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Recruitment and selection process for project team based on fuzzy model

1. Introduction

Recruitment and selection refers to the chain and sequence of activities pertaining to recruitment and selection of employable candidates and job seekers for a project. Every enterprise, business, start-up and entrepreneurial firm has some well-defined employment and recruitment policies and hiring procedures [9]. Methods and soft tools implemented in hiring process can be categorized to one from four groups:

- Assessment of application forms: curriculum vitae, covering letter, personal questionnaire, certificates and diplomas, education rankings;
- Inspection of references: written references, verbal references;
- Interviews: formalized proceedings, informal/easy conversations;
- Tests: skills/competency tests, samples and simulations of work, medical tests, psychological tests.

Some of employers also use of Assessment Center/Development Center services that guarantee professional and complex performance of recruitment process.

All of mentioned methods apart from good points have also bad one that significantly affects on selecting quality. Main disadvantages of described methods are as follow:

- carry out and verify tests for all applicants require great cost of time and labor, thus in situation of large amount of applications there exist a suspicion of unconscientiously work performance,
- assessment of application forms and the review process carried out by human resource can be exposing on lack of impartiality.

The wide description of the recruitment and selection process, as well as tools, methods and methodologies based on psychological tests and standard procedures can be found in exemplary scientific publications [1], [2], [3], [4], [5], [6], [7], [8]. Although all of them presents proposition of the practical attitude to the problem, they don't present however general methodology, which can be implemented to any project team and they don't give the information how to asses the cohesion of the recruited team.

In the light of the aforementioned prerequisites it is easy to notice that there is a need to develop one general model and solving method of structuring project team process, implementation of which ensue:

- impartial and non emotional, thus a fair assessment of each candidate,
- uniform procedure of verification for all applicants.

Determine reference model will form ground for formulate and solve class of problems define in next paragraph.

2. Problem statement

Given is a project, characterized by its complexity, specific/required character of management and time window for its execution.

Given is a set of vacancies necessary to fill in a project team, characterized by required competency level, experience, availability, MBTI profile.

Given is a set of candidates for vacant posts, characterized by their competencies, work experience, psychological profile and availability.

Information about project, vacancies and candidates are formulated in linguistic way. Values of decision variables are define in both precise (crisp) and imprecise (fuzzy) way and can take a form of numbers as well as words.

The following questions are considered:

Does there exist a project team (set of alternative projects teams) allowing to achieve assumed project objectives?

If YES:

Which combination of candidates (alternative sets) allow to achieve assumed project objectives?

Does there exist a candidate, who fulfils given set of the basic criteria and is well adjusted to the project team?

If YES:

Which of candidates is best adjusted to vacant post and to project team?

This paper presents a proposition of general reference model based on fuzzy set theory, model that allows defining and resolving structuring project teams decision problems. Proposed model combine precise and imprecise values of decision variables.

3. Model of recruitment and selecting process

The structuring process of project team has been modeled in three stages.

Stage 1 – Defining of project requirements:

- determination of expected competency level for each post in project,
- determination of behavioral type for each post in project,
- project complexity,
- project character;

Project requirement reference model is multiply input – multiply output (MIMO) type, where project complexity and project character are input variables, while expected competency level for post and expected MBTI profile for post are output variables (Dig. 1).

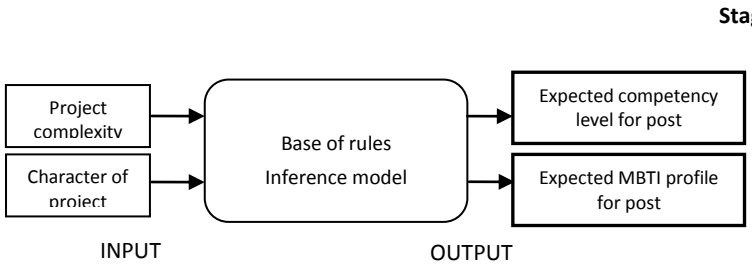

Diagram 1. Multiply input- Multiply output model for Stage 1 recruitment and selection process

The first stage allows identify the main requirements following from project specification.

