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Generalized net model of the decision-making process in building a collaborative information environment

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Abstract: The paper presents a Generalized net model (GN-model) of the decision-making process in building a collaborative information environment using a six-transitions aggregate net. When evaluating the parameters of the individual tokens, the possibility of using fuzzy and intuitionistic fuzzy values is envisaged.

Keywords: groupware, collaborative work, information environment, Generalized nets, modeling

AMS Classification: 03E72, 68Q85

1. INTRODUCTION

When building collaborative environments, it is important to make the right choice of technical means and software solutions that will best meet the needs of appropriate information services. In the process of finding solutions, one of the leading criteria is to improve the efficiency of the teams, to support their cooperation to the maximum extent by providing them with convenient and effective means for joint work. For this purpose, it is not enough just to choose the best tools for a certain type of activity, but they must be able to integrate with each other and work in a similar and non-committal way. If a cloud architecture is used, it is necessary to make an analysis of the software systems and tools that will be used [5], the possible threats in terms of security of the information [6], etc. To support this process, a Generalized Net model for decision-making in building a collaborative environment is presented here.

The generalized nets (GN), created by K. Atanassov in 1982 [1], have found application in fields such as: medicine, economics, transport, industry, computer technology and various methods of database creation, expert systems, modeling of decision-making process and others. [2, 3, 4, 7, 8]

The decision-making process in defining the architecture of the collaborative information environment is expressed in the following: The purposes for which the collaborative environment will be used are defined as well as what functions and services it will provide, what will be its scope, possibilities for realization, etc. The clarification of these issues determines what types of information and

technical means will be used, how the human-machine interface will be organized in the most convenient and efficient way possible. It is a known fact that the more complex an equipment is or the longer it takes to work with it, the sooner or later it ceases to be used. Therefore, the selection and implementation of any system requires an in-depth assessment not only of the individual details, but also of the integration between all its modules and subsystems. In order to realize all this, in the proposed GN-model of the decision-making process in building a collaborative environment, six transitions were used to present the main stages of this process, namely: comparative assessment of the parameters of the information and technical means, analysis of the modern technologies suitable for application, generation of alternative solutions (variants of architectures for building the environment), evaluation of these solutions, selection of the best of them, testing (verification) of the selected variants of solutions (creation of working prototypes) and implementation (realization) of the selected winning solution.

2. GN-MODEL DESCRIPTION

The scheme of the decision-making model for building a collaborative environment implemented with a GN is shown in Fig. 1, and the description is as follows:

$$E = \{Z_1, Z_2, Z_3, Z_4, Z_5, Z_6\}, \text{ where}$$

Z_1 – comparative evaluation of information and technical means
Z_2 – generating alternatives to architecture solutions (configuration) of the collaborative environment
Z_3 – check (evaluation) of the alternatives
Z_4 – solution selection (architecture, configuration of the built environment)
Z_5 – verification of the solution (by testing with a prototype of the collaborative environment)
Z_6 – implementation of the decision (evaluation of the results)

The tokens used in generalized net E are –
α – communication and information tools (software tools, applications) that can be used to build a collaborative environment
β – technical means (video conferencing systems, collaboration displays, electronic boards, servers, etc.) that can be used to build a collaborative environment
γ – technologies, perspective solutions, good practices, etc. methods for improving the architecture and the functionality of the built collaborative environment

ι – information (expert knowledge, heuristics, evaluation criteria, research results, experiments, etc.) related to opportunities for improving the environment for joint work that is being built

ω – target states of the architecture (configuration) of the collaborative environment

φ – alternative solutions (variants of architecture and configuration of the collaborative environment)

τ – tests (test evaluations by users of the individual alternative solutions offered for the construction of the environment)

