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Optimization model of agile team's cohesion

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Abstract

Team's cohesion is one of the most important factors of IT project execution effectiveness. Optimization of team's cohesion gives the possibility of reducing the risk of project failure. It also allows to increase the teamwork efficiency and thus optimize time of tasks execution, increase the guarantee of maintaining the scope of the project and the chance of achieving a given level of products quality. This article presents determination model of team's cohesion, in particular for teams working in Agile frameworks. Presented model is based on so called 'role patterns' and paradigm of fuzzy logic. It also presents optimization model of team members selection based on decision making in the so-called fuzzy environment.

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Keywords: team's cohesion; team selection process; fuzzy logic; optimization;

1. Introduction

For system development projects, people are the major resource. To deliver product with agreed scope, budget and time development team need to be wisely selected. It is known from practice that even team consisting of the best specialists can fail when there is a lack of communication, good will of cooperation, ability to compromise and, so called, chemistry inside the team.

From 1994 to 2012, every two years Standish Group conducted survey for IT project managers, called CHAOS Report[7, 8] which describes effectiveness of IT project execution. In 2012, according to the Report, 39 percent of software projects were categorized as successful – they were completed on time, on budget and met user

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requirements. This is a marked improvement from the first, groundbreaking report in 1994 that labeled only 16.2 percent of projects as successful. Projects described as challenged, meaning they had cost or time overruns or didn't fully meet the user's needs, declined to 39 percent in 2006 from 52.7 percent in 1994. Although, trend of successful project through years 1994 – 2012 is improving, it is still less than 40% of all the projects. Basing on CHAOS studies, which also provide information about main factors for successful and unsuccessful projects, successful projects have a strong non-technical components like executive support (good cooperation within team, managers, project environment), user's involvement, team's strong commitment, while the technology and tools play an important, but minor, role.

CHAOS Report shows also another factor influencing success of IT project – management style. It appears, that from year 2002, when increased popularity of Agile project management, IT projects based on Agile framework are three times more successful than classical (based on so called heavy frameworks) projects. Agile management has proved to be more effective for complex, changeable, unique projects with high uncertainty in terms of user's requirements and final shape of product, meaning for about 90% of all carried out projects.

Rapid changes within IT projects management style, popularity of Agile approaches, has influence not only on way of product development and release but also, or maybe most of all, on development team organization of work and management style. According to Agile approach (especially SCRUM model) role Development Team is defined as a cross-functional group responsible for self-managing and self-organizing to build potentially shippable product increment every Sprint. Larger teams are not self-organized effectively until divided into smaller teams; ideally feature teams with minimal interdependencies, preferably between four to nine people. Team collaboration emerges most naturally in a team room. Team members are collectively responsible for the success of each iteration and of the project as a whole. Agile approach defines also role of Scrum Master, who is responsible for the Scrum process, for teaching Scrum to everyone involved in the project, for implementing Scrum so that it fits within an organization's culture and still delivers the expected benefits and for ensuring that everyone follows Scrum rules and practices. He is a servant-leader for the Scrum Team (Development Team) and does not hold a project manager role. The Scrum Master protects the team from distractions and interruptions and removes impediments affecting the Developing Team [9].

All of these assumptions result in the need to pay even more attention to the process of selecting team members. Self-managing and self-organizing team requires a mature social behavior from team members, in particular in the field of communication, decision making, motivation and commitment to joint action. It cannot or should not be appointed centrally by senior management; rather ought to be wisely selected by a person who will play role of Scrum Master or Product Owner. Ideally, the group formed itself with people who have a desire to work in the Agile model. However, practically the first model (centrally controlled) is most popular one. That is why decision makers should support their choice by using dedicated tools allowing them to optimize team's cohesion. The practice of project management (the classic and agile) shows however the lack of attention in area of this element in the recruitment process. Visible is a big reluctance to assess the soft skills of employees selected to project team, primarily because of its strong connection to the issues of psychology. IT projects are seen as a very technical, and thus in the recruitment process hard competencies are fundamental assessed element. The authors present the view that providing tools allowing for soft skills evaluation would increase the effectiveness and accuracy of project teams selection, and thus the effectiveness of project execution.

This article provides proposition of team's cohesion determination model based on defined role patterns for IT projects and also presents formal way of team selection optimization problem.