Stage 2 – Preliminary verification process includes analyzing of application forms and selection of candidates. Following assessment criteria are taken in to consideration: set of basic criteria, set of required competency, adjustment to Myers-Briggs Type Indicator (MBTI) for chosen posts in project team, availability in given period of time;

Preliminary selection reference model is multiply input – single output (MISO) type. Implementation of this model is additionally divided into four steps (Dig. 2). First step includes all applicants and on every subsequent step the number of candidates is reduce to successful ones from previously stage, that mean candidates with

sufficient adjustment to the post without constraint of grade of membership level. On the last, fourth step of verification, the output list of successful candidates is sort according to grade of membership.

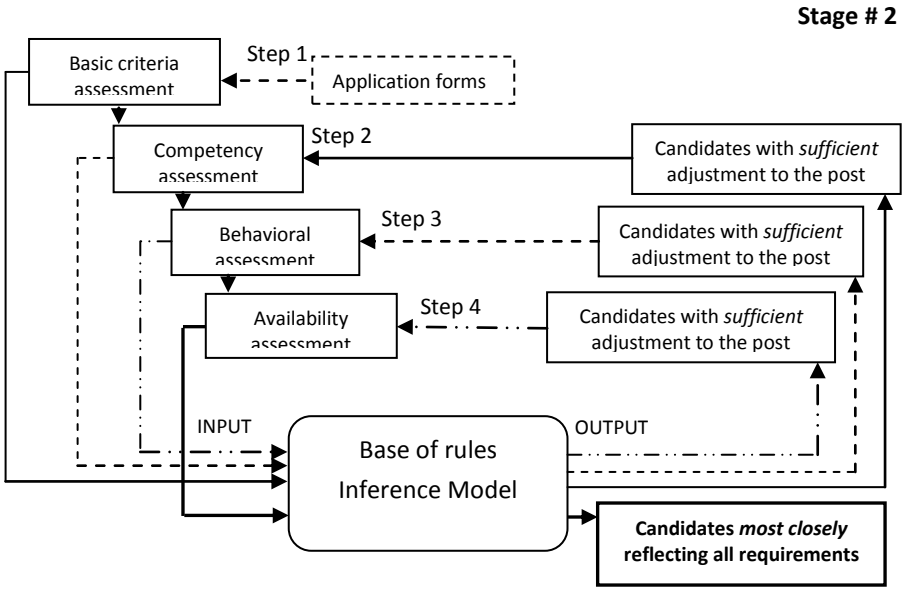

Diagram 2. Model of preliminary selection process

In that way the final set of verified candidates can be placed under final verification process on Stage 3.

Stage 3 – Final selection includes:

- determination of final set of candidates and reserve list, depending on output variables ranges obtained on previous stages,
- grouping chosen set of candidates into alternative project teams, according to psychological profile of group conformity.

Reference model based on fuzzy logic theory is divided according too above named three stages in to: project requirements reference model, preliminary verification reference model and final selection reference model.

4. Fuzzy reference model

Given is a set of linguistics variables $V_i = \{V_1, \ldots, V_n\}$, $i \in \mathrm{N} - \{0\}$, defining input and output criteria of candidates assessment in structuring process of project team. Linguistic variable V_i is characterized by a quadruple $[L_i, T_i(L), \Omega_i, M_i]$, where:

- $L_i = \{L_1, \ldots, L_n\}$, $i \in \mathrm{N} - \{0\}$ – set of names of linguistic variables;
- $T_i(L_i) = \{T_1(L_1), \ldots, T_n(L_n)\}$, $i \in \mathrm{N} - \{0\}$ – set of countable term set of labels or the linguistic values;
- $t_{ij} = \{t_{11}, t_{12}, \ldots, t_{nm}\}$, $i,j \in \mathrm{N} - \{0\}$, $t_{ij} \subset T_i(L_i)$ – set of the linguistic values of linguistic variable;
- $\Omega_i = \{\Omega_1, \ldots, \Omega_n\}$, $i \in \mathrm{N} - \{0\}$ – set of a universes of discourse of linguistic variable V_i;
- $M_i = \{M_1, \ldots, M_n\}$, $i \in \mathrm{N} - \{0\}$ – set of semantic rules;
- $m_{ij} = \{m_{11}, m_{12}, \ldots, m_{nm}\}$, $i,j \in \mathrm{N} - \{0\}$, $m_{ij} \subset M_i$ – variability range for linguistic value t_{ij} with grade of membership equal 0 or 1.

