Fuzzy Petri nets in modelling business processes

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Abstrakt. To describe the „behaviour“ of business processes are used final automats which have a lot of restrictions. This can be simply solved by Petri nets which are more suitable because of their precision and exact specification. In case of extensive real business processes, where connections between individual activities it's possible to describe only vaguely would be more suitable to use classical Petri nets with applied fuzzy logic. This article is about description a application of fuzzy Petri nets for modelling these business processes.

Key words: business processes, fuzzy modelling, Petri nets.

1 Business processes modelling

During business processes modelling is important to devotedly describe associations between activities and roles represented by abilities of participants involved in the process as an activity we understand on atomic (no more divisible) step in the process execution. Role is set of skills which mutually supplement each other. Roles are assigned to individual activities to let them full fill in scope of process execution.

Generally we have three basic approaches for process modelling which are based on elemental types of used abstraction [5]:

1. Functional approach which is aimed at functions, their structures, inputs and outputs.

2. Approach of behaviour specifications aimed at operating aspect of process execution by setting up the events and conditions according to which these individual activities can be executed.

3. Structural approach is aimed at static aspect of process. The goal is to affect entities and sources appearing in process within their attributes, activities (services) and mutual relations.

To describe the behaviour of business processes are used the **final automats**, which have a lot of restrictions e.g. in number of statuses in modelling complicated processes. In order to that are often used Petri nets which were created for extension purposes of modelling possibilities of final automats.

As an advantage of business process modelling by Petri nets we see their formal description which supplements the graphic illustration. Thereby is permit precise and exact specification of the process and so is possible to remove definiteness, uncertainty and contradiction. Except clear graphic expression Petri nets have also very well defined mathematic basics which can be used in various software tools for specification and analysis of business processes solved by IT.

But anyway classical Petri nets can have certain problems in modelling of real and complicated processes. From this reason were created extensions aimed at procuration of increase of modelling power. It is about possibilities for:

- hierarchization,
- Petri nets with additional time,
- Coloured Petri nets.

2 Fuzzy modelling

As another approach of description of real business processes is application of **fuzzy modelling** [4]. If we would like to describe complicated reality then we can decide between relevance of information, which is less exact, and accuracy of information which will be less relevant. If you would increase the exact of processes description we get at the point when accuracy and relevance become mutually contradictable characteristics. For instance process of car production is possible to describe by few sentences where we globally describe individual parts of car and assembly sequence. We found out this way how to assemble a car but we won't know anything about the relations between the individual components, machines and people. If we would like to know more details we have to add data about machines' permeability, performance of people, order of tables etc. But the amount of information is increasing in this case. And they are more exact that mean we will know more but just about a small part of processes in company. If we would like to describe these all processes in company into such details it would end up with huge amount of detail information which nobody would be able to read. A if so, than to understand to such amount of information he would need to use natural language so I would refer to vague characteristic. In other case he would get lost in such exact details because human mind is limited. We can see that accuracy is just illusion, for it is essentially attainable. All these facts are in the background of considerations of fuzzy logic founders [6]. Fuzzy logic basically comes from theory of fuzzy sets and is concerned on vagueness described by mathematics.

In this context there is fuzzy set defined as a set which except of full or no membership permits also partial membership. That means that the item belongs into a set with some particular degree of membership. Function, which links to every single item from universum a degree of membership, is called membership function. Fuzzy theory tries to cover the reality in its vagueness and uncertainty. During nearly 40 years existence is worthy of many solutions of technical problems which was impossible to solve by other tools in practise. To every single item is possible to add the Degree of membership which expresses the measure of membership to particular item into fuzzy set. For instance: when you try to manage complaint of supplier you can set up the measure of membership of the same type of bug into fuzzy sets. You can decide which parts are "good", which parts is possible to "process yet" and which parts is necessary to "scrap". For classical deciding is in this case possible to set up limits of what is still admissible and what is not any more too hard. We can add number from interval <0,1>, which express measure of our conviction. Fuzzy theory notices vaguely specified requirements in question and adequately calculate for that the degree of membership. Fuzzy logic let us use vagueness directly and knows also how to represent it easily.

3 Fuzzy Petri nets

Integration of fuzzy logic into classical Petri nets is possible to implement as following. Let's use definition of fuzzy logic Petri net.

FLPN = (P,T,F,M_0,D,h,a, θ, l) where

P = {p_1, …, p_n} is final set of places,

T = {t_1, …, t_m} is final set of transitions,

F $\subseteq$ (P x T) $\cup$ (T x P) is flow relation, where is

$$\forall t \in T\ \exists p,q \in P : (p,t) \vee (t,q) \in F\ ,$$

M_0: $P \rightarrow \{0,1\}$ is initial marking,

D is final set of statements – $P \cap D = T \cap D = \emptyset, |P| = |D|$,

h: $P \rightarrow D$ is associated function representing bijection from place to statement,

a: $P \rightarrow [0,1]$ is associated function representing a value in place from set of real numbers from 0 to 1,

θ, l: $T \rightarrow [0,1]$ is associated function representing transition value from set of 0 to 1.

