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Ladies and Gentlemen,

Foundation of Management (FoM) journal was established at the Faculty of Management at Warsaw University of Technology in order to provide an international platform of thought and scientific concepts exchange in the field of managerial sciences.

This new publishing forum aims at the construction of synergic relations between the two parallel trends in managerial sciences: social and economical – originating from economic universities and academies and the engineering trend – originating in from factories and technical universities.

Three of the great representatives of the engineering trend in managerial sciences - American Frederic W. Taylor (1856-1915) – developer of high speed steel technology and the founder of the technical with physiological trend in scientific management, Frenchman Henri Fayol (1841-1925), the author of basics of management and the division and concentration of work as well as the Pole Karol Adamiecki (1866-1933) graduate of the Saint Petersburg Polytechnic University and the professor of Warsaw University of Technology, creator of the time-scale system elements scheduling theory and diagrammatic method as well as the basics of the division of work and specialization – have, on the break of the XIX and XX century, all created the universal foundations of the management sciences. Therefore the title of the Foundation of Management is the origin of the scientific and educational message of the journal that is aimed at young scientists and practitioners – graduates of technical and economic universities working in different parts of Europe and World.

The target of the establishers of the Foundation of Management journal is that it will gradually increase its influence over the subjects directly linked with the issues of manufacturing and servicing enterprises. Preferred topics concern mainly: organizational issues, informational and technological innovations, production development, financial, economical and quality issues, safety, knowledge and working environment – both in the internal understanding of the enterprise as well as its business environment.

Dear Readers, Authors and Friends of the Foundation of Management – our wish is the interdisciplinary perception and interpretation of economic phenomena that accompany the managers and enterprises in their daily work, in order to make them more efficient, safe and economic for suppliers and receivers of the products and services in the global world of technological innovation, domination of knowledge, changes of the value of money and constant market game between demand and supply, future and past.

We would like for the Foundation of Management to promote innovative scientific thought in the classical approach towards economic and engineering vision of the managerial sciences.

The Guardian of the journal's mission is its Programme Committee, which participants of which will adapt to current trends and as an answer to the changing economic and social challenges in the integrating Europe and World.

Tadeusz Krupa

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ROLE PATTERNS IN IT PROJECTS TEAMS: DESIGN OF A SELECTION MODULE USING FUZZY LOGIC TECHNIQUES

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Abstract: This paper introduces an approach based on role patterns and modelling by the use of fuzzy logic tool for selection process with limitation to the area of IT projects environment. The article shows a concept of role pattern structures and their further usage in process of forming a fuzzy model dedicated to candidate assessment process support.

Key words: selection process, role patterns, fuzzy logic techniques, MBIT technique.

1 Introduction

This paper introduces an approach based on role patterns and modelling by the use of fuzzy logic tool for selection process with limitation to the area of IT projects environment. This limitation follows the impact caused on team work and team structure by specific models and methods implemented in the IT project management. Popularity of a new, agile philosophy imposed a new perspective and ideas of a team work and introduction of new requirements, alternative to classical project management standards in this field relating to the characteristic of team members.

2 Teams of IT projects

An analysis of current sources of the industry literature [3–5, 9, 10] indicates noticeable process of accomplishing change in an organisational structure of IT project teams conducted in agile methodologies, as well as in happening changes due to requirements put in front of candidates to such teams.

First of all, agile teams of IT projects lose their vertical structure of hierarchy, where a clear subjection and dependence of positions existed. An agile team, by its definition, is a team of equal partners who are supposed to do tasks and make decisions collectively. In the foregoing defined role hierarchy, there is a structure of group superiority, which is characterised by different level of coherence (strength of bonds between members of the team). Not every person is competent to work in such an environment, as not everyone is able to find their place in a group where the role range fades. There is a possibility that people with strong ego and strong leading features will not manage well in the environment of agile projects, because such people will aim to force their ideas and opinions through with leaving no space for compromises and commonly worked out solutions. Also, people with strong introversive characteristics can feel inconvenient in a group functioning that way, because one of the basic work rule of agile teams is running everyday meetings that are based on brainstorm techniques, which requires every member of a group to be engaged in conversations, to report work progress, to talk through problems encountered during tasks executing and collective working through solutions and deciding about the direction of a project development.

Another change is a size of a group. Big, stratified project team very often consisting of over 20 people is changed into 8–10 people team which is a mixture of different personalities and competencies. Depletion of a size team brings the change of requirements of knowledge range of each team member and emphasises complementarity of skills of a team as an entire unit. Team members should have a characteristic of versatility in the range of information technology knowledge, which means that narrowly specialized workers (so called type I) are less willingly employed, and workers type T are employed instead of them. It is expected that versatile people will programme one day, make analysis another day and finally test created piece of programme. Additionally, teams built that way are to guarantee the support between team members in tasks carried out individually and in solving possible problems. Such tendencies are noticeable even at the level of qualifying tests for any technical post in an IT team, when the candidate must prove their command of technologies and methodologies in every possible specialisation groups of IT branch, not only with regard to the post they apply for.

Another characteristic of agile teams is to work in doubtful conditions, which means that commencement of the project is independent of amount of possessed information and its range of changes flexibly according to needs of the client who orders a project. In practice, it means frequently appearing stressful situations and the necessity of reacting fast to changes.

All of these factors affect significantly the way and effectiveness of the team project work, management of such a team and most of all put new requirements in relation to recruitment process and employees selection. Recruitment process and employees selection of IT departments is strongly formalised and in most cases divided into stages encompassing two levels of a job interview: hard competencies tests (practical knowledge and ability to apply it) and at the end negotiating employment conditions. In this whole process, there is no place for evaluation of an adjustment of a given candidate to already existing work team. It is not common to encounter the practices enabling evaluation of the level of coherence of a team as a whole. One may believe that this element is skipped at this level because of the technical difficulties – most companies do not run databases containing personal profiles of current employees, most certainly nobody conducts systematic researches on how the level of hard and soft competencies changes with regard to particular person during the employment. Simultaneously, there are no tools supporting recruitment process, excluding obvious application forms. Secondly, with regard to technical workers, at the level of recruitment, the aspect of soft competencies evaluation and worker's behavioural profile is excluded, adopting the assumption that the person on technical post should, most of all, present a high level of technical knowledge and also practical experience.

Such way of thinking is not incorrect if one takes into consideration the tasks execution effectiveness of a particular worker who has to do one specific work type. Nevertheless, in case of IT projects, work of a particular person is tightly related to cooperation with other team members (communication, ability to solve contentious situations, negotiating) and also the ability to convey information. Actually, every standard of a project management (not only IT project) indicates relation between particular roles in a project, and not only in hierarchical dependence exclusively. The range of tasks execution and also the area of cooperation with other (chosen) team roles are usually established for a given role. Obviously, the strength and cooperation range between particular team members differ between each other.

Additionally, IT projects based on light or agile methodologies need a lot of client's engagement (his representative or the whole implementation team on the client's side) which transfers into the necessity to own high communication skills by the team workers of a deliverer of information technology solutions. The research of IT project conducted in Poland in 2010 [12] shows that success of project execution in Poland depend mostly on a client's engagement into the project execution and also on ability of cooperation between the team of an information technology deliverer and a client's team.

Above specific characteristics of teams of IT projects, at the level of completing, determine the need to provide double evaluation unit: determining project team coherence, which could be called 'team matching' in colloquial language, and also matching individual team members to the group. Execution of the research at the level of choosing single workers to a team, as well as at the level of reorganising the team allows to reduce the risk of ineffective work and the risk of ongoing work in the atmosphere of conflict, and as a result allows to moderate the process of adjusting team members to each other (which is one of four typical stages of a team development).

3 Team's coherence and role patterns

There are five basic features for every small group [6], that is:

- every group has an *aim*; in order to achieve it, group members interact with each other (information flow, cooperation),
- safeguarding of a proper interaction requires arranging the structure of group's relationship hierarchy which manifests various stages of coherence (the strength of group members' bonds),
- the fifth feature of a group is its development; every group goes through a series of stages in a process of creation, functioning and its presumptive dissolution.

At the foundation of the research lies a postulate assuming that group's coherence will be described and assessed with the usage of two variables, id est *interaction strength* among group members (depending on established position's patterns defining the structure of group's relationship) and the *level of topological matching* of group members interacting with each other strongly (the meaning and suitability of a 'strong' interaction will be defined in further parts of this paper).

The *strength of interaction* is defined and understood as imposed (determined by team's roles) strength of relations

among the team's members assigned to specified project roles in the team. This strength is determined by relational position's patterns designed for all team's roles based on a specified standard of conducting IT projects.

The *level of topological matching* will be specified based on psychological tool id est Myers-Briggs Type Indicator (MBTI) pattern allowing to establish personal type of every individual in a team as well as the team as a whole. The level of topological matching will be correlated accurately to *topological role pattern* and *topological-relational role pattern.*

The topological position's pattern indicates what personal type (out of 16 identified in MBTI methodology) is the most or the least appropriate for specified project role, taking the kind of soft or hard competencies characteristic for each of the roles as a criterion.

The topological-relational position's pattern indicates what personal type should be manifested by people cooperating with each other in a team whose relational position shows high *interaction strength*.

On the basis of the pre-suppositions mentioned above the following task has been taken:

Problem defining

An IT project P, run in accordance with specified IT standard, is given. A project team described by set of project roles $R = \{r_1, r_2, \ldots, r_n\}$ is given, to which a worker is matched according to the need of a particular role. A group of recruited candidates $K = \{k_1, k_2, \ldots, k_n\}$ meeting primary criteria (specified technical skills and experience) is given. Role patterns matrixes are defined (relational A_{RWS}, topological A_{TWS} and topological-relational A_{TRWS}) for specified roles in the project. One searches for an answer to a question: *Is there a candidate (set of candidates) matching well to the project team, taking team's coherence as a criterion?* If yes, then: *Which of the candidates fits in the team's structure the most, taking team's coherence as a criterion?*

The subsequent points present an approach to a structure of a module selection that allows to execute the task defined above based on a fuzzy logic modelling tool and MBTI method.