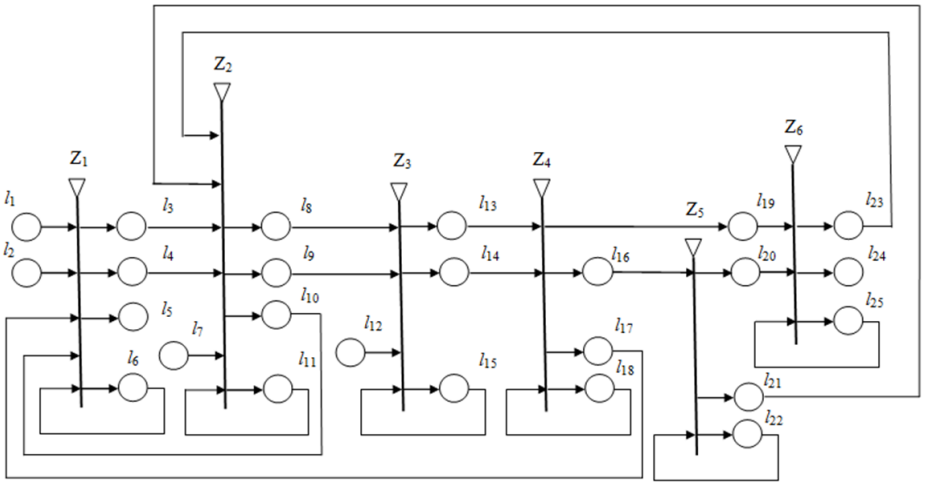

Figure 1. GN-model of the decision-making process in building collaborative information environments

The description of the transitions is as follows:

$$Z_1=<\{l_1, l_2, l_6, l_{10}, l_{17}\},\{l_3, l_4, l_5, l_6\}, r_1, M_1, \vee(l_1, l_2, l_6, l_{10}, l_{17})>, \text{ where}$$

l_1 – initial place in which tokens α (communication and information means) and tokens β (technical means – video conferencing systems, electronic boards, etc.) enter. They are following characteristics:

- X_α ($e^\alpha_{p,1}$, $e^\alpha_{p,2}$, …, $e^\alpha_{p,i}$, …, $e^\alpha_{p,k}$), where $e^\alpha_{p,i}$ e is the evaluation of the i-th parameter of p_i ($i \le k$) evaluation parameters by which the qualities are determined (the applicability) of the respective means (software tool, application) for providing the necessary information services;
- X_β ($e^\beta_{q,1}$, $e^\beta_{q,2}$, …,$^\beta_{q,i}$, …, $e^\beta_{q,s}$), where $e^\beta_{q,i}$ e is the evaluation of the i-th parameter of q_i ($i \le s$) evaluation parameters by which the properties of the

relevant technical means are determined (applicability) to provide the necessary services or to ensure the operation of other means (for example, the appropriate type of server configurations for the installation of software applications, architecture of discussion rooms, etc.).

l_2 – initial place in which tokens γ (technologies, perspective solutions, good practices, etc.) and tokens ι (information - expert knowledge, evaluation criteria, research results, etc.) enter. They are following characteristics:

- X_γ ($e^\gamma_{w,1}$, $e^\gamma_{w,2}$, …, $e^\gamma_{w,i}$, …, $e^\gamma_{w\ n}$), where $e^\gamma_{w,i}$ is the evaluation of the i-th method of w_i ($i \leq n$) evaluation parameters to improve the architecture and functionality of the information environment (technologies, solutions, good practices, etc.);
- $X\iota$ ($e^\iota_{v,1}$, $e^\iota_{v,2}$, … $e^\iota_{v,i}$, …, $e^\iota_{v,m}$), where $e^\iota_{v,i}$ can be an evaluation of the usefulness of the information for an alternative solution for configuring the environment v_i ($i \leq m$).

l_3 – place in which the tokens α, β and γ enter after a comparative evaluation

l_4 – place in which ι-tokens enter after evaluation

l_5 – place in which dropped tokens enter (not suitable for any alternative solution)

l_6 – place of tokens α, β, γ, φ and ι, participating in the process of comparative evaluation of the parameters and improvement of already generated solutions (φ - tokens)

l_{10} – place of alternative configurations (architectures) that need processing (unused tokens α, β and γ) and there is an update of the information (ι-tokens with changed characteristics enter)

l_{17} – place of tokens ι and/or alternative solutions (tokens φ) that do not fully meet the requirements (improvement is needed)

$r_1 =$

	l_3	l_4	l_5	l_6
l_1	F	F	$W_{1,5}$	T
l_2	F	F	$W_{2,5}$	T
l_6	$W_{6,3}$	$W_{6,4}$	$W_{6,5}$	$W_{6,6}$
l_{10}	F	F	$W_{10,5}$	$W_{10,6}$
l_{17}	F	F	$W_{17,5}$	$W_{17,6}$

T – true (transfer is possible), F-false (transfer is not possible)

