\ d_2 & false & true & false \end{array}, \vee(a_4, a_6, b'_1, d_1, d_2)\rangle,$$

where

$W_{a_4,a_6}$ = "$\exists\beta'(\underline{\mathrm{stay}}(\beta', b'_1)\ \&\ (\mathrm{pr}_1\, x_0^{\beta'}) = x_0^{\alpha}$",

where the function stay mean the following:

$$\underline{\mathrm{stay}}\,(\alpha, l) = \begin{cases} 1, \text{ when } \alpha \text{ is in place } l, \\ 0, \text{ when } \alpha \text{ is not in place } l. \end{cases}$$

The $\alpha$-tokens do not obtain any new characteristic in places $a_5$ and $a_6$.

## 3 Conclusion

In the present paper we constructed a new GN-model in the area of ESs. It is extension of Third, Fifth and Eight GN-models from [6]. In this book there are some other GN-models of other ES-types, that also can be re-written in the form of the above extension. For example, we can construct GN-model of an intuitionistic fuzzy ES with the temporal components. All these models show that the concept of an ES can be extended, but in all these extensions it can be described by GNs.

Some extensions of the above model will be presented in future.

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