4 Role patterns structure

In a defined candidate to project team selecting task an assumption is taken that execution of IT project is to be based on standards of running an IT projects. Each standard has defined a range of project roles for which a set of tasks and competences for an effective accomplishment is circumscribed. A team's work is found on interactions of individuals playing specific roles in the project. The strength of these interactions influences the effective execution of assignments. In research the strength of interactions was divided into three ranges taking into consideration the strength of cooperation between various roles and its impact on the effectiveness of tasks realisation. The following groups were distinguished: *lack or poor interaction, moderate interaction and strong interaction*. Given ranges of strength of interactions ought to be interpreted as follows. *Lack or poor interaction* is characteristic for a pair of roles in which cooperation in project team does not occur or occurs sporadically and has no effect on quality/effectiveness of tasks realisation. *Moderate interaction* is characteristic for pair of roles in which cooperation occurs but it has got no significant effect on quality/effectiveness of project tasks realisation. *Strong interaction* is characteristic for pair of roles in which cooperation reaches high level and has got significant effect on quality/effectiveness of project tasks realisation. In order to be able to group these interaction strength values, it is necessary to build *a relational role patterns.*

4.1 Relational role patterns

A relational role pattern describes the strength of interaction among project team roles. The strength of interaction among roles is determined, inter alia, by the specificity of a team management method, methodology of leading the project and thus by specific project team's structure. Simultaneously, the strength of interaction may be influenced by additional factors resulting from, e.g. informal division of power in a team developed in process of collaboration (workers choose their team leaders on their own and use older ones experience regardless of their position in a team). It is vital to emphasise that relational roles patterns should be established accordingly to given organisation's specificity, because single pattern suitable for all IT environment projects does not exist.

A relational roles pattern is formed in process of assigning individual pairs of roles pr_i to strength of interaction through series of comparisons (in pairs) of separate roles. This leads to a creation of relational roles pattern's square matrix A_{WRS}. The relational pattern is presented as matrix A_{WRS} sized $n \times n$, where n represents number of roles in given team model.

$$A_{WRS} = \begin{bmatrix} 0 & \dots & a_{1n} \\ \dots & 0 & \dots \\ a_{1n} & \dots & 0 \end{bmatrix} \quad (1)$$

Diagonal values $a_{i,j} = 0$, for $i, j = 1 \dots n$, where $i = j$.

Values a_{ij} of matrix A_{WRS} placed above diagonal are ratings from range of 0 to 1 (accurate to within decimal number) 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).

$$0 \leq a_{i,j} \leq 1 \quad (2)$$

for where $i, j = 1 \dots n$.

Values *aji* placed below diagonal of the matrix equal values *aij* placed above the diagonal.

$$a_{j,i} = a_{i,j} \quad (3)$$

for where $i, j = 1 \dots n$.

It is assumed that interaction strength evaluation is performed by a group of domain experts $E = \{e_1, \dots, e_m\}$ (management staff of IT teams, long-time IT teams workers) who establish relational patterns for specific methodology. It is crucial to have the rating evaluated by a group of experts of not less than five members. In that case a standardisation, relational role pattern is necessary throughout the process of averaging experts' evaluation results.

$$\frac{1}{m} \sum_{k=1}^{m} a_{ij}^{k} \quad (4)$$

for $i, j = 1 \dots n$, $i \neq j$, $k = 1 \dots m$.

4.2 Topological role patterns

Topological role pattern defines advisable (suggested) personality type wt_i, for $i = 1 \dots 16$, for a given team role, accepting a criterion of demanded hard and soft competences corresponding to the role. In the first place this element must be explained in context of accepted personality types (personality models) ratings of candidates and team members.

4.2.1 Personal models according to Myers-Briggs Type Indicator (MBTI)

There are many personality models such as Five Factor Model, Big Five, Keirsey Temperament Sorter, 16PF or DiSC Personality Profile Assessment, but one of the most world-wide known and used is MBTI [7]. It is based on Carl Jung's theory of psychological type and it assumes that every person has natural preference in perceiving the world and making judgments. Figure 1 shows the basic schema of how people perceive the world and how they make decisions according to Jung.

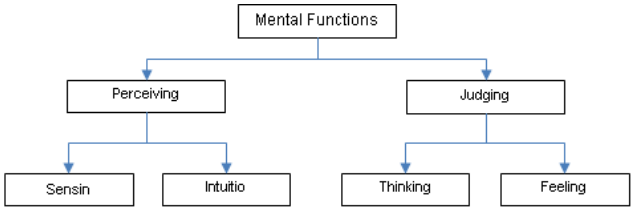


Figure 1. Partition of Mental Functions

People may perceive outer world using their five senses or by intuition when they are unconsciously incorporating and associating ideas coming from outside. With the same approach they can make decisions using logical and impersonated process or subjective approach taking into account personal outcome of the decision.

According to Cakrt, people who prefer to gather information by using all the senses need facts and practical information which they remember much easier than relationship between them or opportunities arising from them. They use their or others' experience as a base for current and future actions. Sensing people work systematically and continuously and they try not to interfere with sudden acts of inspiration or creativity. They are focused on numbers rather than theories and prefer tasks which have tangible end results rather than conceptual divagations.

On the opposite scale, people who are prefer using their intuition in the process of perceiving the world. They are mostly interested in ideas, concepts and possibilities. At the each stage of the work, they have the big picture in mind often forgetting the details. They usually try different ways of approaching the same problem just to check which one is better. They seek relations between different facts and try to understand the meaning behind the obvious statements [2].

When it comes to processing information and making decision, Jung divided people into two categories: ones that follow impersonated logical process using thinking approach and ones that rely on their feelings taking into consideration other people impacted by the outcome of particular decision.

Table 1 summarises the main differences between thinkers and feelers.

Table 1. Main differences between Thinker and Feeler [2]

	Thinker	Feeler
Is focused on	Logical parameters of the problem, rules, truth	Human values, harmony, emotions
Relies on	Past, presence, future	Past
At work is	Impersonated, well organised, result oriented	Friendly, interested in others, taking issues personally
Strengths are	Toughness, rationalism, logical thinking	Loyalty, empathy, personal involvement
Possible weaknesses are	Too analytical, emotionless, rigid	Sentimental, avoiding conflicts and confrontations

Another dimension where Jung observed dichotomous preferences in people's behaviour was the vital energy orientation. He distinguished two groups based on a fact that if a person takes the energy from the inner world of concepts and ideas or from the outer world of people and actions.

A person with extroverted preference is characterised by general openness to the world and other people. Such person is open and friendly and has a lot of people around. Takes on new tasks and adventures with pleasure and visibly expresses all emotions. Prefers open communication and usually by talking. Extroverted person is very sociable and learns best by doing and discussing. On the other hand an introverted person is very private and contained. Prefers communication in writing and learns best by reflection and theoretical approach. Introverted person takes initiative seldom unless the issue is very important to him or her (see Figure 2).

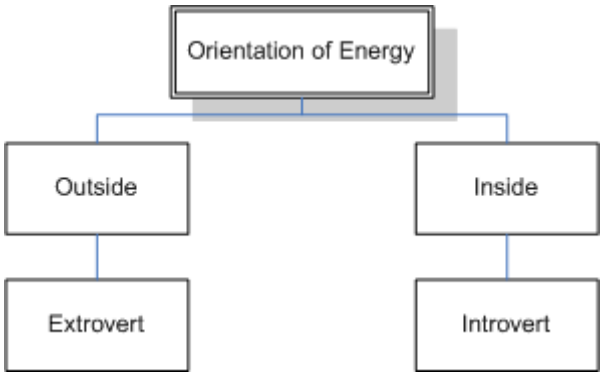


Figure 2. Energy orientation dichotomy

The last functional dichotomy that completes the four dimensions of personality type is the judgment-perception preference. Within this dimension people differ on attitude toward the way they deal with the outer world. People who prefer judging attitude usually are systematic, methodical and organised in their lives. They make short- and long-term plans in order to avoid decision not be made and issues not decided upon. On the opposite scale are people with observing preference. They are usually spontaneous, casual and flexible. They quickly and easily adapt to changes and open and energised when many things are happening at once.

Based on the above dimensions, personality type is defined by four pairs of dichotomous attributes: **E**xtroversion/**I**ntroversion, **S**ensing/i**N**tuition, **T**hinking/**F**eeling and **P**erceiving/**J**udging. Combination of one attribute from each pair creates sixteen psychological types wt_i that a person can be described by and they are listed in Table 2.

Table 2. MBTI Personality Types

ISTJ	ISFJ	INFJ	INTJ
ISTP	ISFP	INFP	INTP
ESTP	ESFP	ENFP	ENTP
ESTJ	ESFJ	ENFJ	ENTJ

Each type shows such preference. For example a person characterised by type ISTJ is rather introvert that collects data by sensing makes decision by logical analysis and prefers systematic and planned way of acting.

In order to analyse and create the desired team structure, each of the MBTI types is decomposed in single attributes and those attributes are valued from the perspective of cooperation capabilities [11].

This task is assigned to psychology experts whose expertise and experience allow to build suitable topological role patterns for specific work environment and team roles characterised by indicated group of competence expectations.