2. The Role Patterns

This part of the article presents the author's proposal of the Role Patterns allowing to save the knowledge and experts evaluation in the defined areas of employee selection for IT project team. The main idea and causes for construction of this model has been more detail described in previous works[15,16,17].

At the core of the ongoing research lay the assumption that the Team Cohesion (*TC*) will be evaluated from the perspective of three values: Team Competence Complementarity Index (*CCIt*), Role Typological Matching Index (*TMIr*) and the Team Typological Matching Index (*TMIt*) of the team members, who have a strong mutual interaction (the meaning and the relevance of the "strong" interaction evaluation will be explained later in this work).

The variable *TMIr* value is determined on the basis of Typological Role Pattern matrix (A_{TRP}) which consists expert knowledge about assigning individual project roles *r* to preferred topological profiles *tp*. Typological Role Pattern is based on Myers-Brigs Type Indicator[11], and gives information of how 'good' or 'bad' each of sixteen defined MBTI typological profiles tp_i matches to defined role profile (taking into consideration required hard and soft skills). Typological Role Pattern matrix (A_{TRP}) is sized *n* x *m*, where *n* stands for number of roles in specific role model and *m* number of personality types tp_i judged in context of position roles.

$$A_{TRP} = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \cdots & \cdots & \cdots \\ a_{m1} & \cdots & a_{mn} \end{bmatrix}, \quad (1)$$

where $0 \le a_{ij} \le 1$, for $i = 1 \ldots n$, $j = 1 \ldots m$. Diagonal values $a_{i,j} \neq 0$, for $i = j$. Values a_{ji} placed below diagonal of the matrix differs from values a_{ij} placed above the diagonal.

$$a_{j,i} \neq a_{i,j}, \quad (2)$$

for $i \neq j$, where $i = 1 \ldots n$, $j = 1 \ldots m$.

The variable *TMIt* value is determined on the basis of Typological-Relational Role Pattern matrix (A_{TRRP}) which consists expert knowledge about collaboration effectiveness (non-confrontationality and good communication) between two people with a specific *tp* profile, remaining together in a strong interaction within team. Typological-Relational Role Pattern's matrix (A_{TRRP}) is sized *n* x *n*, where *n* stands for number of typological profile tp_i according to MBTI.

$$A_{TRRP} = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \cdots & \cdots & \cdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix}, \quad (3)$$

where $0 \le a_{ij} \le 1$, for $i, j = 1 \ldots n$.

The strength of interaction is defined and understood as imposed (determined by team's roles) strength of relations amongst the team's members assigned to specified project roles in the team. This strength is determined by Relational Position's Patterns matrix (A_{RPP}) designed for all team's roles based on a specified standard of conducting IT projects. The Relational Position's Pattern matrix is presented as matrix (A_{RPP}) sized *n* x *n*, where *n* represents number of roles in given team model.

$$A_{RPP} = \begin{bmatrix} 0 & \cdots & a_{1n} \\ \ldots & 0 & \ldots \\ a_{n1} & \cdots & 0 \end{bmatrix}. \quad (4)$$

Diagonal values $a_{i,j} = 0$, for $i, j = 1 \ldots n$, where $i = j$. Values a_{ij} of matrix A_{RPP} placed above diagonal are ratings from range of 0 to 1, attributing 0 to the poorest interaction (people with comparable roles do not have to collaborate) and 1 to the strongest interactions (people with comparable roles strongly collaborate with each other).

$$0 \le a_{i,j} \le 1, \quad (5)$$

for $i \neq j$, where $i, j = 1 \ldots n$. Values a_{ji} placed below diagonal of the matrix equal values a_{ij} placed above the diagonal.

$$a_{j,i} = a_{i,j}, \tag{6}$$

for $i \neq j$, where $i, j = 1 \ldots n$.