Given are standard, piecewise linear shapes of membership functions (MBF) represents the degree to which the crisp value of linguistic variables V_i belong to a fuzzy set. In other words, MBF represents terms describing linguistic variables.

Although scientific publications have suggested many different types of MBF for fuzzy logic, standard MBF are used in most practical applications. Great value of piecewise linear type of MBF is the fact, that only

minimum information is necessary to define them. For example to define triangular MBF it is enough to define three values: most typical value as a middle of variability range also maximum and minimum values for that range.

Reference model assume using of following MBF shapes (Dig. 3):

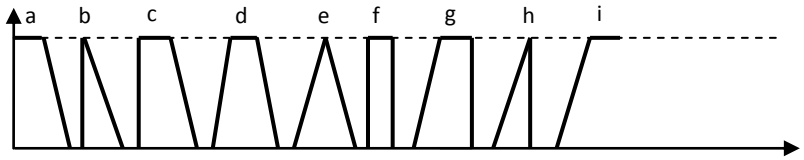

Diagram 3. Shapes of most common piecewise linear membership functions

a) Left external (**LE**); b, h) Triangular asymmetrical (**TA**); c, g) trapezoidal asymmetrical (**TRA**); d) trapezoidal symmetrical (**TRS**), e) triangular symmetrical (**TS**), f) rectangular (**R**), i) right external (**RE**).

Table 1. Project requirement reference model

PROJECT REQURIMENTS REFERENCE MODEL						
$\mathbf{V_i}$	$\mathbf{L_i}$	$\mathbf{T_i(L_i)}$	$\mathbf{t_{ij}}$	$\mathbf{\Omega_i}$	$\mathbf{M_i}$	$\mathbf{m_{ij}}$
V_1	Project complexity level	$T_1(L_1)$	t_{11}(low) t_{12}(medium) t_{13}(high)	*expert knowledge*	M_1	*expert knowledge*
V_2	Project character	$T_2(L_2)$	t_{21}(technical) t_{22}(technical/soft) t_{23}(soft)	*expert knowledge*	M_2	*expert knowledge*
V_3	Expected competency level for post	$T_3(L_3)$	t_{31}(medium) t_{32}(medium high) t_{33}(high)	*expert knowledge*	M_3	*expert knowledge*
V_4	Expected MBTI profile for post	$T_4(L_4)$	t_{41}(ISTJ) t_{42}(ISTP) t_{43}(ESTP) t_{44}(ESTJ) t_{45}(ISFJ) t_{46}(ISFP) t_{47}(ESFP) t_{48}(ESFJ) t_{49}(INFP)	[1÷16] *u: points*	M_4	m_{41} [1:1] S m_{42} [2:1] S m_{43} [3:1] S m_{44} [4:1] S m_{45} [5:1] S m_{46} [6:1] S m_{47} [7:1] S m_{48} [8:1] S m_{49} [9:1] S

			t_{410}(ENFP) t_{411}(ENFJ) t_{412}(INTJ) t_{413}(INTP) t_{414}(ENTP) t_{415}(ENTJ) t_{416} (INFJ)			m_{410} [10:1] S m_{411} [11:1] S m_{412} [12:1] S m_{413} [13:1] S m_{414} [14:1] S m_{415} [15:1] S m_{416} [16:1] S