The structure of *topological role pattern* consists in assigning individual project roles r_i to preferred topological pattern wt_i. A group of work psychology experts $Ep = \{ep_1, \ldots, ep_l\}$ assigns each topological pattern wt_i to rating from 0 to 1 (in range of decimal values) judging its

adequacy for given project role. This creates a matrix of topological role pattern A_{TWS} sized $n \times m$, where n stands for number of roles in specific role model and m number of personality types judged in context of position roles.

$$A_{TWS} = \begin{bmatrix} a_{11} & \dots & a_{1n} \\ \dots & \dots & \dots \\ a_{m1} & \dots & a_{mn} \end{bmatrix} \tag{5}$$

where $0 \leq a_{i,j} \leq 1$, for $i = 1 \dots n, j = 1 \dots m$. 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.

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

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

It is crucial to have the rating evaluated by a group of experts of not less than five members. In that case a standardisation of relational role pattern is necessary through a process of averaging experts' evaluation results.

$$\frac{1}{l} \sum_{k=1}^{l} a_{ij}^{k} \tag{7}$$

for $i = 1 \dots n, j = 1 \dots m, k = 1 \dots l$.

4.3 Topological-relational role patterns

From previous researches, it has been presumed that topological matching people to team roles will be important for those combinations of roles which remain in a strong interaction, which is why *topological-relational role patterns* are built only for those role pairs that are allocated to this level of interaction strength group.

Topological-relational role patterns define indicated personality type preferences for pair combined comparisons from the group of a high level of interaction. In other words it is elucidated what personality types ought to (may) effectively cooperate with each other and which ones should not be teamed. This task is again assigned to psychology expert's opinion.

The form of *topological-relational role pattern* consists in assigning (defining) respective pairs of roles from a strong interaction group to topological matching rating taking into account the effectiveness (amicability) of collaboration. A group of work psychology experts $Ep = \{ep_1, \dots, ep_l\}$ assigns each relational pair from strong interaction group to a rating from 0 to 1 (in a range of decimal values) stipulating capability of cooperation for all personality types put in pairs. It results in creation of *topological-relational role pattern's* matrix A_{TRWS} sized $n \times n$, where n stands for number of personality types according to MBTI.

$$A_{TRWS} = \begin{bmatrix} a_{11} & \dots & a_{1n} \\ \dots & \dots & \dots \\ a_{n1} & \dots & a_{nn} \end{bmatrix} \tag{8}$$

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

It is crucial to have the rating evaluated by a group of experts of not less than five members. In that case a standardisation of relational role pattern is necessary through a process of averaging experts' evaluation results according to formula (7).

Created role patterns are foundation for comparison of candidate's score obtained in process of selection for proper project role to expected (perfect) results defined by domain experts for a given enterprise.

Possibility of applying those patterns requires building an assessment instrument for evaluating and ranking verified candidates according to arranged rules. It is ought to be emphasised that all patterns (matching rules) are built based on an expert's knowledge. All the scores also involve quality evaluation of so-called soft aspects of person's competencies, which requires applying approximate and intuitive ratings burdened with each domain expert's subjective point of view based on linguistic evaluation. Those features fit in characteristics of fuzzy logic instrument in which conducted research is one of the chosen methods for description of knowledge necessary in a selection process.

5 Fuzzy modelling based on system expert's knowledge

Modelling based on system expert's knowledge (domain expert) is built on experience and expertise of a person who knows the system well. In considered case of role patterns structure domain experts from IT group and occupational psychology are employed. Experts' knowledge has a dual character – open (conscious expertise) and unconscious (intuitional expertise, so called 'hunch'). Open knowledge may be expressed in words and passed to another person, whereas unconscious knowledge is difficult to be enunciated (described). Combination of the two above mentioned kinds of knowledge about reality system in expert's mind is defined as *mental* or *mind model* [1]. In process of knowledge extraction from system expert only open expertise is acquired, which is manifested as

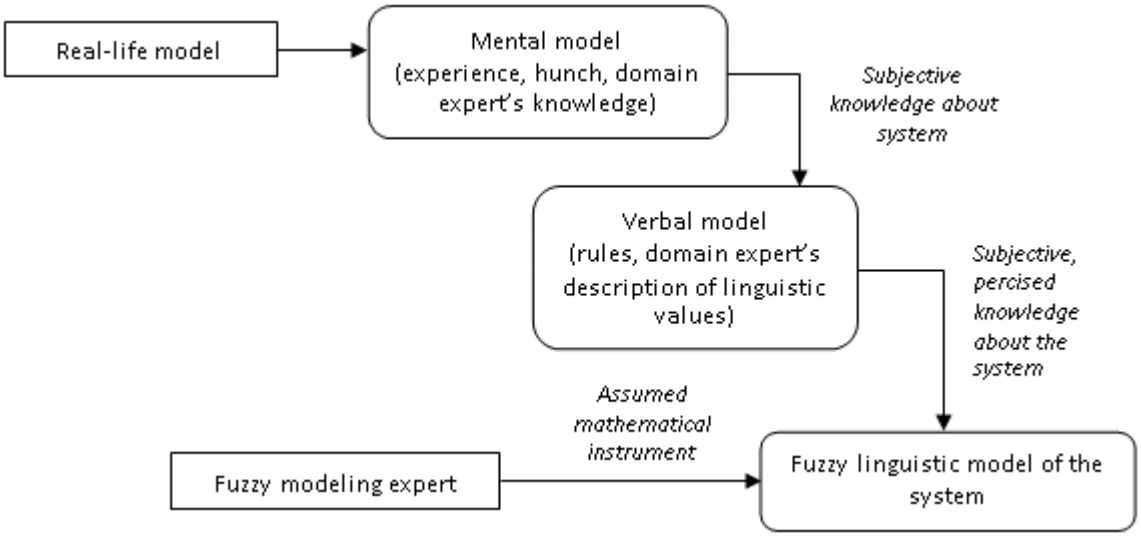


Figure 3. The creation process of real-life system fuzzy linguistic model [8]

word rules indicating enter/exit relationship type:

$$\text{IF } (x_1 \text{ if } A_i) \text{ AND } (x_2 \text{ if } B_j) \text{ THEN } (y \text{ is } C_k) \qquad (9)$$

where: x_1, x_2 – system's input; y – system's output; A_i, B_j, C_k – fuzzy sets used for linguistic evaluation of a system output by an expert.

Rules exemplification: IF (the team is experienced) AND (the project is well defined) THEN (meeting deadline is possible). System expert also assesses the way of valuation of used linguistic ratings through particularising labels and value ranges, for example 'experienced team' stands for a team that has worked together on projects for at least 5 years.

A set of verbal rules defining system's input/output relationship and a set of verbal information about linguistic value used by an expert is called system's *verbal model*. Verbal model is usually flatter than mental model, because the first one does not include intuitional knowledge which is not possible for an expert to pass. The system expert is also not able to get across the knowledge about illation mechanisms taking place in his mind, about a kind (form) of membership function describing linguistic values, about kind of logical operators used in process of metal data processing, etc.

All that information necessary for *fuzzy linguistic model* creation of a given system must be supplemented supposedly (intuitively) by a *modeller*, who can be termed fuzzy modelling expert [8].

Information flow that takes place in the process of the system fuzzy, linguistic model creation is presented in Figure 3.

6 Fuzzy model structure

Fuzzy logic instrument is based on a group of primary concepts allowing the model knowledge about described systems. Hereunder there are main definitions in accordance with research literature [8].

Linguistic variable – this input/output figure or state variable, which is evaluated by linguistic rating, called linguistic values. For example: ship's speed, tension, temperature.

Linguistic value – is a verbal value of linguistic figure. For example: very big, average, old, young.

Variable linguistic space – is a set of all linguistic values used for assessment of a given linguistic variable. It is lettered in capital Latin characters, e.g.: X_L = {*negative, positive*} = $\{x_{L1}, x_{L2}\}$.

The linguistic space is a finite dimensional set.

Variable numeric space (consideration space) – is all numeric values set that can be taken by the set in considered system or such values which are vital for problem solving (model system). Variable numeric space is lettered in capital Latin characters, for example:

- $X = \{x\}$ – infinitely dimensional space, e.g. $x \in \mathbb{R}$
- $X = \{x_1, x_2, ..., x_n\}$ – finitely dimensional space, discreet, e.g. $\{x_1 = 0.75, x_2 = 1\}$

Fuzzy set. A fuzzy set A, in some numeric space of consideration X is called a pair set:

$$A = \left\{ \left(\mu_A^*(x), x \right) \right\} \qquad (10)$$

where: μ_A is *membership function* of fuzzy set A which associates each element $x \in X$ to a *membership grade*

$\mu^*_A(x)$ to fuzzy set A, when: $\mu_A(x) \in [0,1]$. *Membership function* models numeric space X of a given variable to a range [0,1]:

$$\mu_A : X \to [0,1] \tag{11}$$

Fuzzy modelling expert's role is competent choice of method of obtained knowledge representation to modelled phenomenon (range of knowledge). With limited spectrum of information about modelled system a polygonal function is used. In order to model this function a minimal amount of information is required [data concerning modal functions points (minimum, average, maximum)]. Simultaneously carried out researches, concerning mainly evaluative decisions, show that a person uses (often subconsciously) so called intuitive functions which are continuous in numeric consideration space which means that any small change of observed variable x does not cause abrupt change of speed of this variable rating (quality rating). In case of polygonal functions abrupt changes are characteristic feature which indicates that those functions are good approximation of human way of judging. That is the reason why in the process of building a model of human's psychological assessment function, intuitional function will be applied, including Gauss's symmetric function with critical point for modelling internal fuzzy sets and sigmoidal functions of fixture to external sets representation.