$W_{1,5}$ = $W_{2,5}$ = „incoming tokens are not applicable” (cannot be used for the intended purpose)

$W_{6,3}$ = „comparative evaluations of the parameters of tokens α, β and γ meet the requirements for integration between them”

$W_{6,4}$ = „there are ι-tokens involved also in other transitions" (they are dropped)
$W_{6,5}$ = „there are tokens whose evaluations are below the required threshold" (they are dropped)
$W_{6,6}$ = „evaluation process in progress"
$W_{10,5}$ = „there are tokens (α, β, γ or ω) that are not used" (they are dropped)
$W_{10,6}$ = „the generated solutions (φ-tokens) do not meet the requirements (ω-tokens) and an update is needed"
$W_{17,5}$ = „there are tokens (φ) that do not meet the requirements (tokens ω)" (they are dropped)
$W_{17,6}$ = „further evaluation and updating of φ-tokens is needed" (change in the characteristics of already selected solutions using data transferred from tokens ι, based on experience gained)

$M_1 =$

	l_3	l_4	l_5	l_6
l_1	0	0	$m_{1,5}$	N
l_2	0	0	$m_{2,5}$	N
l_6	$m_{6,3}$	$m_{6,4}$	$m_{6,5}$	$m_{6,6}$
l_{10}	0	0	$m_{10,5}$	$m_{10,6}$
l_{17}	0	0	$m_{17,5}$	$m_{17,6}$

N takes values from 0 to the maximum possible number of tokens for a given situation of using the model
$m_{1,5} = m_{2,5} = m_{6,3} = m_{6,4} = m_{6,5} = m_{6,6} = m_{10,5} = m_{10,6} = m_{17,5} = m_{17,6}$ – from 0 to the maximum number of tokens for this transition

$$Z_2=<\{l_3, l_4, l_7, l_{11}, l_{21}, l_{23}\},\{l_8, l_9, l_{10}, l_{11}\}, r_2, M_2, \vee(l_3, l_4, l_7, l_{11}, l_{21}, l_{23})>, \text{where}$$

l_7 – initial place of tokens ω, with characteristics (target states, evaluation criteria) $X_{\omega}(e^{\omega}_{f,1}, e^{\omega}_{f,2}, \ldots, e^{\omega}_{f,i}, \ldots, e^{\omega}_{f,g})$, where $e^{\omega}_{f,i}$ is the evaluation of the i-th parameter of f_i ($i \leq g$) evaluation parameters (criteria of the target state, to which the built environment must correspond to the maximum extent)
l_8 – place in which the generated (in transition Z_2) tokens φ (alternative solutions) enter, with characteristics $X_{\varphi}(e^{\varphi}_{r1}, e^{\varphi}_{r2}, \ldots e^{\varphi}_{ri}, \ldots, e^{\varphi}_{rd})$, where e^{φ}_{ri} is an evaluation of the i-th solution of r_i ($i \leq d$) alternative solutions, regarding the architecture and configuration variant of the collaborative environment
l_9 – place occupied by tokens ω and ι (target states and information)
l_{11} – place of tokens (α, β, γ, ω and ι) and an implementation of a process for generating alternative solutions (φ-tokens) for architecture (configuration) of collaborative environment

l_{21} – place occupied by tokens ι (bearing acquired heuristics) and tokens φ (implemented solutions), which can be improved after analysis of the executed testing (by prototype) of the variant of the information environment

l_{23} – place occupied by tokens φ that can be used to acquire knowledge (heuristics) in new generations of solutions

$r_2 =$

	l_8	l_9	l_{10}	l_{11}
l_3	F	F	F	T
l_4	F	$W_{4,9}$	$W_{4,10}$	$W_{4,11}$
l_7	F	$W_{7,9}$	F	$W_{7,11}$
l_{11}	$W_{11,8}$	F	$W_{11,10}$	$W_{11,11}$
l_{21}	F	F	F	$W_{21,11}$
l_{23}	$W_{23,8}$	F	F	$W_{23,11}$

$W_{4,9}$ = „incoming ι-tokens are not related to the generation of alternatives”

$W_{4,10}$ = „there is a change in the characteristics of ι-tokens” (additional information is obtained about the generated solutions which can be used to support the analysis in the comparative evaluations in transition Z_1)

$W_{4,11}$ = „there is a request for information about the process of generating alternative solutions”