Table 2. Preliminary verification reference model

PRELIMINARY VERIFICATION REFENRECE MODEL						
V_i	**L_i**	**$T_i(L_i)$**	**t_{ij}**	**Ω_i**	**M_i**	**m_{ij}**
V_5	Practice on independently post	$T_5(L_5)$	t_{51}(low) t_{52}(medium low) t_{53}(medium high) t_{54}(high)	*Expert knowledge*	M_5	*Expert knowledge*
V_6	Participation in project teams	$T_6(L_6)$	t_{61}(small) t_{62}(medium) t_{63}(high)	*Expert knowledge*	M_6	*Expert knowledge*
V_7	Candidate competency level	$T_7(L_7)$	t_{71}(low) t_{72}(medium) t_{73}(high)	*Expert knowledge*	M_7	*Expert knowledge*
V_8	MBTI profile	$T_8(L_8)$	t_{81}(ISTJ) t_{82}(ISTP) t_{83}(ESTP) t_{84}(ESTJ) t_{85}(ISFJ) t_{86}(ISFP) t_{87}(ESFP) t_{88}(ESFJ) t_{89}(INFP) t_{810}(ENFP) t_{811}(ENFJ) t_{812}(INTJ) t_{813}(INTP) t_{814}(ENTP) t_{815}(ENTJ) t_{816} (INFJ)	[1÷16] *u: points*	M_8	m_{81} [1:1] S m_{82} [2:1] S m_{83} [3:1] S m_{84} [4:1] S m_{85} [5:1] S m_{86} [6:1] S m_{87} [7:1] S m_{88} [8:1] S m_{89} [9:1] S m_{810} [10:1] S m_{811} [11:1] S m_{812} [12:1] S m_{813} [13:1] S m_{814} [14:1] S m_{815} [15:1] S m_{816} [16:1] S
V_9	Availability	$T_9(L_9)$	t_{91}(consistent) t_{92}(inconsistent)	*Expert knowledge*	M_9	*Expert knowledge*
V_{10}	Post character	$T_{10}(L_{10})$	t_{101}(independent) t_{102}(dependent)	*Expert knowledge*	M_{10}	*Expert knowledge*
V_{11}	Post adjustment	$T_{11}(L_{11})$	t_{111}(sufficient) t_{112}(insufficient)	*Expert knowledge*	M_{11}	*Expert knowledge*

Table 3. Input and output data for second stage of verification process

STEP	Input variables	Output variables
1	V_5, V_6, V_{10}	V_{11}
2	V_7, V_{10}	V_{11}
3	V_8, V_{10}	V_{11}
4	V_9, V_{10}	V_{11}

As the results of Stage 2 obtained is a set of candidates fulfill with at least 0.5 grade of membership all basic criteria. On this stage however candidates are not jet categorized according to their achieved results, and also are not 'confront whit each other'. That mean the competencies of candidates are enough for the posts, but there is no guarantee of effective, peaceable cooperation with others team members. Those two important elements are obtained and verify on Stage 3.

The final selection process, as in the case of the second Stage, is divided in to two steps. The first step allows categorizing selected on Stage 2 candidates according to the results achievements. That allows creating a list of basic candidates for project team, and two additional reserve lists.

The second step of final selection process allows checking adjustment of chosen candidates according to their MBTI profile, and ability to work in selected team. It is crucial stage, as it is know that even the best specialist, when are unable to work with each other, can bring undertaken project to failure.

The reference model for step one in final selection process is MISO type, where V_7,V_8,V_{11}, are input variables and V_{12} is output variable.

As the result of this process three list of candidates are prepared: **basic list** includes candidates who assignment to the vacant post is not les than 0.8 grade of membership; **reserve A list** includes candidates who assignment to the vacant post is between 0.6÷ 0.8 grade of membership, **reserve B list** includes candidates who assignment to the vacant post is between 0.5 ÷ 0.6 grades of membership.