6.1 Fuzzy model for assessment of interaction strength among roles in team

The model for assessment of interaction strength among roles in team is built in SISO (single input, single output) system, where with an input of a system variable x_{RWS} is given – cooperation level of project role pair pr_i, for which:

- linguistic space X_L of input variable x_{RWS}: $\{A_1$ – low, A_2 – average, A_3 – high$\}$,
- numeric space X_N of input variable x_{RWS}: $\{x_{RWS} \in \mathbb{R}, 0 \leq x_{RWS} \leq 1\}$,

and system output result in – interaction strength of project role pair, for which:

- linguistic space Y_L of output variable y_{RWS}: $\{B_1$ – lack or low, B_2 – average, B_3 – high$\}$,
- numeric space Y_N of output variable y_{RWS}: $\{y_{RWS} \in \mathbb{R}, 0 \leq y_{RWS} \leq 1\}$,

It is assumed that sets A_i and B_i are described by following functions:

- for system input

$$\mu_{A1}(x_{RWS}) = \frac{1}{1+e^{-a(x_{RWS}-b)}},$$
$$\mu_{A2}(x_{RWS}) = e^{-\left(\frac{x_{RWS}-b}{a}\right)^2},$$
$$\mu(x_{RWS_{k1}}) = 0.5,$$
$$\mu(x_{RWS_{k2}}) = 0.5$$
$$\mu_{A3}(x_{RWS}) = \frac{e^{-a(x_{RWS}-b)}}{1+e^{-a(x_{RWS}-b)}}$$

- for system output

$$A_{RWS} = \begin{bmatrix} 0 & \dots & a_{1n} \\ \dots & 0 & \dots \\ a_{n1} & \dots & 0 \end{bmatrix} \Longrightarrow$$
$$\mu_{C1}(y_{RWS}) = \frac{1}{1+e^{-a(y_{RWS}-b)}},$$
$$\mu_{C2}(y_{RWS}) = e^{-\left(\frac{y_{RWS}-b}{a}\right)^2},$$
$$\mu(y_{RWS_{k1}}) = 0.5,$$
$$\mu(y_{RWS_{k2}}) = 0.5$$
$$\mu_{C3}(y_{RWS}) = \frac{e^{-a(y_{RWS}-b)}}{1+e^{-a(y_{RWS}-b)}}$$

In a process of modelling the system output sets y_{RWS} a standardised pattern for positioning relation A_{RWS} is used. Values received from experts assessments are assorted to three linguistic sets B_1, B_2, B_3, accepting rating range from 0 to 1 (e.g. $y_{RWS_{B_1}}[0 \div 0.5]$, $y_{RWS_{B_2}}[0.3 \div 0.8]$ and $y_{RWS_{B_3}}[0.5 \div 1]$).

Additionally the internal function's description (Gauss' function) both system input and output is broadened by notion of critical point k of membership function that allows to indicate such point of this function in which membership level equals 0.5. Introducing critical point k is a measure that enables defining basic set characteristic points which membership level equals 0.5. Contemporaneously an assumption is accepted that adjacent (outer) membership functions will intersect with Gauss' function at points x_{k_1}, x_{k_2} and y_{k_1}, y_{k_2}, and hence critical points will be set for those coordinates which do not clearly belong to either outer or inner fuzzy set.

A knowledge base is represented as If – Then type of rule including all combinations of input variable values and respective set of conclusions.

$$\text{IF } x_{RWS} \text{ IS } A_i \text{ THEN } y_{RWS} \text{ IS } B_i$$

Example 1:

Project P, in which the following set of project roles appears $R = \{r_1, r_2, r_3, r_4, r_5, r_6\}$, is considered. There is a project management model given for which the domain experts IT defined a standardised relational positional pattern A_{RWS} shown in the following matrix:

$$A_{RWS} = \begin{bmatrix} 0 & 1 & 0,2 & 0,7 & 0,5 & 0,3 \\ 1 & 0 & 0,8 & 0,2 & 0,4 & 1 \\ 0,2 & 0,8 & 0 & 0,5 & 0,6 & 0,2 \\ 0.7 & 0,2 & 0,5 & 0 & 1 & 0,4 \\ 0,5 & 0,4 & 0,6 & 1 & 0 & 0,6 \\ 0,3 & 1 & 0,2 & 0,4 & 0,6 & 0 \end{bmatrix}$$

All the obtained results are grouped into three linguistic sets defining the strength of interaction of chosen roles pairs id est *lack* or *low* (B_1), *average* (B_2), *high* (B_3). On the basis of experts' opinions a model of value division is accepted which is based on the following way of assigning to particular sets: extreme value for *lack* or *low* 0, typical value for set *average* 0.5, extreme value for set *high* 1. The values which are critical points and . Taken ranges will be output set models y_{RWS}.

The strength of interaction is determined by frequency (significance) of cooperation among roles during realisation of a project. It is assumed that frequency (significance) of cooperation will be described in three linguistic sets, id est *low* (A_1), *average* (A_2), *high* (A_3). On the basis of experts' opinions a points model of frequency (significance) of cooperation among roles evaluation is accepted, where 0 points is given to a pair of roles which have to collaborate in a project and 10 points to a pair of roles which have to collaborate constantly. The intervening results, from range 0–10 are assigned to remaining intervening states. In order to design ranges the experts were asked to give opinion on which value it is difficult to assign *low* or *average* value set and analogously which one belongs to *average* or *high* set. Indicated by experts values 3 and 7 form points $x_{RWS_{k1}}$ and $x_{RWS_{k2}}$. The assumed ranges will form a model of output sets x_{RWS}.

The experts built a knowledge base defining correlation between model's states of input and output. This knowledge base include following rules:

- R1: If x_{RWS} is *low* Then y_{RWS} is *lack or row*
- R2: If x_{RWS} is *average* Then y_{RWS} is *average*
- R3: If x_{RWS} is *high* Then y_{RWS} is *high*.

The above mentioned model involving relational role pattern and division of its value to fuzzy sets is an image of perfect situation developed for given project management model. A project supervisor taking a candidate for position r_2 ought to define frequency of their cooperation with other project roles. Because every project, regardless of accepted methodological postulates, goes by its own principles, it is the project supervisor who delegates tasks for project roles as well as scope and method of cooperation between the roles. The discussed project includes following set of role pairs $PR = \{pr_1, pr_2, \ldots, pr_{15}\}$, accepting assumption (1–3), where $pr_1 = a_{12}, pr_2 = a_{13}, pr_4 = a_{14}, pr_5 = a_{15}, pr_6 = a_{16}, pr_7 = a_{23}, pr_8 = a_{24}, pr_9 = a_{25}, pr_{10} = a_{26}, pr_{11} = a_{34}, pr_{12} = a_{35}, pr_{13} = a_{36}, pr_{14} = a_{45}, pr_{15} = a_{46}$.

The project supervisor determined the following cooperation frequency values for the discussed project: $X_{RWS} = \{x_{RWS,pr_1} = 4, x_{RWS,pr_2} = 2, x_{RWS,pr_3} = 6, x_{RWS,pr_4} = 2, x_{RWS,pr_5} = 8, x_{RWS,pr_6} = 3, x_{RWS,pr_7} = 10, x_{RWS,pr_8} = 7, x_{RWS,pr_9} = 2, x_{RWS,pr_{10}} = 4, x_{RWS,pr_{11}} = 5, x_{RWS,pr_{12}} = 9, x_{RWS,pr_{13}} = 2, x_{RWS,pr_{14}} = 3, x_{RWS,pr_{15}} = 8\}$.

Using the above mentioned model implemented in MatLab Fuzzy Toolbox environment, it is possible to conduct the following assessment (Figure 4).

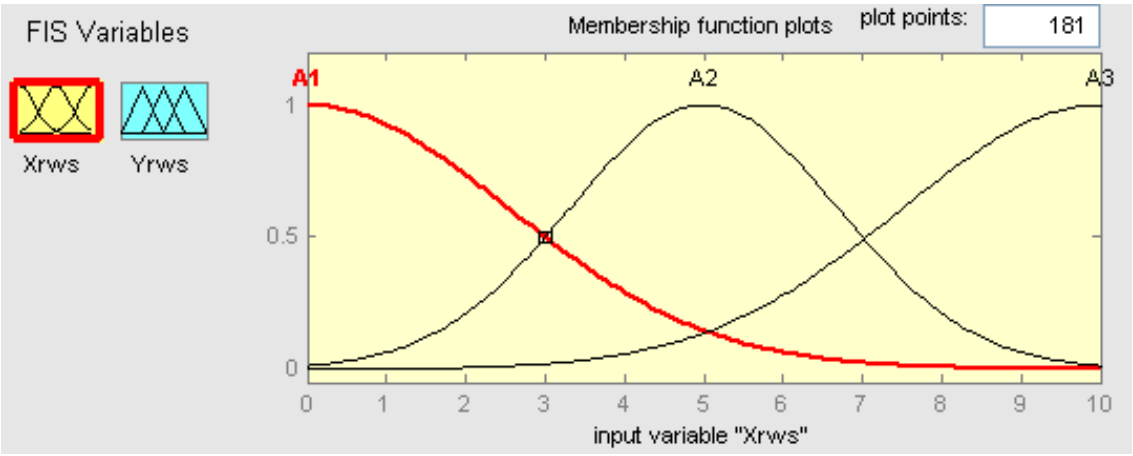
A candidate to a role r_2 is evaluated thus it is necessary to assess the strength of interactions his/her roles with other roles in a team, id est for pairs $pr_1, pr_7, pr_8, pr_9, pr_{10}$.

The chosen role pairs obtained the following results: $y_{RWSpr_1} = 0.48$, $y_{RWSpr_7} = 0.796$, $y_{RWSpr_8} = 0.586$, $y_{RWSpr_9} = 0.307$, $y_{RWSpr_{10}} = 0.48$. Those results allow to group information about strength of interactions among separate role pairs to following sets: pr_1, pr_8 and pr_{10} to *average* set, pr_9 *lack* or *row* set, and pair pr_7 to *high* set. It means that candidate performing a task of role r_2 will remain in the strongest interaction with employee performing role r_3. In a topological relational model exactly this pair of roles will be tested for matching in the light of MBTI profile.

