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MODELING OF DECISION MAKING PROCESS ON THE RIVER WATER QUALITY ANALYSING BY USING GENERALIZED NETS

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Abstract: The paper represent one realization of Generalized Net (GN) for formal description of the Decision Making Process (DMP) in the River's Water Quality Management. This Generalized model of DMP includes except estimates of the water quality and decision making to improve on water quality and more rational river's water management.

Keywords: generalized nets, decision making process, river, water quality, model, management

Introduction

The Task of Decision Making includes one set of alternative actions and the person making decision, must choose the best alternative in respect of concrete goal or aggregate of goals. After decision making the person must check for the efficiency of the results. The main elements of the Decision making task are: goal, restriction, states of the environment (outside and inside), alternatives, results and rules for choice. This Decision Making Process (DMP) using and Decision Maker, when estimate quality of the river waters and search for appropriate mechanism to approve their state. The model of this process maybe to describe with Generalized Nets [1],[3].

Description of Decision Making Process's model for water quality analyzing by means of Generalized Net

According to [4], when estimate quality of the river waters is necessary to analyzing the values of following more important parameters: unsoluble substance; transparency; color; pH; NH_4+; $NO_2–$; $NO_3–$; $PO_4–$; dissolved oxygen; permanganate oxidizability; biochromate oxidizability; BOD_5.

After analyzing, the water is classify in one of following categories:

- I category – „The best clear"
- II category – „Clear"
- III category – „Satisfactory clear"
- IV category – „Polluted"
- V category – „Very polluted"

In some cases the water maybe to content very dangerous chemical substance. When the water is classify in category: „Consists of very dangers chemicals". The Decision Maker generate alternative of decision, estimating it (there efficiency, price, if have available resources and oth.) and choose one or several alternatives (making decision). After making decision, the Decision Maker verifying chosen decision (alternative) and follow execution of the decision. In the process execution of decision is possibility chosen alternative to be change or commute with other alternative. After that to making new analyze of alternatives about resources, price, technical ensure and, maybe to be chose other alternative.

The scheme of the decision making's model on water management estimate, realized by means of generalized net, is presented in figure 1. The description of the GN-model is following:

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

Z_1 – parameters estimating of river water quality
Z_2 – generating of alternatives of decisions about water quality improve
Z_3 – alternatives estimating
Z_4 – choice of alternative
Z_5 – performing and control of the decision