Table 4. Final selection reference model 1

FINAL SELECTION REFERENCE MODEL 1						
V_i	**L_i**	**$T_i(L_i)$**	**t_{ij}**	**Ω_i**	**M_i**	**m_{ij}**
V_7	Competency level	$T_7(L_7)$	t_{72}(medium) t_{73}(high)	*Expert knowledge*	M_7	*Expert knowledge*
V_8	MBTI profile	$T_8(L_8)$	t_{81}(ISTJ) t_{82}(ISTP) t_{83}(ESTP) t_{84}(ESTJ) t_{85}(ISFJ) t_{86}(ISFP) t_{87}(ESFP)	[1÷16] *u: points*	M_8	m_{81} [1:1] S m_{82} [2:1] S m_{83} [3:1] S m_{84} [4:1] S m_{85} [5:1] S m_{86} [6:1] S m_{87} [7:1] S

			t_{88}(ESFJ) t_{89}(INFP) t_{810}(ENFP) t_{811}(ENFJ) t_{812}(INTJ) t_{813}(INTP) t_{814}(ENTP) t_{815}(ENTJ) t_{816} (INFJ)			m_{88} [8:1] S m_{89} [9:1] S m_{810}[10:1] S m_{811}[11:1] S m_{812}[12:1] S m_{813}[13:1] S m_{814}[14:1] S m_{815}[15:1] S m_{816}[16:1] S
V_{11}	Post adjustment	$T_{11}(L_{11})$	t_{111}(sufficient) t_{112}(insufficient)	*Expert knowledge*	M_{11}	*Expert knowledge*
V_{12}	Assignment	$T_{20}(L_{20})$	T_{201}(basic) T_{202} (reserveA) T_{203}(reserveB)	*Expert knowledge*	M_{20}	*Expert knowledge*

The second step of the final selection process allows compare of chosen candidates according to the posts and relation occurring between those posts and to MBTI profile of candidates. The comparison results alternative sets of team, fulfilling given assessment criteria, are generated.

Table 5. Final selection reference model 2

TEAM ADJUSTMENT REFERENCE MODEL 2						
V_i	**L_i**	**$T_i(L_i)$**	**t_{ij}**	**Ω_i**	**M_i**	**m_{ij}**
V_{13}	Post A character	$T_{13}(L_{13})$	$t_{13,1}$(executive) $t_{13,2}$(subsidiary)	*Expert knowledge*	M_{13}	*Expert knowledge*
$V_{13'}$	Post B character	$T_{13'}(L_{13'})$	$t_{13',1}$(executive) $t_{13',2}$(subsidiary)	*Expert knowledge*	M_{14}	*Expert knowledge*
V_8	MBTI profile candidate A	$T_8(L_8)$	$t_{8,1}$(ISTJ) $t_{8,2}$(ISTP) $t_{8,3}$(ESTP) $t_{8,4}$(ESTJ) $t_{8,5}$(ISFJ) $t_{8,6}$(ISFP) $t_{8,7}$(ESFP) $t_{8,8}$(ESFJ) $t_{8,9}$(INFP) $t_{8,10}$(ENFP) $t_{8,11}$(ENFJ) $t_{8,12}$(INTJ) $t_{8,13}$(INTP) $t_{8,14}$(ENTP) $t_{8,15}$(ENTJ) $t_{8,16}$ (INFJ)	[1÷16] *u: points*	M_8	$m_{8,1}$ [1:1] S $m_{8,2}$ [2:1] S $m_{8,3}$ [3:1] S $m_{8,4}$ [4:1] S $m_{8,5}$ [5:1] S $m_{8,6}$ [6:1] S $m_{8,7}$ [7:1] S $m_{8,8}$ [8:1] S $m_{8,9}$ [9:1] S $m_{8,10}$ [10:1] S $m_{8,11}$ [11:1] S $m_{8,12}$ [12:1] S $m_{8,13}$ [13:1] S $m_{8,14}$ [14:1] S $m_{8,15}$ [15:1] S $m_{8,16}$ [16:1] S