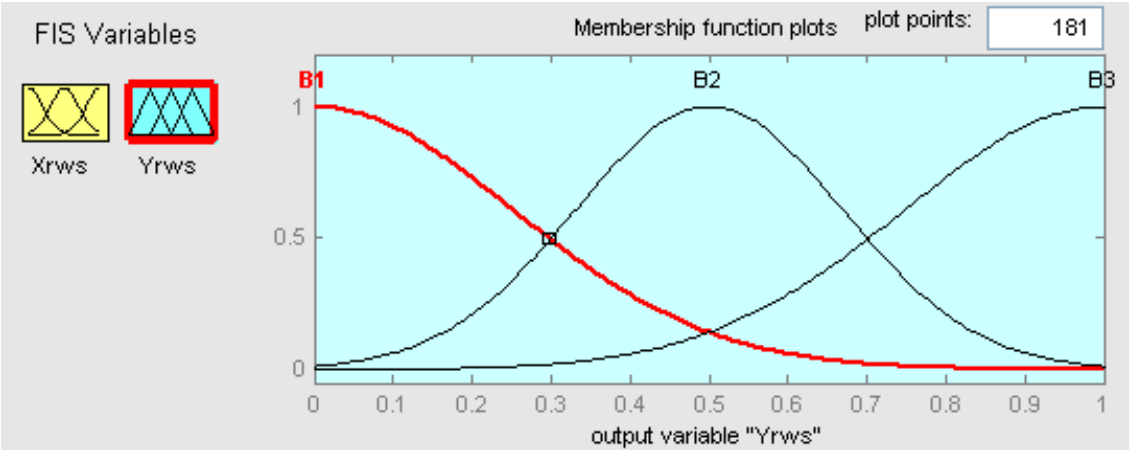
6.2 Fuzzy model for topological role pattern assessment

According to MBTI method human's mental functions are divided into four groups: *perceptual function*, which introduces two types of perception: Sensing(S) and iNtuition (N); *judgement function* which introduces two types of assessing: Thinking (T) and Feeling (F); *attitude to the world function* which introduces two kinds of approaches: Extroversion (E) and Introversion (I); *attitude to the outer world function* which introduces two kinds of attitudes: Judging (J) and Perceiving (P).

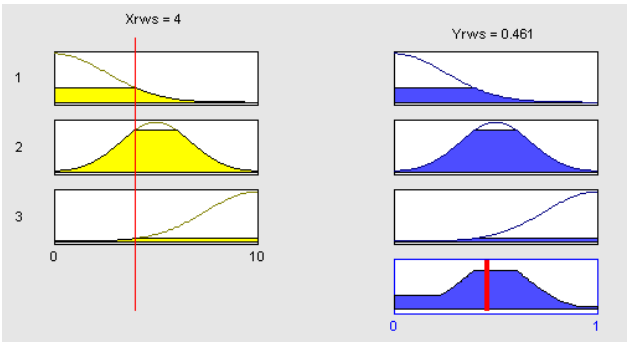
Each basic function goes through phenomenon of subtypes proportion – every human is characterised by both subtypes of given function, but it is the predominance of one over another that classifies a man to 1 of 16 MBTI specified character groups. Extreme states such as 0:1 and 1:0 usually do not occur, which means there are no extreme extroverts or introverts. Accepting that each mental function is assessed by two subtypes, which strength val-



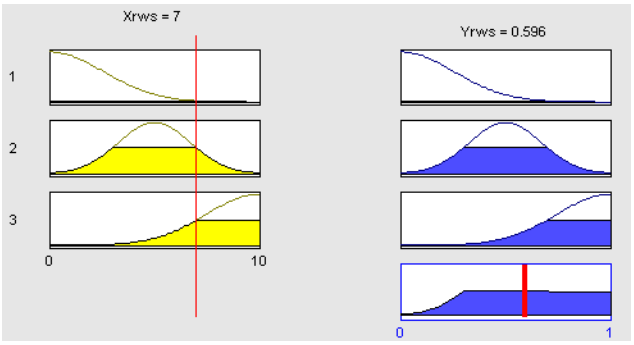
a



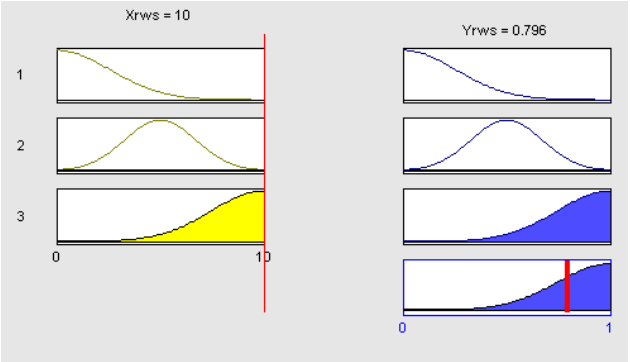
b



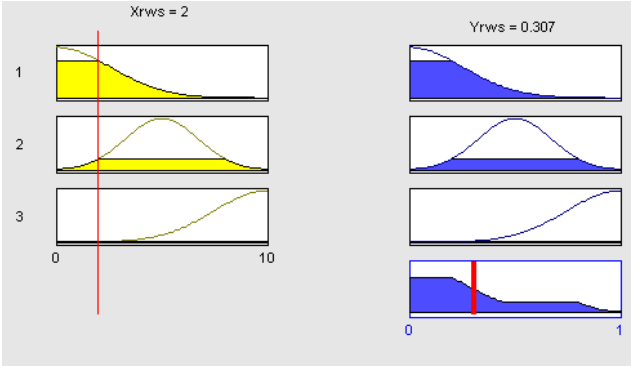
c



d



e



f

Figure 4. (a) input, (b) output, (c) results for $pr1$ and pr_{10}, (d) results for pr_8, (e) results for pr_7, (f) results for pr_9.

ue changes inversely proportionately against each other, therefore one may conclude that it is enough to evaluate the strength of only one subtype of a given function to obtain information about the second subtype of this function influence value.

For this assumption fuzzy model of topological role pattern evaluation is built in MISO (multiple input, single output) system, where model input is given linguistic variables x_i: (x_1 – sensual perception S, x_2 – analytical assessment T, x_3 – extraversion E, x_4 – judgmental basis J), for which:

- linguistic space X_L of variables x_{TWS}: {low, average, high};
- numeric space X_N of variables $x_{TWS} = \{x: x_{TWS} \in \mathbb{Z}, 0 \leq x_{TWS} \leq \text{max pt.}\}$,
- linguistic space sets are described by membership functions:

$$\mu_{low}(x_{TWS}) = \frac{1}{1+e^{-a(x_{TWS}-b)}},$$

$$\mu_{avarage}(x_{TWS}) = e^{-\left(\frac{x_{TWS}-b}{a}\right)^2},$$

$$\mu(x_{TWSk_1}) = 0.5,$$

$$\mu(x_{TWSk_2}) = 0.5,$$

$$\mu_{high}(x_{TWS}) = \frac{e^{-a(x_{TWS}-b)}}{1+e^{-a(x_{TWS}-b)}},$$

and linguistic variable r_i – project role, $r_i = \{r_1,\ldots, r_n\}$, for which sets defining linguistic space of variable appear as singletons, $\mu(r_i) = 1$; at the model's output adjustment y_{TWS} of desirable topological role pattern *wti* for chosen project role r_i will be obtained, for which:

- linguistic space Y_L of variable y_{TWS}:{unacceptable, acceptable, suitable};
- numeric space Y_N of variables y_{TWS}: $\{y \in \mathbb{R}, 0 \leq y_{TWS} \leq 1\}$,
- linguistic space sets of output variable are described by membership functions:

$$A_{TWS} = \begin{bmatrix} a_{11} & \ldots & a_{1n} \\ \ldots & \ldots & \ldots \\ a_{m1} & \ldots & a_{mn} \end{bmatrix} \Longrightarrow$$

$$\mu_{unacceptable}(y_{TWS}) = \frac{1}{1+e^{-a(y_{TWS}-b)}},$$

$$\mu_{acceptable}(y_{TWS}) = e^{-\left(\frac{y_{TWS}-b}{a}\right)^2},$$

$$\mu(y_{TWSk_1}) = 0.5,$$

$$\mu(y_{TWSk_2}) = 0.5,$$

$$\mu_{suitable}(y_{TWS}) = \frac{e^{-a(y_{TWS}-b)}}{1+e^{-a(y_{TWS}-b)}}$$

Similarly to strength of role interactions model the process of modelling sets of system output uses standardised role relation pattern A_{TWS} as well as Gauss' function with critical points *k*.

A knowledge base is represented as If – Then type of rule including all combinations of input variable values and respective set of conclusions.