$W_{7,9}$ = „ω tokens are needed to evaluate alternative solutions” (in transitions Z_3 or Z_4)

$W_{7,11}$ = „there is a process of generating tokens φ” (solutions for architectures, environment configurations)

$W_{11,8}$ = „there are generated or updated tokens φ”

$W_{11,10}$ = „there are unused tokens α, β and γ” or „there are ι-tokens with changed characteristics”

$W_{11,11}$ = „alternative generation process in progress”

$W_{21,11}$ = „at place l_{21} there are tokens ι or tokens φ that need updating”

$W_{23,11} = W_{23,8}$ = „there are successful tokens φ that can be used as heuristics”

$M_2 =$

	l_8	l_9	l_{10}	l_{11}
l_3	0	0	0	N
l_4	0	$m_{4,9}$	$m_{4,10}$	$m_{4,11}$
l_7	0	$m_{7,9}$	0	$m_{7,11}$
l_{11}	$m_{11,8}$	0	$m_{11,10}$	$m_{11,11}$
l_{21}	0	0	0	$m_{21,11}$
l_{23}	2	0	0	$m_{23,11}$

$m_{4,9} = m_{4,10} = m_{4,11} = m_{7,9} = m_{7,11} = m_{11,8} = m_{11,10} = m_{11,11} = m_{21,11} = m_{23,11}$ – from 0 to the maximum number of tokens for this transition

$Z_3=<\{l_8, l_9, l_{12}, l_{15}\},\{l_{13}, l_{14}, l_{15}\}, r_3, M_3, (\wedge(l_8, l_9)\vee l_{12}\vee l_{15})>$ where

l_{12} – place in which the tokens τ (tests) enter, with characteristics $X_\tau(e^\tau_{y,1}, e^\tau_{y,2}, \ldots e^\tau_{y,i},\ldots, e^\tau_{y,s})$, where $e^\tau_{y,i}$ is an evaluation of certain parameters - such as convenience of operation, provision of the required service, speed, number of failures, etc., regarding a given alternative solution y_i ($i \leq s$)

l_{13} – place occupied by tokens φ (alternatives)

l_{14} – place occupied by tokens ι and τ (information and tests)

l_{15} – place occupied by tokens φ and τ and a process of evaluation of alternative solutions is performed

$r_3 =$

	l_{13}	l_{14}	l_{15}
l_8	F	F	T
l_9	$W_{9,13}$	F	$W_{9,15}$
l_{12}	F	$W_{12,14}$	$W_{12,15}$
l_{15}	$W_{15,13}$	F	$W_{15,15}$

$W_{9,13}$ = „incoming tokens ω and ι in place l_9 do not have characteristics for evaluation of alternatives" (not used by Z_3, but necessary for some of the following transitions)

$W_{9,15} = \neg W_{9,13}$

$W_{12,14}$ = „there are entered tokens τ in place l_{12}, which do not have characteristics for evaluation of alternatives" (not used by Z_3, but necessary for some subsequent transitions)

$W_{12,15}$ = „there are entered τ and a process of evaluation of alternative solutions is carried out"

$W_{15,13}$ = „there are φ, that have been tested" (evaluated)

$W_{15,15}$ = „alternatives check process in progress"

$M_3 =$

	l_{13}	l_{14}	l_{15}
l_8	0	0	$m_{8,15}$
l_9	$m_{9,13}$	0	$m_{9,15}$
l_{12}	0	$m_{12,14}$	$m_{12,15}$
l_{15}	$m_{15,13}$	0	$m_{15,15}$

$m_{8,15} = m_{9,13} = m_{9,15} = m_{12,14} = m_{12,15} = m_{15,13} = m_{15,15}$ – from 0 to the maximum number of tokens for this transition

$Z_4=<\{l_{13}, l_{14}, l_{18}\},\{l_{16}, l_{17}, l_{18}, l_{19}\}, r_4, M_4,(l_{13}\vee l_{14}\vee l_{18})>$, where

l_{16} – place in which the tokens φ, ι and τ enter

l_{18} – place of tokens φ, ω and ι for an implementation of a process for selecting a solution for an architecture of a collaborative environment

l_{19} – place of tokens φ (solutions that do not require prototype testing)