$V_{8'}$	MBTI profile candidate B	$T_8(L_8)$	$t_{8,1}$(ISTJ) $t_{8,2}$(ISTP) $t_{8,3}$(ESTP) $t_{8,4}$(ESTJ) $t_{8,5}$(ISFJ) $t_{8,6}$(ISFP) $t_{8,7}$(ESFP) $t_{8,8}$(ESFJ) $t_{8,9}$(INFP) $t_{8,10}$(ENFP) $t_{8,11}$(ENFJ) $t_{8,12}$(INTJ) $t_{8,13}$(INTP) $t_{8,14}$(ENTP) $t_{8,15}$(ENTJ) $t_{8,16}$ (INFJ)	[1÷16] *u: points*	$M_{8'}$	$m_{8,1}$ [1:1] S $m_{8,2}$ [2:1] S $m_{8,3}$ [3:1] S $m_{8,4}$ [4:1] S $m_{8,5}$ [5:1] S $m_{8,6}$ [6:1] S $m_{8,7}$ [7:1] S $m_{8,8}$ [8:1] S $m_{8,9}$ [9:1] S $m_{8,10}$ [10:1] S $m_{8,11}$ [11:1] S $m_{8,12}$ [12:1] S $m_{8,13}$ [13:1] S $m_{8,14}$ [14:1] S $m_{8,15}$ [15:1] S $m_{8,16}$ [16:1] S
V_{14}	Effectiveness of cooperation	$T_{14}(L_{14})$	t_{14}(low) t_{14}(medium) t_{14}(high)	*Expert knowledge*	M_{14}	*Expert knowledge*

Models shown in tabular presentations Tab1., Tab2., Tab4., Tab5., includes following symbols for MBTI profiles combination: *E* – Extraversion, *I* – Introversion, *S* – Sensing, *N* – Intuition, *T* – Thinking, *F* – Feeling, *J* – Judging, *P* – Perceiving.

To conduct the structuring process basing on presented reference models it is necessary to implement this model in fuzzy system.

5. Fuzzy system structure

Fuzzy system implementing proposed in chapter 4 reference model is presented on diagram 4. This system includes all divided reference models from Stage 1 to Stage 3.

It can be notice that designed system structure includes seven rule bases. This solution follows from two main reasons.

Process of candidates verification is divided on stages and steps, which means, that on each step different criteria's are checked; this allow on gradual selection of candidates; from this reason output values form one stage are implemented as an input values for next stage.

Divided rule bases allow to minimize number of rules taking part in inference process; for example if on stage 2 instead of four different rule blocks with total number of rules equal 66, only one rule block would be design, the number of rules would increase to 1536. Rule base with so many rules is difficult to design and to guarantee correctness of its implementation. Moreover computation of the results would require more time.