In the case of Scrum as a management method, the construction of *TRP* requires the project role of the Team to be made more specific. While this role is assumed to be an individual unit, it contains a set of individuals, specialists, with assigned roles regarding business analysis, the development of IT system architecture, programming, testing, and the implementation of developed solutions. Therefore, the typological job position indicator for the Scrum model does not describe three roles (according to the Scrum Guide) but seven project roles, where the Team role includes five specialized roles associated with the performance of project tasks. In effect, the developed model assumes a set of project roles $R = \{r_1,\ldots, r_7\}$ = {Product Owner, Scrum Master, Business Process Analyst, Designer, Programmer, Tester, Implementer}, where the roles $r_3 - r_7$ are sub-roles of the Team role. A set of sixteen personality types (according to MBTI) $PT = \{pt_1, pt_2,\ldots, pt_{16}\}$ was also adopted.

Example of the *TRP* indicator is presented below:

$$A_{TRP} = \begin{bmatrix} 0,3 & 0,2 & 0,3 & 0,4 & 0,9 & 0,8 & 0,5 & 0,6 & 0,6 & 0,3 & 0,6 & 0,9 & 0,8 & 0,5 & 0,7 & 0,8 \\ 0,3 & 0,2 & 0,2 & 0,4 & 0,4 & 0,2 & 0,2 & 0,2 & 0,7 & 0,9 & 0,8 & 0,8 & 0,2 & 0,2 & 0,2 & 0,2 \\ 0,8 & 0,3 & 0,3 & 0,5 & 0,4 & 0,3 & 0,2 & 0,3 & 0,9 & 0,5 & 0,5 & 0,8 & 0,7 & 0,5 & 0,4 & 0,5 \\ 0,9 & 0,3 & 0,2 & 0,5 & 0,6 & 0,3 & 0,2 & 0,2 & 0,8 & 0,2 & 0,1 & 0,4 & 0,5 & 0,2 & 0,1 & 0,1 \\ 0,6 & 0,5 & 0,6 & 0,7 & 0,4 & 0,2 & 0,2 & 0,2 & 0,5 & 0,4 & 0,8 & 0,8 & 0,3 & 0,3 & 0,2 & 0,2 \\ 0,5 & 0,7 & 0,9 & 0,5 & 0,2 & 0,7 & 0,8 & 0,8 & 0,5 & 0,7 & 0,8 & 0,5 & 0,2 & 0,5 & 0,3 & 0,3 \\ 0,5 & 0,6 & 0,7 & 0,3 & 0,2 & 0,3 & 0,4 & 0,2 & 0,4 & 0,7 & 0,8 & 0,4 & 0,2 & 0,2 & 0,2 & 0,1 \end{bmatrix}. \tag{7}$$

The obtained values, representing expert knowledge and their assessment of the quality of the fit for the personality type to the role, specifying the *TMIr* are grouped into four linguistic sets: *bad, average, good, very good*, assuming the interval variability to be: for bad [0 – 0,3], medium [0,2 – 0,5] good [0,4 – 0,8], very good [0,7 – 1].

The elements of A_{TRRP} matrix determine the strength of the interaction *SI* between roles in the team and are grouped into three linguistic sets: *weak, medium, strong*, assuming the interval variability to be: for weak [0 – 0.4], medium [0,3 – 0,7], strong [0,6 – 1]. Taking into account that in the case of Scrum teams, the strength of the relationship between all roles is high, it was decided to implement the *TRRP indicator* for all combinations of roles (21 patterns).

The elements of A_{RPP} matrix determine the *TMIt* degree of typological matching to the team (co-workers) and are grouped into four linguistic sets: *weak, average, good, very good*, assuming the interval variability to be: for weak [0 – 0.3], medium [0.2 – 0.5], good [0.4 – 0.8], very good [0.7 – 1]. The need for these indicators results from the necessity to support value judgments and to rank the evaluation of team members.

2.1. Determining input value for fuzzy model.

Figure 1 presents way of determining value for variables *TMIr* and *TMIt*. In case of *TMIr* variable determination the mechanism indicating the value may be based on simple principle system, in which experts' knowledge implied in A_{TRP} pattern is expressed by IF – THEN rule. For Fig.1. example the value of *TMIr* variable is an outcome of the rule execution:

IF r_c = R2 AND tp_c = ESTP THEN *TMIr* = 0,3.