$r_4 =$

	l_{16}	l_{17}	l_{18}	l_{19}
l_{13}	F	F	$W_{13,18}$	F
l_{14}	$W_{14,16}$	F	$W_{14,18}$	$W_{14,19}$
l_{18}	$W_{18,16}$	$W_{18,17}$	$W_{18,18}$	$W_{18,19}$

$W_{13,18}$ = „there are entered tokens φ and a solution selection process is in progress”

$W_{14,16}$ = „ the incoming tokens ι and τ in place l_{14} do not have solution selection characteristics” (not used by Z_4, but required for transitions Z_5 and Z_6)

$W_{14,18} = \neg W_{14,16}$

$W_{14,19}$ = „there are entered tokens ι at place l_{14} which are used only for the execution of the decision” (necessary for transition Z_6)

$W_{18,16}$ = „there are tokens φ that have been evaluated and must be tested with a prototype” (for more complex systems)

$W_{18,17}$ = „there are tokens φ that are not selected” (do not meet the requirements and need to be reworked or rejected)

$W_{18,18}$ = „decision selection process in progress”

$W_{18,19}$ = „there are tokens φ, selected for final solutions” (for simpler systems when no prototype testing is required)

$M_4 =$

	l_{16}	l_{17}	l_{18}	l_{19}
l_{13}	0	0	$m_{13,18}$	0
l_{14}	$m_{14,16}$	0	$m_{14,18}$	$m_{14,19}$
l_{18}	3	$m_{18,17}$	$m_{18,18}$	$m_{18,19}$

$m_{13,18} = m_{14,16} = m_{14,18} = m_{14,19} = m_{18,17} = m_{18,18} = m_{18,19}$ – from 0 to the maximum number of tokens for this transition

$$Z_5=<\{l_{16}, l_{22}\},\{l_{20}, l_{21}, l_{22}\}, r_5, M_5, (l_{16} \wedge l_{22})>, \text{ where}$$

l_{20} – place occupied by tokens φ and ι after testing the solutions (with prototype)

l_{22} – place occupied by tokens φ, ι and τ for testing the solutions (with prototype)

$r_5 =$

	l_{20}	l_{21}	l_{22}
l_{16}	F	F	T
l_{22}	$W_{22,20}$	$W_{22,21}$	$W_{22,22}$

$W_{22,20}$ = „test passed”
$W_{22,22}$ = „the decision is being checked”
$W_{22,21} = \neg W_{22,20}$

M_5 =

	l_{20}	l_{21}	l_{22}
l_{16}	0	0	3
l_{22}	1	$m_{22,21}$	3

$m_{22,21}$ – from 0 to the maximum number of tokens for this transition

$$Z_6=<\{l_{19}, l_{20}, l_{25}\},\{l_{23}, l_{24}, l_{25}\}, r_6, M_6, (l_{19} \vee l_{20} \vee l_{25})>, \text{ where}$$

l_{24} – final (target) place occupied by the token φ (selected, tested and implemented solution for building an architecture for a collaborative environment)
l_{25} – place in which the token φ (executing final decision) and the token ι (for obtaining heuristic information from the construction process) enter

r_6 =

	l_{23}	l_{24}	l_{25}
l_{19}	F	F	T
l_{20}	F	F	T
l_{25}	$W_{25,23}$	$W_{25,24}$	$W_{25,25}$

$W_{25,24}$ = „implementation of the solution is successful”
$W_{25,23} = \neg W_{25,24}$
$W_{25,25}$ = „decision execution process in progress”

M_6 =

	l_{23}	l_{24}	l_{25}
l_{19}	0	0	$m_{19,25}$
l_{20}	0	0	$m_{20,25}$
l_{25}	$m_{25,23}$	1	1

$m_{19,25} = m_{20,25} = m_{25,23}$ – from 0 to the maximum number of tokens for this transition

3. Conclusion

The generalized net model described here is suitable for presenting the decision-making process in building collaborative environments, providing an opportunity to perform an in-depth analysis at each stage for a reasonable choice of the best solution for building the information environment. The estimations e^{α}_{p},

e^{β}_{q}, e^{γ}_{w}, e^{ι}_{v}, e^{ω}_{f}, e^{φ}_{r} and e^{τ}_{y} of the characteristics of the tokens and predicates ($W_{i,j}$) can be represent in the generalized net with different values: {0,1} – for the classical case; [0,1] – for ordinary fuzziness, or [0,1] × [0,1] – for intuitionist fuzziness and uncertainty of both types (fuzziness and chance).

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