For $\forall$ x$\in (P \cup T)$

${}^{\bullet}x = \{y \mid yFx\}$, input set (preset) element x

$x^{\bullet} = \{y \mid xFy\}$, output set (postset) element x

For $\forall p \in P$, valid for following:

$M'(p) = M(p) + 1,$ if $p \in t^{\bullet} - {}^{\bullet}t$;

$M'(p) = M(p) - 1,$ if $p \in {}^{\bullet}t - t^{\bullet}$;

$M'(p) = M(p),$ otherwise,

$\alpha(p) = \lambda_t \alpha(p')$ if $\alpha_1 \geq \theta_t \wedge p \in t^{\bullet} \wedge p' \in {}^{\bullet}t$.

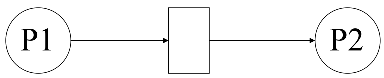
Pro $t \in T^{AND}$ is $\alpha(p) = \lambda_t \min_{\forall p' \in {}^{\bullet}t} \alpha(p')$ if

$$\min_{\forall p' \in {}^{\bullet}t} \{\alpha(p')\} \geq \theta_t \wedge p \in t^{\bullet}$$

a pro $t \in T^{OR}$ is $\alpha(p) = \lambda_t \max_{\forall p' \in {}^{\bullet}t} \alpha(p')$ if

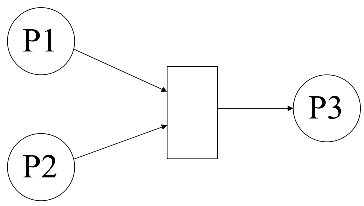
$$\max_{\forall p' \in {}^{\bullet}t} \{\alpha(p')\} \geq \theta_t \wedge p \in t^{\bullet}.$$

Now let's express IF-THEN rules and their transformation into fuzzy logic by Petri nets.
Rule IF p1 THEN p2 let's express



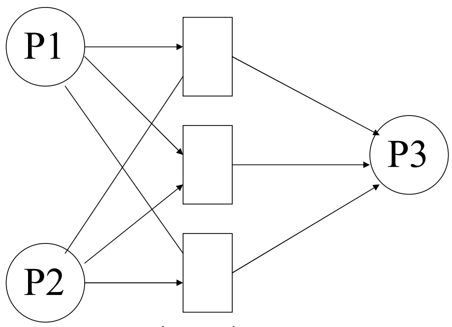
And in fuzzy logic $\alpha_2 = \lambda_t \alpha_1$ if $\alpha_1 \geq \theta_t$.

Rule IF p1 AND p2 THEN p3 is expressed:



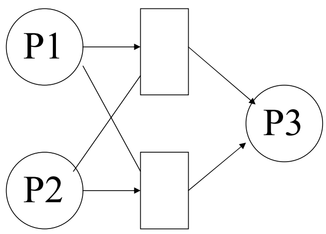
And in fuzzy logic $\alpha_3 = \lambda_t \min_{\alpha_i \geq \theta_{t_{AND}}} \{\alpha_1 \alpha_2\}$ pro i=1 $\wedge$ 2.

Rule IF p1 OR p2 THEN p3 we express by inhibitive edges



And in fuzzy logic $\alpha_3 = \lambda_{t_{OR}} \max_{\alpha_i \geq \theta_{t_{OR}}} \{\alpha_1 \alpha_2\}$ pro i=1 $\vee$ 2.

Rule IF p1 XOR p2 THEN p3 express by inhibitive edges



And in fuzzy logic $\alpha_3 = \lambda_{t_{XOR}} \alpha_1$ if $\alpha_1 \geq \theta_{t_{XOR}} \wedge \alpha_2 = 0$,

$\alpha_3 = \lambda_{t_{XOR}} \alpha_2$ if $\alpha_2 \geq \theta_{t_{XOR}} \wedge \alpha_1 = 0$.

By the application of fuzzy logic into Petri nets spring up strong tool for modelling of real business processes especially for:

- Easy comprehensibility and elaborate mathematic devise,

- Quite easy and simple proposal,
- Modulability of solution – it is possible to add and delete individual modules without necessity of recreating the whole system,
- Robustness of suggestion that means system is not necessary to modify in case of change of solution parameters of task in frame of particular surroundings.

4 Integration of system for modelling of business processes with information system QI

For securing good quality of company management is advantageous to integrate information system with process system. This integration let us to do change in incorporation of information system. His functions are machine-controlled and run by process system that means that information system purvey an order of functions to users and at the same time hand over reports to process system which evaluate them and according to the results process the movement in process map. This way is implemented the run of functions of information system by process system.

University of Ostrava in Ostrava in cooperation with company DCC a.s. generate currently a tool for process management and its implementation into information system QI [2]. The goal is to create inside of the information QI a tool which will work on the basics of fuzzy Petri nets.

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