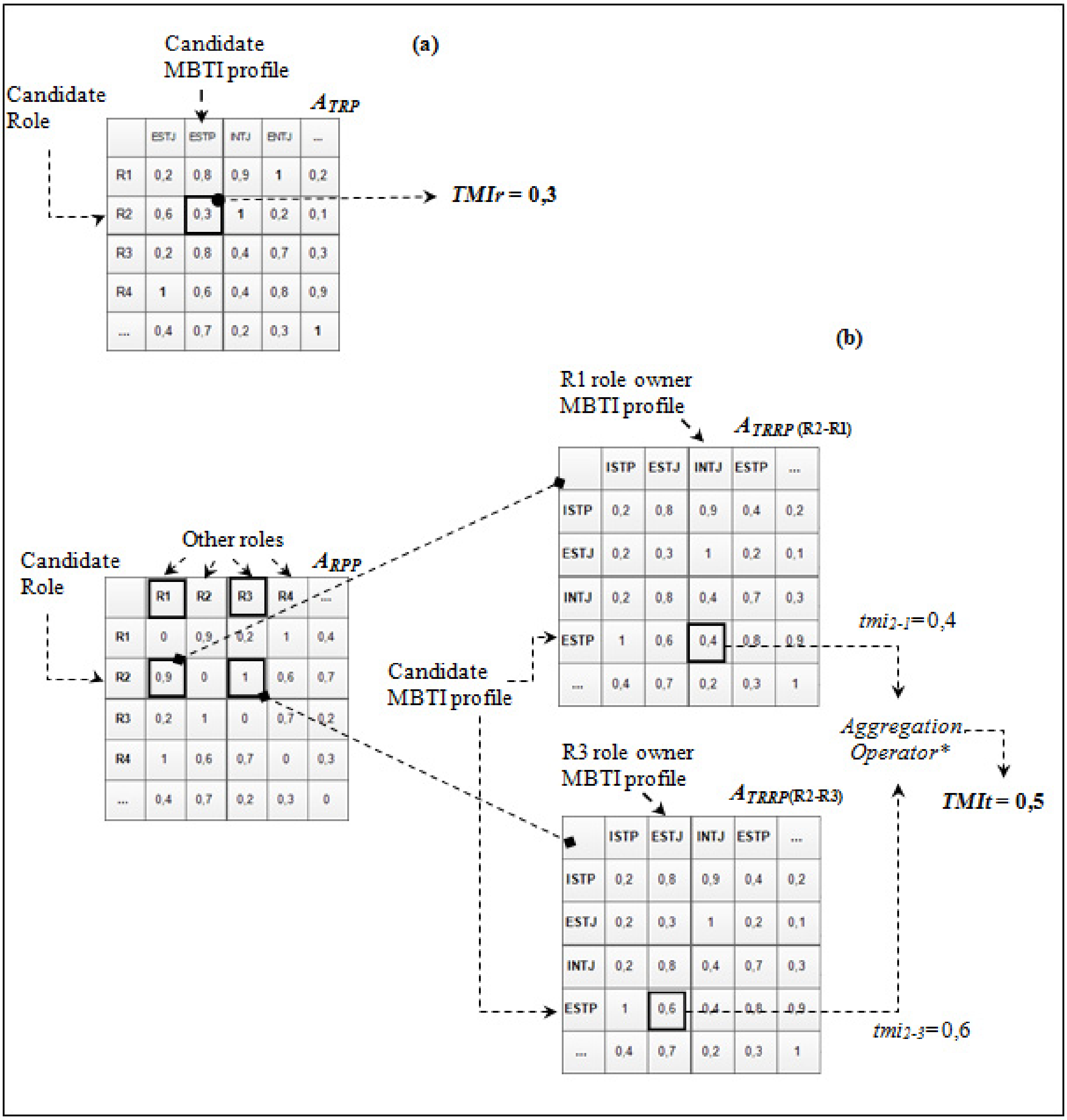

Fig. 1. (a) Determining value of *TMIr* variable; (b) Determining value of *TMIt* variable