IF x_{TWS_1} IS A_i AND x_{TWS_2} IS B_i AND x_{TWS_3} IS C_i AND x_{TWS_4} IS D_i AND r_i IS E_i THEN x_{TWS} IS F_i

Example 2

This example covers evaluation of candidate's match in terms of his/her personality type compatibility with prepared topological pattern built by occupational psychology experts. Following Example 1, a candidate performing a task assigned to role r_2 is evaluated. The occupational psychology experts *Ep* built matrix A_{TWS} for the set of all project roles according to assumptions (5–7), including results of matching personality types $PT = \{pt_1, \ldots, pt_{16}\}$ to each of six project roles.

$$A_{TWS} = \begin{bmatrix} 0{,}2 & 0{,}1 & 0{,}5 & 0{,}9 & 1 & 0{,}3 & 0{,}7 & 0{,}2 & 0{,}4 & 0{,}7 & 0{,}8 & 0{,}3 & 0{,}6 & 0{,}2 & 0{,}1 & 0{,}6 \\ 0{,}9 & 0{,}5 & 0{,}8 & 0{,}6 & 0{,}2 & 0{,}4 & 0{,}5 & 0{,}1 & 0{,}5 & 0{,}2 & 1 & 0{,}3 & 0{,}7 & 0{,}1 & 0{,}8 & 0{,}2 \\ 0{,}6 & 0{,}8 & 0{,}6 & 0{,}9 & 0{,}1 & 0{,}8 & 0{,}2 & 0{,}3 & 0{,}8 & 0{,}6 & 0{,}4 & 0{,}5 & 0{,}7 & 0{,}7 & 0{,}2 & 0{,}4 \\ 0{,}4 & 0{,}3 & 0{,}1 & 0{,}7 & 0{,}1 & 0{,}2 & 0{,}6 & 0{,}8 & 0{,}7 & 0{,}4 & 0{,}5 & 0{,}9 & 1 & 0{,}5 & 0{,}3 & 0{,}4 \\ 0{,}9 & 0{,}7 & 0{,}3 & 0{,}2 & 1 & 0{,}4 & 0{,}9 & 0{,}6 & 0{,}1 & 0{,}5 & 0{,}4 & 0{,}1 & 0{,}8 & 0{,}7 & 0{,}5 & 0{,}3 \\ 0{,}6 & 0{,}5 & 0{,}8 & 1 & 0{,}2 & 0{,}4 & 09 & 0{,}7 & 0{,}1 & 0{,}6 & 0{,}8 & 1 & 0{,}2 & 0{,}4 & 0{,}6 & 0{,}2 \end{bmatrix}$$

Obtained results are grouped into three linguistic sets defining a match of personal type to project role for considered roles, id est *unacceptable* (F_1), *acceptable* (F_2), *suitable* (F_3).On the basis of the experts' opinions a value division model was accepted. This model is based on the following values assignment to respective sets: extreme value for *unacceptable* 0, typical value for *acceptable* 0.5, extreme value for set *suitable* 1. The values which are critical points $y_{TWS_{k1}} = 0.4$ and $y_{TWS_{k1}} = 0.6$. Taken ranges will be output set models .

Assessing candidate's personal type requires running tests which result in numerical outcome for four psychological functions groups and in each of them for two of those functions types. Accepting the assumption from Section 6.2, fuzzy description needs assessments of only four subtypes, id est S, T, E, J (alternatively N, F, I, P).

Above subtypes are fuzzy model input variables. Every input variable *xi* has the same model of linguistic sets description, id est grouping values into three sets *low* (A_1, B_1, C_1, D_1), *average* (A_2, B_2, C_2, D_2) and *high* (A_3, B_3, C_3, D_3), which are defined by sigmoidal and Gauss's functions. There are critical points for output functions – respectively 0 as minimum for outer left and 50 for outer right, typical value for *average* range is 25. Gauss's critical points are determined $x_{TWS_{kr1}} = 20$ and $x_{TWS_{kr2}} = 30$. Accepted ranges are input set model . Additionally the system's input is given variable $r = \{r_1, \ldots, r_6\}$, defining which role from the set of project roles R is evaluated in the light of desirable MBTI character of personal profile. Variable r_i is described by fuzzy sets in form of singleton (E_1, …, E_6).

There is a knowledge base built for accepted model, including following rules:

IF x_{TWS_1} IS A_i AND x_{TWS_2} IS B_i AND x_{TWS_3} IS C_i AND x_{TWS_4} IS D_i AND r_i IS E_i THEN x_{TWS} IS F_i

In a quoted example, the knowledge base has 486 rules describing correlations between system input sets and designed output.

Assuming that considered candidate's test's results are: S = 24, T = 36, E = 16, J = 40, for system's input one needs to give value $x_1 = 25$, $x_2 = 36$, $x_3 = 16$, $x_4 = 40$ and $r_i = r_2$.

Model's implementation in MatLab environment, using Mamdany's model, max-prod inference mechanism and sharpening based on the centre of a gravity model allows to get result $y_{TWS} = 0.36$ which means candidate's MBTI profile, described as INTJ from indicated characteristics, is *acceptable* result for a given project role. Next step is to determine whether INTJ personal type will harmonise with personal type of an employee acting as role r_3, for which there is a strong interaction level with role r_2.

6.3 Fuzzy model for topological–relational role pattern assessment

Fuzzy model using *topological–relational role pattern* is built in SISO system, where system input is given variable x_i: (x_1 – personality type of recruited candidate, x_2 – personality type of a candidate whose role has strong interaction with recruited candidate) so that:

- consideration space X of variables x_{TRWS1} and x_{TRWS2}: $\{pt_1, \ldots, pt_{16}\}$,
- each personal type is described by singleton type of set for x_{TRWS1}: A_1, …, A_{16}, for x_{TRWS2}: B_1, …, B_{16}, for which ,

and variable pr_i – pair of project roles $pr_i = \{pr_1, \ldots, pr_{15}\}$, for which sets describing linguistic space of variable are formed as singletons (C_1, … C_{15}), for which $\mu(pr_i) = 1$

and at model's output one will obtain value of variable y_{TRWS} – matching of desirable topological patterns, for which:

- linguistic space Y_L of variable y_{TRWS}: {unacceptable, acceptable, suitable},
- numeric space Y_N of variable y_{TRWS}: $\{y_{TRWS} \in \mathbb{R}, 0 \leq y_{TRWS} \leq 1\}$,
- linguistic spaces sets of output variable are described by membership functions:

$$A_{TRWS} = \begin{bmatrix} a_{11} & \ldots & a_{1n} \\ \ldots & \ldots & \ldots \\ a_{n1} & \ldots & a_{nm} \end{bmatrix} \Longrightarrow$$

$$\mu_{unacceptable}(y_{TRWS}) = \frac{1}{1+e^{-a(y-b)}},$$

$$\mu_{acceptable}(y_{TRWS}) = e^{-\left(\frac{y-b}{a}\right)^2},$$

$$\mu(y_{TRWSk_1}) = 0.5,$$

$$\mu(y_{TRWSk_2}) = 0.5,$$

$$\mu_{suitable}(y_{TRWS}) = \frac{e^{-a(y-b)}}{1+e^{-a(y-b)}}$$

Analogously to above mentioned models also here the process of modelling systems output sets uses standardised position relation pattern A_{TRWS} as well as Gauss' function with critical points *k*.

A knowledge base is represented as If – Then type of rule including all combinations of input variable values and respective set of conclusions.

IF x_{TRWS_1} IS A_i AND x_{TRWS_2} IS B_i AND pr_i IS C_i THEN x_{TRWS} IS D_i

Example 3:

Continuing thoughts from Example 1, in effect of interaction strength assessment between role r_2 of considered/recruited candidate and other roles in a team a conclusion is drawn that it is role r_3 that remains in the strongest interaction with role r_2. For this pair of roles pr_7 it is necessary to check the topological match of people who are employed to get through them.

Let us assume that a candidate recruited to role r_2 has ISTJ character type, id est pt_1, but a person employed for role r_3 has ESFP character type, id est pt_{10}. In order to assess the quality of those two types it is necessary to use built, standardised topological–relational matrix of role patterns A_{TRWS} developed by occupational psychology experts *Ep.* Matrices A_{TRWS} are built for every set of roles in a given project management model $A_{TRWS_i} = \{A_{TRWS_1}, \ldots, A_{TRWS_n}\}$.

In a quoted example for defined role pair pr_7 the experts built a relational–topological matrix, for values which

were grouped into three linguistic sets defining topological matching of considered roles, id est *unacceptable* (D_1), *acceptable* (D_2), *suitable* (D_3). On the basis of experts' opinions a model of value division is accepted which is based on the following way of assigning to particular sets: extreme value for *unacceptable* 0, typical value for set *acceptable* 0.5, extreme value for set *suitable* 1. The values which are critical points $y_{TRWS_{k1}} = 0.4$ and $y_{TWS_{k2}} = 0.6$. Taken ranges will be output set models y_{TWS}.

The knowledge base enabling to assess topological match includes 9215 rules which stems from an amount of sets describing input variables (x_1 – 16 sets, x_2 – 16 sets, pr_i – 36 sets) which describe all topological combinations for all accepted pairs of roles, accepting assumptions (5) and (6).

For a chosen role pair pr_7 a result is obtained: $y_{TRWS,pr_1} = 0.69$, which means that this result classifies match of those

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

two personal types to *suitable* set. That means a candidate performing tasks for role r_2 and employee with role r_3 have compatible characters in terms of possibility for an effective cooperation.

7 Summary

This paper shows fragmentary models in chosen aspects that allow to design processes of candidate's assessment for project position. Those models are appropriate for assessment and match of single candidate to already existing project team or for designing one that consists of new candidates. The quoted method of assessment postulates verification of three main aspects: (a) evaluation of candidate's match in terms of compatibility of MBTI personal type with adopted topological pattern designed by occupational psychology experts, (b) indication of which roles a candidate will remain in strong interactions with and (c) assessment of candidate's topological match for a given role with personal type of people playing roles which remain in strong interaction with candidate's role.

All those measures aim at streamlining project team's cooperation quality through providing coherence of competence and character.

Using fuzzy logic tool for model description seems to be natural, due to necessity of considering information supplied by the experts and information concerning aspects of soft competencies described in words, based on intuition and domain experts' empiric knowledge, in decisional process.

It is vital to take into consideration the aspect of possible implementation of various kinds of fuzzy sets representations for description of decisional variables and the impact of representation choice on quality (preciseness/adequacy) of acquired results in taken tasks.

This paper aims at expounding the sheer idea of applying role patterns in which further stages become foundation for modelling of expected outputs of fuzzy system model in process of recruitment and selection of employees for project teams.

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SEVERAL REMARKS ON BANACH–MAZUR GAMES AND ITS APPLICATIONS

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Abstract: Certain type of perfect information games (PI-games), the so-called Banach–Mazur games, so far have not been applied in economy. The perfect information positional game is defined as the game during which at any time the choice is made by one of the players who is acquainted with the previous decision of his opponent. The game is run on the sequential basis. The aim of this paper is to discuss selected Banach–Mazur games and to present some applications of positional game.