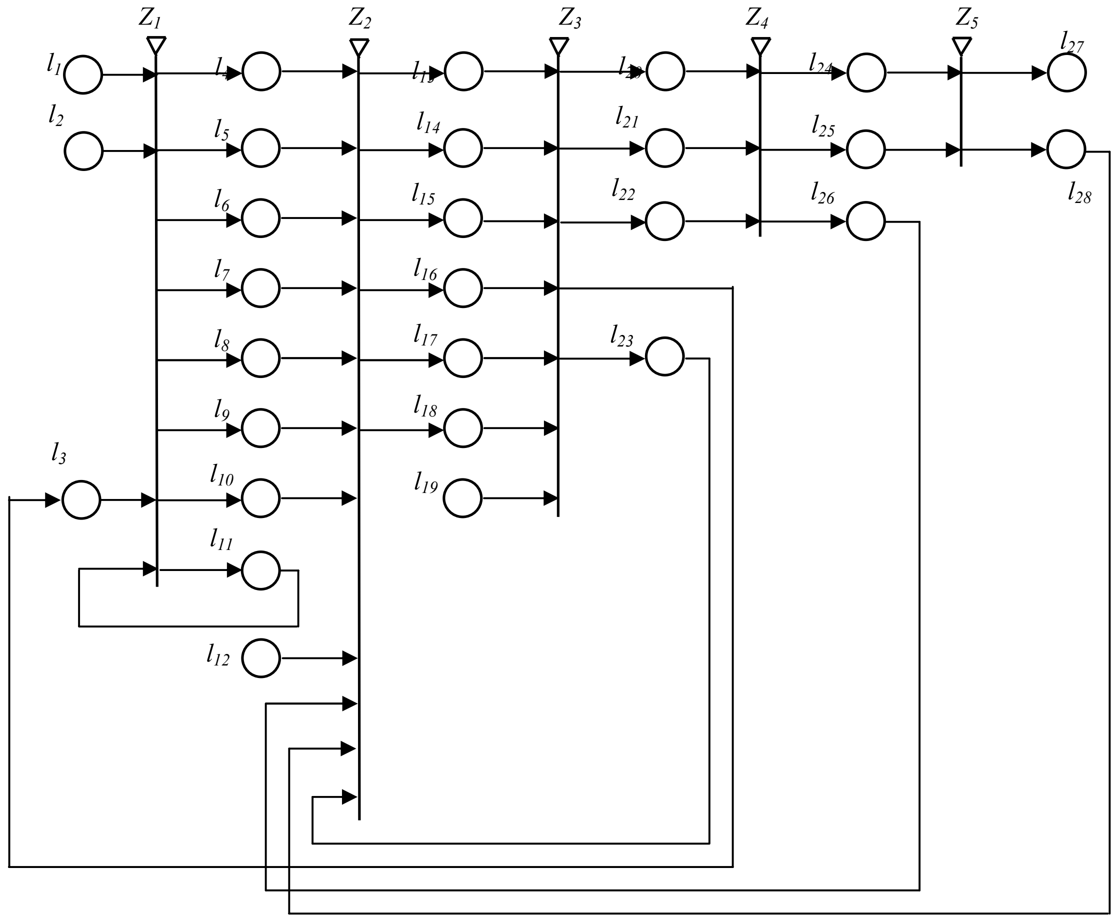

Fig.1 Generalized net model of River Water Quality Analyst Process (RWQAP) and Decision Making Process to water quality improve.

Tokens, using in Generalized Net E, are:

α – the object (system), which has been managed (river water), with following characteristics:

$X_\alpha(e^\alpha_{p1}, e^\alpha_{p2}, \ldots, e^\alpha_{pi}, \ldots, e^\alpha_{pk})$, where e^α_{pi} is the estimate on i- parameters from k $(i \le k)$ defined (essentials) estimation's parameters of water quality;

β – resources (subproducts, production powers, personal), with following characteristics:

$X_\beta(e^\beta_{r1}, e^\beta_{r2}, \ldots, {}^\beta_{ri}, \ldots, e^\beta_{rs})$, where e^β_{ri} $(i \le s)$ is the estimate on i- resources from s necessary resources for perform of some alternative;

γ - alternatives about improve the water quality methods, with following characteristics:

$X_\gamma(e^\gamma_{w1}, e^\gamma_{w2}, \ldots, e^\gamma_{wi}, \ldots, e^\gamma_{wn})$, where e^γ_{pi} is the estimate on i- parameters from w $(i \le n)$ defined (essentials) estimation's parameters;

ι – information (additional analysis of water quality, apriory information, risk and oth.), with following characteristics:

$X\iota(e^{\iota}_{v1}, e^{\iota}_{v2}, \ldots e^{\iota}_{vi}, \ldots, e^{\iota}_{vm})$,), where e^{ι}_{vi} perhaps to be estimation usefulness of information about some alternative v ($i \leq m$).

$\mathbf{e^{\alpha}_{p}}$, $\mathbf{e^{\beta}_{q}}$, $\mathbf{e^{\gamma}_{w}}$ and $\mathbf{e^{\iota}_{v}}$ are functions in the GN, where they includes values in intervals: {0,1} – for common case; [0,1] – for normal fuzzy, or [0,1], [0,1] – for intuitionistic fuzzy [2] and non-determination a both type (fuzzy and fortuity).

For flexibility estimation of the different parameters is prefer to use intuitionistic fuzzy estimations. Therefore, everywhere in the represented GN-model, the estimations $\mathbf{e_k}^{\{\alpha, \beta, \gamma, \iota\}}$ looks like:

$\mathbf{e_j}^{\{\alpha, \beta, \gamma, \iota\}} = \{<\mu_j, \nu_j> (\mu_j, \nu_j \in R \ \& \ \mu_j \geq 0 \ \& \ \nu_j \geq 0 \ \& \ \mu_j + \nu_j \leq 1)\}$, for j=1,…k, where:

μ_j – the rate of sure about particular parameter (alternative)

ν_j – the rate of unsure particular parameter (alternative)

$\pi_j = 1 - \mu_j - \nu_j$ – the rate of indetermination (potential array to non-standard making decisions)

The description of the transactions is following:

$Z_1=<\{l_1, l_2, l_3, l_{11}\},\{l_4, l_5, l_6, l_7, l_8, l_9, l_{10}, l_{11}\}, t^1_1, t^1_2, r_1, M_1, \vee(l_1, l_2, l_3, l_{11})>$, where

l_1 – initial place – here go into α-tokens – the water for analyst, which will be analyze, with characteristic $X_\alpha(e^{\alpha}_{p1}, e^{\alpha}_{p2}, \ldots, e^{\alpha}_{pi}, \ldots, e^{\alpha}_{pk})$

l_2 – initial place – here go into α-tokens – the water for analyst, when hasn't been manage analyze

l_3 – place, here go into α-tokens (the object – river water), for precise analyst

l_4 – place, here go into α-tokens, after precise analyst and are have additional characteristics

l_5 – place of α-tokens, when the water has been determinate in the category „First – the best clear"

l_6 – place of α-tokens, when the water has been determinate in the category „Second – clear"

l_7 – place of α-tokens, when the water has been determinate in the category „Third – satisfactory clear"

l_8 – place of α-tokens, when the water has been determinate in the category „Fourth – polluted"

l_9 – place of α-tokens, when the water has been determinate in the category „Fifth – very polluted"

l_{10} – place of α-tokens, when the water has been determinate in the category „Consists of very dangers chemicals"

l_{11} – initial place – here go into α-tokens – the water for analyst, when can't measure the parameters

$t^1_1 = T_0$,

$t^1_2 = t_0$ (elementary step)

r_1 =

	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}
l_1	F	$W_{1,5}$	$W_{1,6}$	$W_{1,7}$	$W_{1,8}$	$W_{1,9}$	$W_{1,10}$	$W_{1,11}$
l_2	F	F	F	F	F	F	F	$W_{2,11}$
l_3	T	T	T	T	T	T	T	T
l_{11}	F	$W_{11,5}$	$W_{11,6}$	$W_{11,7}$	$W_{11,8}$	$W_{11,9}$	$W_{11,10}$	$W_{11,11}$

T- true (allowable transition), F-false (non allowable transition)

$W_{1,5}$ – when the parameter's values corresponding to water quality category: „First – the best clear"

$W_{1,6}$ – when the parameter's values corresponding to water quality category: „Second – clear"

$W_{1,7}$ – when the parameter's values corresponding to water quality category: „Third – satisfactory clear"

$W_{1,8}$ – when the parameter's values corresponding to water quality category: „Fourth – polluted"

$W_{1,9}$ – when the parameter's values corresponding to water quality category: „Fifth – very polluted"

$W_{1,10}$ – when the parameter's values corresponding to water quality category: „Consists of very dangers chemicals"

$W_{1,11} = W_{2,11}$ – when impossibility to measure the water's parameters

$W_{11,5} = W_{11,6} = W_{11,7} = W_{11,8} = W_{11,9} = W_{11,10} = \neg W_{1,11}$

$W_{11,11}$ – await

M_1 =

	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}
l_1	0	0-max	0-max	0-max	0-max	0-max	0-max	0-max
l_2	0	0	0	0	0	0	0	0-max
l_3	0-max	0-max	0-max	0-max	0-max	0-max	0-max	0-max
l_{11}	0	0-max	0-max	0-max	0-max	0-max	0-max	0-max

$m_{1,5...1,11} = m_{2,11} = m_{3,4...3,11} = m_{11,5...11,11}$ – from 0 to maximum quantity, necessary for analyze (0-max)

Z_2=<{l_4, l_5, l_6, l_7, l_8, l_9, l_{10}, l_{12}, l_{23}, l_{26}, l_{28}},{l_{13}, l_{14}, l_{15}, l_{16}, l_{17}, l_{18}}, t^2_1, t^2_2, r_2, M_2,v(l_4, l_5, l_6, l_7, l_8, l_9, l_{10}, l_{12}, l_{23}, l_{26}, l_{28})>, where

l_3, l_4, l_5, l_6, l_7, l_8, l_9, l_{10} – as into transition Z_1

l_{12} – initial place of ι-tokens with characteristics $X\iota(e^{\iota}_{v1}, e^{\iota}_{v2}, \ldots e^{\iota}_{vi}, \ldots, e^{\iota}_{vm})$, for additional information about propriety of generated alternatives

l_{13} – place of γ-tokens (generated alternatives) when are „necessity of urgent actions (crisis)"

l_{14} – place of γ-tokens (generated alternatives) when are requisite actions "stopping pollution"

l_{15} – place of γ-tokens (generated alternatives) when are requisite actions "rectification of the river's waters"

l_{16} – place of γ-tokens (generated alternatives) when are requisite actions "increase of clear water stream"

l_{17} – place of γ-tokens (generated alternatives) when are requisite actions "alarm for danger of infection"

l_{18} – place, when missing actions

l_{23} – place, here go into β-tokens, when missing resources (or they are deficit), requisite to the γ_i - alternative

l_{26} – place, when don't chosen alternative

l_{28} – place, here go into γ-tokens, after unsuccess previous chosen alternative (back bond)