The mechanism of *TMIt* variable's value determination requires more steps. Firstly, the value of interaction *SI* between particular role (role R2 in the example) and other roles in the project team is calculated on the basis of A_{RPP} matrix. Values possible for variable *SI* range from 0 for the lowest value of interaction to 1 for the highest. Those are divided into three linguistic groups: *weak* (e.g. for 0 < *SI* <= 0,4), *medium* (e.g. for 0,5 <= *SI* <= 0,7), *strong* (e.g. for 0,8<= *SI* <=1). Next step requires only those team roles which value of interaction with compared role (i.e. R2) equals or surpasses value 0,8. Selection process may also be based on principle system which covers the knowledge from A_{RPP} matrix, e.g. IF r_c = R2 AND r_t = R1 THEN *SI* = 0,9, where r_c – considered team role and r_t – compared team role. Additionally, regulations determining which pairs of roles are or are not given next step consideration are executed. Taking into account regulations of *SI* variable value, the conclusion ought to imply information about decision of execution *sd,* which is presented by dual values: 0 for lack of next step execution, 1 for next step execution, e.g. IF *SI* = 0,3 THEN *sd* = 0; IF *SI* = 0,8 THEN *sd* = 1.

For pairs of roles, which values *SI* are acceptable for strong group qualification, further steps of typological consistency determination are taken. Verification process is run for every qualified pair of roles, in example from Fig.1 it is pair R2-R1 and R2-R3. At this stage, relying on defined expertise expressed in principle form, it is necessary to regulate the value of *TMIt* variable, which is aggregation of values from consecutive comparisons of pairs $tmi_{t,j}$. In a particular case, when only one pair of roles is verified, value $TMI_t = tmi_{t,j}$. In case of aggregation of results taken from respective A_{TRRP} matrices one should determine the operator of aggregation. Given example presents usage of the arithmetic average operator.

The variable *CCIt* value is determined by recruiter on the basis of typical recruitment process, meaning CV analysis, direct interviews and/or technical tests. This variable value is subjective assessment of recruiter or can be determine as a sum of points from interview questionnaire results.

Variables *TMIr*, *TMIt* and *CCIt* are input to fuzzy principle, regulating the level of consistency *TC* of the whole project team.

2.2. Optimization model of team members selection

Variables *TMIr*, *TMIt* and *CCIt* values, beyond being the basis for the designation of team's cohesion, can be also implemented for team member choice optimization from a given set of candidates. For this purpose optimization model can be based on decision making in the so-called fuzzy environment[1], consisting of fuzzy objective, fuzzy constraint, and fuzzy decision. It constitutes one of the basic fuzzy models for multiple criteria decision making. In the considered model, following Rutkowski[9], X_{op} designate a set of options (also called the elections or the alternatives), where $X_{op} = \{x\}$. The fuzzy objective is defined as a fuzzy set *G* described in a set of options X_{op}. Fuzzy set *G* is described by a membership function that associates a certain value from the range [0,1] with each element *x* .

$$\mu_G(x): X_{op} \rightarrow [0,1], \forall x \in X_{op} \tag{8}$$

This value, called *grade of membership* informs about the extent to which the element *x* belongs to the fuzzy set *G* (i.e., fuzzy objective).

The *fuzzy constraint* is defined as a fuzzy set *C* described in a set of options X_{op}. Fuzzy set *C* is described by a membership function that associates a certain value from range [0,1] with each element *x*.

$$\mu_C(x): X_{op} \rightarrow [0,1], \forall x \in X_{op} \tag{9}$$

This value, called *grade of membership* informs about the extent to which the element *x* belongs to the fuzzy set *C* (fuzzy constraint). Considering the process of decision making that is fulfilling both fuzzy objective *G* and fuzzy constraint *C*, a *fuzzy decision D* is defined. *D* is, in fact, a fuzzy set formed as a result of the fuzzy objective and fuzzy constraint intersection:

$$D = G \cap C, \tag{10}$$

where for each $x \in X_{op}$

$\mu_D(x) = T\ (\mu_G(x), \mu_C(x)).$ (11)

Equation (4) allows for following an interpretation of the decision making in a fuzzy environment, that is, it allows "to attain a fuzzy objective *G* and fulfill the fuzzy constraint *C*". A precise form of notation in Eq. (10) depends on the assumed *t*-norm.

Implementation of the model for an effective team selection requires a definition of a set of criteria for candidates assessment in terms of *fuzzy objectives G*, and employment conditions in terms of *fuzzy constraints C*. Individual candidate *x* (where $x \in X_{op}$, $X_{op} = \{x_1, \ldots, x_n\}$, $k = 1, \ldots, n$) is assessed from the viewpoint of meeting all objectives G_n while satisfying constraints C_m that have been defined for a particular model. As the team structuring requires identification of more than one assessment criterion, the considerations presented above can easily be generalized for a multi-constraint and multi-objective environment.