Key words: Banach–Mazur games, modelling of economic phenomena, Dutch auction, chess.

JEL Classification: C72, D44.

AMS Classification: 62P20, 91B26

1 Introduction

The most seriously played games of perfect information (which we call PI–games) are chess. The principles of chess laid foundations for development of the latest software, which process lasted many years. Perfect information means that at each time only one of the player moves, which means the game depends only one of their choices, they remember the past, and in principle they know all possible future of the game. The first published paper devoted to general infinite PI–games is by Gale and Stewart (1953), but the first interesting theoretical infinite PI-game was invented by S. Mazur about 1935 in the Scottish Book [7]. Positional games were created in 1940s by a prominent range of Polish mathematicians, belonging to the Lwow School of Mathematics. Owing to the authors' names they are otherwise known as Banach–Mazur games.

This paper aims to address the most common versions of Banach–Mazur games, their modifications and their possible applications.

2 The Banach-Mazur games and their applications

The relevant issue in the area of competitiveness is games displaying an infinite number of strategies. The overwhelming majority of dilemmas related to the above games were defined in the period from 1935 to 1941 and incorporated into the so-called Scottish Book. The Scottish Book referred to a notebook purchased by a wife of Stefan Banach and used by mathematicians of the Lwow School of Mathematics (such as Stanisław Mazur, Stanisław Ulam and Hugo Steinhaus) for jotting down mathematical problems meant to be solved. The Scottish Book used to be applied for almost 6 years. Many problems presented therein were created in previous years and not all of them were solved. After the World War II, Łucja Banach brought the Book to Wrocław, where it was handwritten by Hugo Steinhaus and in 1956 sent to Los Alamos (USA, Mexico) to Stanisław Ulam. Ulam translated it into English, copied at his own expense and dispatched to a variety of universities. The book in question proved to enjoy such a great popularity that it was soon published and edited – mainly in English [1]. The Scottish Book presents the following game no. 43 elaborated by Stanisław Mazur [7].

Example 1. (Mazur)

Given is a set E of real numbers. A game between two players I and II is defined as follows: player I selects an arbitrary interval d_1, player II then selects an arbitrary segment (interval d_2 contained in d_1; then player I in turn selects an arbitrary segment d_3 contained in d_2, and so on. Player I wins if the intersection $d_1, d_2, ..., d_n,...$ contains a point of set E; otherwise he loses. If E is complement of a set of first category, there exists a method through which player I can win; if E is a set of first category, there exists a method through which player II will win.

Problem. It is true that there exists a method of winning for the player I only for those sets E whose complement is, in certain interval, of first category; similarly, does a method of win exist for player II of E is set of first category (see [5])?

Addendum: Mazur's conjecture is true.

Modifications of Mazur's game are follows.

Example 2. (Ulam)

There is given a set of real numbers E. Players I and II give in turn the digits 0 or 1. Player I win if the number formed by these digits in given order (in the binary system) belongs to E. For which E does there exists a method of win for player I (player II)?

Example 3. (Banach)

There is given a set of real numbers E. The two players I and II in turn give real number which are positive and such that a player always gives a number smaller than the last one given. Player I wins if the sum of the given series of numbers is an element of the set E. The same question as for Example 2.

Example 4. (some popular modification Banach–Mazur game)

Two players choose alternatively one digit from the set 0, 1, …, 9. Through their choices they generate an infinite sequence of digits, e.g. 5, 7, 9, 1, … Such a sequence may be denoted by a number 0.5791...∈[0, 1]... Before the game begins, a subset X of the section [0, 1] is to be defined. Player I win provided that the mutually generated number belongs to the set concerned. Player II wins if the number at issue does not fall within the set in question.

The conclusion seems inescapable that the above game has a winning strategy. One may assume that at the beginning the players should establish the set X taking the following form [0,1; 0,3]. Having arranged such a set, player I may initially select the digit 1 or 2, strategy makes him win the game automatically. The selection of any other digit will result in the win of player II.

Formally we can write PI games as follows:

Let A is called the set of strategies of player I, B be the set of strategies of player II.

φ: $A \times B \to \overline{\Re}$, where $\overline{\Re} = \Re \cup \{-\infty,+\infty\}$ ($\Re$ is the set of real numbers).

This game is played as follows:

Player I chooses $a \in A$ and player II chooses $b \in B$. Both choices are made independently and without any knowledge about the choice of the other player. Then player II pays to player I value $\varphi(a,b)$. If $\varphi(a,b) < 0$ means that player II gets from player I the value $|\varphi(a,b)|$.

Idea of an infinite game of perfect information is the following:

- let $\omega \in \{0,1,2\ldots\}$,
- there is a set P called the set of choices,
- player I chooses $p_0 \in P$, next player II chooses $p_1 \in P$, than player I chooses $p_2 \in P$, etc.

There is a function $f: P^{\omega} \to \overline{\Re}$, such that the end player II pays to player I the value $f(p_0,p_1\ldots)$

Definition 1. The triple $\langle A,B,\varphi\rangle$ is said to be game of perfect information (PI-game) if there exists a set P such that A is set of all function

$$A = \left\{ a : \bigcup_{n<\omega} P^n \right\}, \text{ where } P^0 = \{\phi\},$$

$$B = \left\{ b : \bigcup_{0<n<\omega} P^n \to P \right\},$$

and there exists a function $f: P^{\omega} \to \overline{\Re}$ such that $\varphi(a,b) = f(p_0,p_1\ldots)$ where $p_0 = a(\varphi)$, $p_1 = b(p_0)$, $p_2 = a(p_1)$, $p_3 = b(p_0,p_2)$, $p_4 = a(p_1,p_3)$.

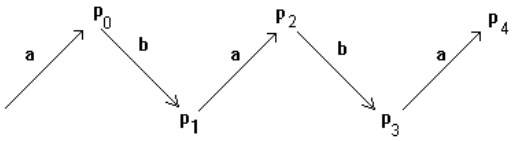

Figure 1. PI-game

A game $\langle A,B,\varphi\rangle$ defined in this way will be denoted $\langle P^{\omega},f\rangle$ or $\langle P^{\omega},X\rangle$.

The sequence $p = (p_0,p_{1\ldots})$ be called a game, any finite sequence $q = (p_{0,\ldots,}p_{n-1}) \in P^n$ is called position.

f is characteristic function of a set $X \subseteq P^{\omega}$,

$$\begin{cases} f(p) = 0 & \text{if} \quad p \notin X \\ f(p) = 1 & \text{if} \quad p \in X \end{cases}.$$

The player I wins the game if $f(p) = 1$ and player II wins the game if $f(p) = 0$.

Definition 2. [8]. A game $\langle A,B,\varphi\rangle$ is called *determined* if

$$\inf_{b\in B}\sup_{a\in A}\varphi(a,b) = v = \sup_{a\in A}\inf_{b\in B}\varphi(a,b) \qquad (1)$$

where v is value of the game (common value v of both sides of this equation is called the value of the game $\langle A,B,\varphi\rangle$).

Remark. A game is determined if and only if the game has a value.

A game is not determined if

$$\inf_{b\in B}\sup_{a\in A}\varphi(a,b) < v < \sup_{a\in A}\inf_{b\in B}\varphi(a,b) \qquad (2)$$

Note. If the game is not determined, then the left–hand side of Equation (1) is larger than the right–hand side of Equation (1).

If the game has a value v and there exists an a_0 such that $\varphi(a_0, b) \geq v$ for all b, then a_0 is called an optimal strategy for player I. If $\varphi(a, b_0) \leq v$ for all a, the b_0 is called an optimal strategy for player II.

We will say that $\langle P^\omega, f\rangle$ is a win for player I or a win for the player II if $\langle P^\omega, f\rangle$ has value 1 or 0, respectively. If $f: P^\omega \to \overline{\Re}$ has the property that there exists an n such that $f(p_0, p_1 \ldots)$ does not depend on the choice p_i with $i > n$, then $\langle P^\omega, f\rangle$ is called a finite game.

The following theorems are true.

Theorem 1. [8]. Every finite game has a value.

Proof ([8], proposition 2.1, p. 45).

Theorem 2. [8]. There exist sets $X \subseteq \{0,1\}^\omega$ such that game $<\{0,1\}^\omega, X>$ is not determined.

Proof ([8], proposition 3.1, p. 46).

Theorem 3. [8]. If the set $X \subseteq P^\omega$ jest closed or open, then the game $\langle P^\omega, X\rangle$ is determined.

Proof ([8], proposition 3.2, p. 46).

Theorem 4. [8]. If player II has a winning strategy in Banach–Mazur game, then X is not countable.

Another interpretations of Banach–Mazur games.

Example 5. (Mycielski)

A set S is given. Player I splits S on two parts. Player II chooses one of them. Again player I splits the chosen part on two disjoint parts and player II chooses one of them, etc. Player I wins if and only if intersection the chosen parts is not empty and player II wins if and only if it is empty.

Remark. Player I has a winning strategy if and only if $|S| \leq 2^{\aleph_0}$, and the player II has a winning strategy if $|S| \leq \aleph_0$, where $|S|$ means cardinality of set S, $\aleph_0$ is aleph zero – cardinality of integer numbers.

Theorem 5. [8]. If player II has a winning strategy for Banach–Mazur game, then $|S| \leq \aleph_0$.

The proofs of above theorems have used the Axiom of Choice [4]. Mycielski and Steinhaus conjecture that the Axiom of Choice is essential in any proof of the existence of sets $X \subseteq \{0,1\}^\omega$ such that the game $<\{0,1\}^\omega, X>$ is not determined. In the same order of ideas, Theorem 5 shows that Continuum Hypothesis ($2^{\aleph_0} = c$ – continuum or we have not any cardinal number between $\aleph_0$ and $2^{\aleph_0}$) is equivalent to the determinacy of natural class of PI games.