$t^2_1 = T_0$

$t^2_2 = t_0$ (elementary step)

r_2 =

	l_{13}	l_{14}	l_{15}	l_{16}	l_{17}	l_{18}
l_4	$W_{4,13}$	$W_{4,14}$	$W_{4,15}$	$W_{4,16}$	$W_{4,17}$	$W_{4,18}$
l_5	F	F	F	F	F	T
l_6	F	F	F	F	F	$W_{6,18}$
l_7	F	$W_{7,14}$	$W_{7,15}$	$W_{7,16}$	F	$W_{7,18}$
l_8	F	$W_{8,14}$	$W_{8,15}$	$W_{8,16}$	$W_{8,17}$	F
l_9	$W_{9,13}$	$W_{9,14}$	$W_{9,15}$	$W_{9,16}$	$W_{9,17}$	F
l_{10}	T	T	T	T	T	F
l_{12}	T	T	T	T	T	T
l_{23}	T	T	T	T	T	T
l_{26}	T	T	T	T	T	T
l_{28}	T	T	T	T	T	T

$W_{4,13} = W_{4,14} = W_{4,15} = W_{4,16}$ – when the result of analyst increase the norms

$W_{4,17} = W_{8,17} = W_{9,13} = W_{9,17}$ – when the result of analyst very increase the norms

$W_{4,18} = W_{6,18} = W_{7,18} = \neg W_{4,13}$ – when the parameter's values corresponding to the norms for "I-category of water"

$W_{7,14} = W_{7,15} = W_{7,16} = W_{8,14} = W_{8,15} = W_{8,16} = W_{9,14} = W_{9,15} = W_{9,16}$ – when don't missing resources

$t^2_2 = t_0$ (elementary step)

M_2 =

	l_{13}	l_{14}	l_{15}	l_{16}	l_{17}	l_{18}
l_4	0-max	0-max	0-max	0-max	0-max	0-max
l_5	0	0	0	0	0	0-max
l_6	0	0	0	0	0	0-max
l_7	0	0-max	0-max	0-max	0	0-max
l_8	0	0-max	0-max	0-max	0-max	0
l_9	0-max	0-max	0-max	0-max	0-max	0
l_{10}	0-max	0-max	0-max	0-max	0-max	0
l_{12}	0-max	0-max	0-max	0-max	0-max	0-max
l_{23}	0-max	0-max	0-max	0-max	0-max	0-max
l_{26}	0-max	0-max	0-max	0-max	0-max	0-max
l_{28}	0-max	0-max	0-max	0-max	0-max	0-max

Z_3=<{l_{13}, l_{14}, l_{15}, l_{16}, l_{17}, l_{18}, l_{19}},{l_{20}, l_{21}, l_{22}, l_{23}}, t^3_1, t^3_2, r_3, M_3,(v(l_{13}, l_{14}, l_{15}, l_{16}, l_{17}, l_{18})∧ l_{19}))>, where

l_{13}, l_{14}, l_{15}, l_{16}, l_{17}, l_{18}, l_{23} – as into transition Z_2

l_{19} – initial place, here go into β-tokens (resources) with characteristic $X_\beta(e^\beta_{q1}, e^\beta_{q2}, \ldots, {}^\beta_{qi}, \ldots, e^\beta_{qs})$

l_{20} – place, here go into the most appropriates alternatives (γ_i-tokens, i=1,..s)

l_{21} – place, here go into the appropriates alternatives (γ_j-tokens, j=1,..n)

l_{22} – place, here go into the additional (reservation) alternatives (γ_k-tokens, k=1,..m)

$t^3_1 = T_0$

$t^3_2 = t_0$ (elementary step)

r_3 =

	l_{20}	l_{21}	l_{22}	l_{23}
l_{13}	T	T	F	T
l_{14}	$W_{14,20}$	$W_{14,21}$	$W_{14,22}$	$W_{14,23}$
l_{15}	$W_{15,20}$	$W_{15,21}$	$W_{15,22}$	$W_{15,23}$
l_{16}	$W_{16,20}$	$W_{16,21}$	$W_{16,22}$	$W_{16,23}$
l_{17}	$W_{17,20}$	$W_{17,21}$	$W_{16,22}$	$W_{17,23}$
l_{18}	F	F	$W_{18,22}$	T
l_{19}	$W_{19,20}$	$W_{19,21}$	$W_{19,22}$	$W_{19,23}$