For $n > 1$ fuzzy objectives $G_1, \ldots, G_n$, and $m > 1$ fuzzy constraints $C_1, \ldots, C_m$ defined in a set of options $X_{op,}$ fuzzy decision *D* is determined in the following way:

$$D = G_1 \cap \ldots \cap G_n \cap C_1 \cap \ldots \cap C_m, \tag{12}$$

where for each $x \in X_{op}$

$$\mu_D(x) = T\{\mu_{G1}(x), \ldots, \mu_{Gn}(x), \mu_{C1}(x), \ldots, \mu_{Cm}(x)\}. \tag{13}$$

Maximizing decision is an option $x^* \in X_{op}$, such that:

$$\mu_D(x^*) = \boldsymbol{max_{x \in X} \mu_D(x)}. \tag{14}$$

The most suitable candidate for a vacancy is determined according to Eq. (14).

Lets discuss example where fuzzy objectives *G* are define as follow: G_1 – "MBTI profile of verified candidate need to be consistent with expected MBTI profile of vacant role", G_2 – "MBTI profile of verified candidate need to be consistent with MBTI profile of close coworkers (roles)", G_3 – "project management experience over five years". Constraint C_1 defines "willingness to accept salary at a certain level". Set of options $X_{op} = \{x_1, x_2, x_3, x_4\}$ is a set of four applicants for role R2. Basing on verified MBTI profile of applicants and on expert knowledge contains in role patterns (A_{TRP}, A_{RPP}) built are fuzzy sets of the form:

$$G_1 = \frac{0,6}{x_1} + \frac{0,3}{x_2} + \frac{1}{x_3} + \frac{0,2}{x_4},\ G_2 = \frac{0,9}{x_1} + \frac{0,6}{x_2} + \frac{0,8}{x_3} + \frac{0,5}{x_4},\ G_3 = \frac{0,3}{x_1} + \frac{0,7}{x_2} + \frac{1}{x_3} + \frac{1}{x_4},\ C_1 = \frac{0,5}{x_1} + \frac{0,7}{x_2} + \frac{0,6}{x_3} + \frac{0,6}{x_4}.$$

Maximazing decision *D* is an option such that: $D = G_1 \cap G_2 \cap G_3 \cap C_1$. Assuming MIN as a aggregation operator, decision $D = \frac{0,3}{x_1} + \frac{0,3}{x_2} + \frac{0,6}{x_3} + \frac{0,2}{x_4}$. It means that the most suitable candidate for a vacant role R2 is candidate x_3, as he reached the highest value of the degree of certainty ($\mu(x_3) = 0,6$).

3. Fuzzy model of team's cohesion determination

A MISO (Multiple Input – Single Output) model [9] is built after taking the equations expertise as a value for input variables: *TMIr*, *TMIt*, subjective judgment of the recruiting person for input variable *CCIt* and determining system output as *TC*.

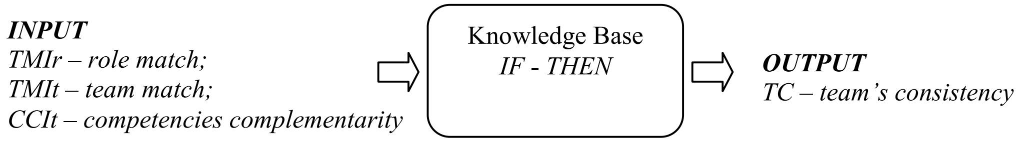

Fig. 2. MISO model.

In order to build a model of team's consistency rating it is vital to apply intuitional functions, such as Gauss's symmetric function with critical point for modeling inner fuzzy sets and sigmoidal functions of fixture to outer sets representation. The above mentioned choice of function is based on results of research, mainly concerning classification decisions which prove that a man applies (often subconsciously) so called intuitional functions, continuous in whole numeric span of consideration area, which means that discretionarily small change of observed variable *x* does not result in abrupt change of rating speed of this variable (quality rating)[18].