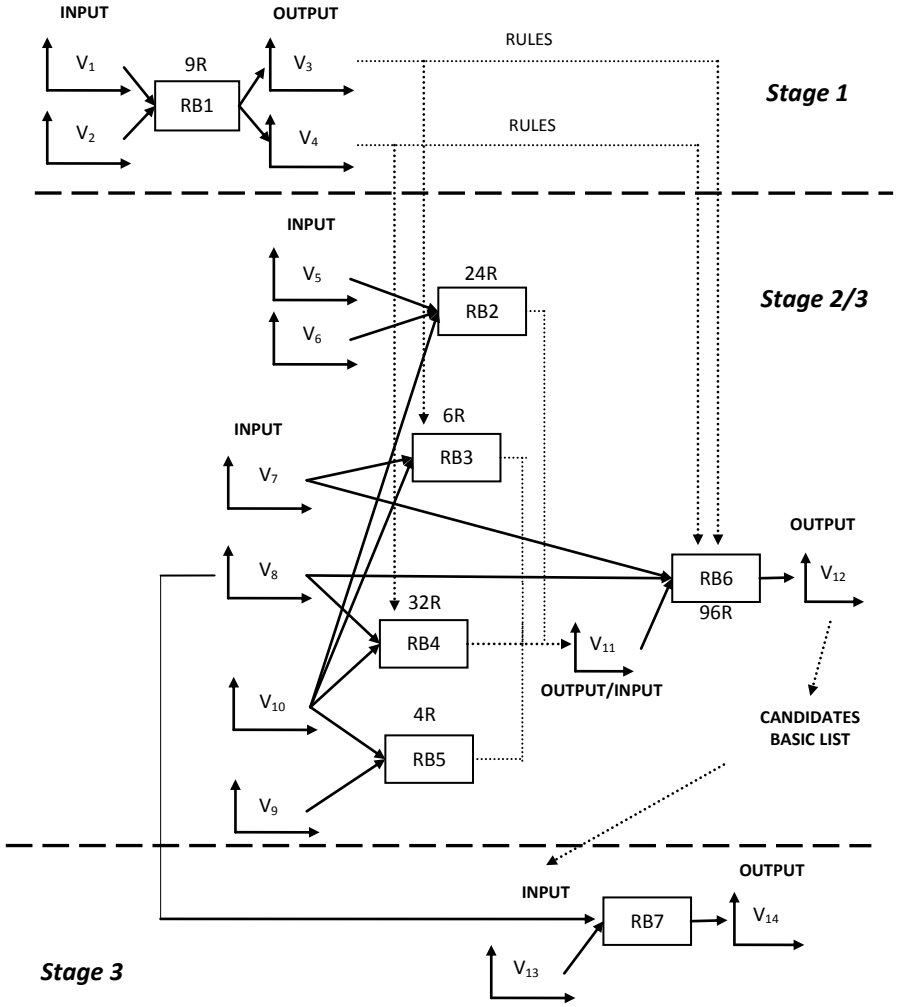

Diagram 4. Fuzzy system structure

According to presented diagram 4, rule base number 1 is applied on Stage 1 in project requirements specification. Output information form this stage constitutes input project criteria defined in rule base on Stage 2.

For Stage 2 four rule bases are defined – number 2, 3, 4 and 5. Output variable V_{11} from this Stage is apply as an input variable for Stage 3 with rule bases number 6 and 7.

As the result of the inference in rule base number 6 obtained is the basic list of best-adjusted candidates, and two additional reserve lists. The candidates form basic list are verify on next step (rule base number 7) according to their psychological profile and effectiveness of cooperation in given project team. That allow to group chosen candidates in project teams.

6. Conclusion remarks

The article present proposition of general reference model for recruitment and selection process, which is included to the multicriteria decision problems. Within the framework of proposed reference model supplementation of verify and determine membership function shapes implemented for describing linguistic variables variability ranges is necessary. Simultaneously tasks allowing defining and solving reverse decision problems in structuring team process are undertaken. The reverse problem allow answer to the exemplary question: Does there exist such a combination of qualification and competencies level for given project team, which guarantee successful implementation of project tasks? And if 'yes' What are the variability ranges of competencies, qualification and psychological profile for particular team members that guarantee undisturbed project execution and achievement of project objectives?

References

1. BELBIN M. R.: *Team Roles at Work*, Butterworth Heinemann, 2nd ed., 2010
2. BELBIN M. R.: *Management Teams: Why They Succeed or Fail*, Butterworth Heinemann, 3rd ed., 2010
3. DAVIDSON FRAME J.: *Managing Projects in Organisations*, Jossey-Bass Business & Management Series, San Francisco 2008, str. 51-54
4. GREENBERG J., BARON R.A.: *Behavior in Organizations: Understanding and Managing the Human Side of Word (4th Ed.)*,Needham Heighs, Allyn and Bacon 1993, str. 216.
5. HAMMER A.L., SCHNELL E.R.: *FIRO-B Technical Guide*.
6. MYERS, BRIGGS I., MYERS, P. B.: *Gifts Differing: Understanding Personality Type*. Mountain View, CA: Davies-Black Publishing (1980, 1995).
7. MYERS BRIGGS I., McCAULLEY M. H.; QUENK N. L., HAMMER A. L.: *MBTI Manual (A guide to the development and use of the Myers Briggs type indicator*), Consulting Psychologists Press; 3rd Edition, 1998, str. 131
8. PFEIFFER W.J., JONES J.E.: *A handbook of structured experiences for human relations training*, University Associates, 1985
9. www.ehow.com/about_5208890_definition-recruitment-selection.html

Abstract

This paper presents a proposition of general reference model based on fuzzy set theory, model that allows defining and resolving structuring project teams decision problems. Proposed model combine precise and imprecise values of decision variables. The model allows formalising in mathematical way linguistic, rough assessment of human behaviour, competency, and psychological profile according to vacant posts, project and team requirements.