$W_{14,20} = W_{15,20} = W_{16,20}$ – if it haves requisite resources and the alternatives are with the most high estimation

$W_{14,21} = W_{15,21} = W_{16,21}$ – if it haves requisite resources and the alternatives are with high estimation

$W_{14,22} = W_{15,22} = W_{16,22}$ – if it haves requisite resources and haven't alternatives with more high estimation

$W_{14,23} = W_{15,23} = W_{16,23} = W_{17,23}$ – if it haven't requisite resources for the given alternative

$W_{17,20}$ – if it have big danger

$W_{17,21} = \neg W_{17,20}$

$W_{18,22}$ – if don't requisite additional actions (all parameter's values are in norms)

$W_{19,20} = W_{19,21} = W_{19,22} = W_{19,23}$ – if it haves requisite resources

$t^3_2 = t_0$ (elementary step)

M_3 =

	l_{20}	l_{21}	l_{22}	l_{23}
l_{13}	0-max	0-max	0	0-max
l_{14}	0-max	0-max	0-max	0-max
l_{15}	0-max	0-max	0-max	0-max
l_{16}	0-max	0-max	0-max	0-max
l_{17}	0-max	0-max	0	0-max
l_{18}	0	0	0-max	0-max
l_{19}	0-max	0-max	0-max	0-max

$Z_4=<\{l_{20}, l_{21}, l_{22}\},\{l_{24}, l_{25}, l_{26}\}, t^4_1, t^4_2, r_4, M_4,(l_{20} \vee l_{21} \vee l_{22})>$, where

$l_{20}, l_{21}, l_{22}, l_{26}$ – as into transitions Z_3 и Z_2

l_{24} – place with the best alternatives (γ_{best} – tokens)

l_{25} – place with additional (reserve) alternatives (γ_{add} – tokens)

$t^4_1 = T_0$,

$t^4_2 = t_0$ (elementary step)

r_4 =

	l_{24}	l_{25}	l_{26}
l_{20}	$W_{20,24}$	$W_{20,25}$	$W_{20,26}$
l_{21}	$W_{21,24}$	$W_{21,25}$	$W_{21,26}$
l_{22}	$W_{22,24}$	$W_{22,25}$	$W_{22,26}$

$W_{20,24} = W_{21,24} = W_{22,24}$ – if the alternative is chosen

$W_{20,25} = W_{21,25} = W_{22,25} = \neg W_{20,24}$

$W_{20,26} = W_{21,26} = W_{22,26}$ – if are requisite resources

M_4 =	l_{24}	l_{25}	l_{26}
l_{20}	0-max	0-max	0-max
l_{21}	0-max	0-max	0-max
l_{22}	0-max	0-max	0-max

Z_5=<{l_{24}, l_{25}},{l_{27}, l_{28}}, t^5_1, t^5_2, r_5, M_5,(l_{24} v l_{25})>, where

l_{24}, l_{25}, l_{26}, l_{28} – as into transitions Z_4, Z_2 and Z_1

l_{27} –place, here go into γ-tokens after perform and verification of decision (success of the chosen alternative)

$t^5_1 = T_0$,

$t^5_2 = t_0$ (elementary step)

R_5 =	l_{27}	l_{28}
l_{24}	$W_{24,27}$	$W_{24,28}$
l_{25}	$W_{25,27}$	$W_{25,28}$

$W_{24,27} = W_{25,27}$ – if the decision is successful

$W_{24,28} = W_{25,28} = \neg W_{24,27}$

M_5 =	l_{27}	l_{28}
l_{24}	0-max	0-max
l_{25}	0-max	0-max

Conclusion

The finding of enough efficient and grounded decisions in the waters management is very complex process, because Decision making process is working with a large set of data, a big part of which are with fuzzy and non-precise character. The person often makes decisions in limited conditions – time, resources, data, risk and oth. The GN-model of the Decision making process, represented in this paper, is one attempt to using of GN(s) for modelling to water management processes and especially in water's quality estimates. Generalized nets are flexibility, simple and quiet effective formalism for description making of complex water management processes.

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