Thus input variable *TMIr* is described as follows:

$$\mu_{A1}(x_{TMIr}) = \frac{1}{1+e^{-a(x_{TMIr}-b)}}, \tag{15}$$

$$\mu_{A2}(x_{TMIr}) = e^{-\left(\frac{x_{TMIr}-b}{a}\right)^2},\ \mu(x_{TMIr_{k1}}) = 0.5, \mu(x_{TMIr_{k2}}) = 0.5, \tag{16}$$

$$\mu_{A3}(x_{TMIr}) = e^{-\left(\frac{x_{TMIr}-b}{a}\right)^2},\ \mu(x_{TMIr_{k1}}) = 0.5, \mu(x_{TMIr_{k2}}) = 0.5, \tag{17}$$

$$\mu_{A4}(x_{TMIr}) = \frac{e^{-a(x_{TMIr}-b)}}{1+e^{-a(x_{TMIr}-b)}}. \tag{18}$$

for x_{TMIr}: {A_1 – bad, A_2 – average, A_3 – good, A_4 – very good}; $x_{TMIr} \in \mathbb{R}$, $0 \le x_{TMIr} \le 1$.

The same applies to: variable *TMIt*, when x_{TMIt}: {B_1 – bad, B_2 – average, B_3 – good, B_4 – very good}; $x_{TMIt} \in \mathbb{R}$, $0 \le x_{TMIt} \le 1$, variable CCI_t, when x_{CCIt}: {C_1 – weak, C_2 – good, C_3 – very good}; $x_{CCIt} \in \mathbb{R}$, $0 \le x_{CC} \le 1$. Variable *CCIt* is established based on analysis of members of a team being able to accomplish all tasks or, in case of newcomers to the team, on their competencies complimentarity with the others in the group. Recruiters subjectively evaluate candidates' competencies judging their CVs and/or technical tests which are used at the selection stage. Variable *CCIt* comes in three linguistic values *weak* for value 0 – 0,5; *good* for value 0,4 – 0,8; *very good* for value 0,7 – 1.

Variable *TC* is described analogically, for y_{TC}: {D_1 – low, D_2 – medium, D_3 – high}; $y_{TC} \in \mathbb{R}$, $0 \le y_{TC} \le 1$.

Ranges of variability for linguistic values D_1, D_2, D_3 are respectively *low* [0 – 0,5]; *medium* [0,4 – 0,8]; *high* [0,7 – 1]. In order to choose it is crucial to build an expertise data base which is formed as a set of oral regulations determining dependents of input/output type:

IF (x_1 is A_i) AND (x_2 is B_j) AND (x_3 is C_k) THEN (y is D_l) (19)

where x_1, x_2, x_3 – system input; y – system output; A_i, B_j, C_k, D_l – fuzzy sets used for linguistic assessment of system output. Here is an example of principle for choice of project team:

IF (*TMIr* is A_1) AND (*TMIt* is B_1) AND (*CCIt* is C_1) THEN (*TC* is D_1) (20)

A vital part is also played by choice of inference mechanism, which is run in three stages: calculation of particular principles execution level, calculation of activation of respective principles level and calculation of outcome result fixture on the basis of activation of respective principles. Thus, it is necessary to properly choose the

T-norm and S-norm operators as well as to choose adequate method of defuzzification in order to specify given fuzzy result.

4. Summary

The problem of team assessment has been observed by several authors [3, 4, 8, 12, 13, 14, 15] who claim that the metrics to measure behavioral cohesion of the entire team with respect to the organizational structure of the team and the levels of responsibility and decision powers within the team structure is of significant importance. These authors postulated the necessity of providing methods and models combining assessment mechanisms of both hard and soft skills. They proposed models of such mechanisms based on multiple criteria with fuzzy logic as the underlying reasoning formalism.

The major goal of the proposed in this paper model is raising the efficiency of team cooperation and the execution effectiveness of adopted tasks, by increasing the cohesion of the team in the sense of complementing competencies as well as interpersonal characteristics of the team as a whole. Use of the fuzzy logic formalism is dictated by its greatest advantage, an ability of defining and measuring imprecise information about behavioral and psychological features of a candidate, difficult to model in terms of conventional mathematics. Additionally, as in the selection process, information accuracy and quality depend on the information sources. Here, the fuzzy logic formalism allows textual and linguistic data with different (less or more) granularity in quantification.

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