3 Prime numbers and Banach–Mazur games

While creating the original variants of Banach–Mazur games, one may apply the properties of prime numbers, as they constitute a countable set. That ensures that the game in question may be deemed as determined.

Example 6.

Game G_1. Player I chooses number $s_1 = 2n_1 + k$, where $k < n$ and calculates an element of the sequence taking the form:

$$x_n = \begin{cases} 2^{-n} & \text{where} \quad \exists p, q \in P_r \quad \text{such that} \quad 2n + k = p + q(^*) \\ 2^{-k} & \text{where} \quad k \leq n \quad \neg\exists p, q \in P_r \quad \text{such that} \quad 2n + k = p + q(^*) \end{cases} \tag{3}$$

P_r denotes the set of prime numbers whose divisor is 1.

Player II selects a subsequent number $s_2 = 2n_2 + k$, where $s_2 > s_1$ and finds an element of the sequence taking the form (Equation 3). The analogical action is taken by player I, etc. If $\lim_{n\to\infty} x_n \to 0$, then player I wins; otherwise player II is a winner. Is there any winning strategy?

Note. According to Ref. [6], the properties of prime numbers may be summarized as follows:

Property 1. Each natural number bigger than 4 may be presented as the sum of two prime odd numbers.

Thus, player II can subsequently select odd numbers and in his k-step he may choose the number which fails to satisfy the condition (*). Then $x_k > x_k - 1$, thus x_k does not converge to 0. Hence, player II has a winning strategy. It should be emphasized that the set of sequences taking the form (Equation 3) constitutes a set of first category and is countable. Therefore, referring back to the considerations as described in (2), the game may be declared as determined (Theorem 4 is satisfied).

Example 7.

Game G_2. The game is analogical to game G_1 as defined in Example 6. However, the numbers selected by the players in order to generate the elements of sequence x_n should satisfy the requirement (**) specified in the following formula:

$$x_n = \begin{cases} 2^{-n} & \text{where} \quad \exists p,q,t \in P_r \quad \text{such that} \quad 2n+k = p+q+t(^{**}) \\ 2^{-k} & \text{where} \quad k \leq n \quad \neg\exists p,q,t \in P_r \quad \text{such that} \quad 2n+k = p+q+t(^{**}) \end{cases} \tag{4}$$

Analogically to the previous case, P_r denotes the set of prime numbers. Is there a winning strategy?

In the event of G_2, the following property of prime numbers should be applied [6].

Property 2. Each odd number bigger than 7 may be presented as the sum of three prime numbers.

While applying Property 2, one may assume that player II selects subsequent even numbers bigger than or equal to 8. Provided that he may choose the number which fails to meet the condition (*). He has, thus, a winning strategy.

Conclusion. Games G_1 and G_2 are determined, because player II has a winning strategy.

4 About some applications of PI games

Banach–Mazur games used to enjoy great popularity, mainly among mathematicians. When dealing with those games, the chief question was: is there a winning strategy guaranteed for any of the players? Taking into account the Axiom of Choice, already at the beginning of the 20th century it was proven that there were certain sets X for which neither player may adopt a winning strategy. The introduction of a new axiom to a set theory, known as the axiom of determination, significantly facilitated the search for a winning strategy. Different variants of Banach–Mazur games were analyzed in terms of the satisfaction of determination condition. It was proven that suppose one may find a set whose subsets are assigned a non-trivial measure, being a countable additive extension, vanishing on points and taking the value of 0 or 1, then all the analytic subsets defined on the set concerned are determined, or at least one of them has a winning strategy.

Banach–Mazur games can be classified as infinite multistage games with perfect information. In practice, they are illustrated by the situations where *the winner takes everything* (compare the Colonel Blotto Game). Moreover, the games where the win is determined already at the initial stage, rely on a *first come*, *first served* basis. In terms of economy, such a game corresponds to the auction where a product (item) is offered up for bid. In such a case the buyer who wins the auction *takes everything*. Analogically to many positional games, the first participant submitting a bid determines the course of auction. Whenever the bid does not reach the sale price offered by the seller, other bidders may outbid the reserve price or withdraw from the auction. For instance, the digit selected by the participant initiating the game may not guarantee that the number generated in a following sequence will belong to a given interval (compare Example 4). Notwithstanding the type of auction the optimal strategy adopted by a bidder resides in offering such a price will warrant the win (i.e. the purchase of a product), however, which does not exceed his own valuations of an item in question. In the event of Dutch auction the price is gradually lowered until some auctioneer is willing to accept the announced price – such a participant wins the auction. It is a typical example of a game based on a *first come*, *first served* ground. The games introduced in previous examples serve as an illustration for the Dutch auction.

The most common, 'finite' positional game with perfect information is chess which laid foundations for artificial intelligence algorithms applied in various domains, including the construction of dynamic equilibrium models as well as the description of economic systems lacking the equilibrium. In 1949, the American mathematician C. E. Shannon setup the guidelines for computer chess game, which were being gradually improved in ensuring years. In the 1950s, the lion's share of the Artificial Intelligence research focused predominantly upon the chess game basis, as they were considered a good model for human intelligence. From the historical angle, what may be perceived as a breakthrough point is the match held in May 1997 in the Manhattan district, where the chess champion Garry Kasparov was defeated by the IBM's computer Deep Blue! Up to that moment the chess was deemed as one of several games in which a human being could prevail over the machine. The reason for that phenomenon may be explained by the fact that the number of variants applicable to one game composed of 100 movements amounts 10^{155}. The computers of older generation used to calculate every operation and thus were not able to analyze all possible options within three permissible minutes. Conversely, the players aimed to select the best variants, as they were not capable of computing possibilities. The pivotal role was played both by their knowledge and experience. Notwithstanding the significant advancement of technology which felicitated the computerized data processing, the useless strategies were removed from the available algorithms and 600 thousand chess openings as well as a considerable set of chess masters' games were imprinted to the machine languages.

Unlike the previous algorithms, the newly created methods prompted the computer to search for the move usually made by the top players. In 1996, Kasparov won the match in Philadelphia with a computer, where the score was 4:2. The match initiated a real battle against the human mind, which resulted in the further enhancement of computer's strategies upon modifications reflecting the thinking process conducted by a chess champion while attempting to predict the consecutive moves of his opponent. One may claim that in 1997 Kasparov was almost forces to play a game not only with a technologically modified computer but also with 'the spirit of his predecessors'.

In 2011 IBM developed a smart computer named Watson, which understands questions posed in natural language and is able to gather as well as browse an enormous amount of information more effectively than a human being. Having competed against two masters of American show *Jeopardy*, Watson won the first prize. It acquires a massive amount of data extracted from medical periodicals and rapidly analyses thousands of particular medical cases, which is unattainable even by the most talented doctors. Watson presents the best options which lay foundations for a further diagnosis. The works aiming to develop computers of new generation, i.e. quantum computers which can employ a specific class of quantum phenomena and make independent decisions are still underway.

The Artificial Intelligence is more and more often applied in energetics – to create systems not only monitoring the course of specific processes, but also involved in planning and decision-making procedures. It is used also for the purposes of image processing, e.g. in cameras, supporting financial decisions as well as in many other domains of everyday life.

It is worth mentioning one of the most fascinating personalities of sports and science, Robert James Fischer who was famous for his exceptionally talented and rebellious mind. He played hundreds of outstanding games, implemented many innovative solutions and introduced the so-called Fischer clock enabling to keep track of the total time each player takes for his or her own moves. Due to some personal reasons he was not able to play the game with the computer. Just wonder who would have won in such a competition.

In the light of the game theory, it should be emphasized that due to its limited range of strategies the chess game is indeterminate, fact the vast majority of chess players remain unaware.

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BARRIERS FOR ECO-INNOVATIONS: A CASE STUDY OF A SMALL FIRM IN POLAND[1]

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Abstract: This paper is mainly based on a case study of Tuzal Ltd. – a small firm acting in the eco-innovation market in Poland. The main aim of the paper is to analyze main barriers which are being met by enterprises, especially small firms, acting in the eco-innovation market. The following barriers are analysed: problems in convincing customers to innovative solutions; a specific nature of cooperation with local administration units; continuous changes in legal regulations; an increasing market competition; a lack of funds for marketing; a generation gap and a retirement age of the company's owner.

Key words: eco-innovation, environmental technologies, small firms.

1 Introduction

Taking decisions in a flat decision problem (or in other Recently, we can observe a growing role of eco-innovations, both as a research subject and as a part of business as well. However, managers, especially in small and medium-sized enterprises (SMEs), must be fully aware of numerous barriers in the eco-innovation market and should know how to overcome them.

The paper's aim is to analyse main barriers which are being met by enterprises, especially small firms, acting in the eco-innovation market. The paper is mainly based on a case study of Tuzal Ltd. – a small firm acting in the eco-innovation market in Poland.

We shall try to show that a small firm which intends to launch eco-innovations must run a skilful, balanced 'game' between factors favourable and non-favourable to such activities.

2 A short literature survey

A scientific literature on eco-innovations is already quite rich [5, 7, 11]. A big emphasis on eco-innovation, in the context of the sustainable development, is being put by the European Council within such documents as *Europe 2020*, *Innovation Union* and *Eco-innovation Action Plan* (*EcoAP*) or the earlier Eco-Management and Audit Scheme (EMAS) of 2001.

One of three main goals of 'Europe 2020' strategy is building a greener society. An issue of eco-innovation is mentioned in several places in *Innovation Union*, e.g. in 15th and 18th action points. *EcoAP*, accepted just recently, directly results from *Innovation Union* – one of seven EU flagship initiatives.

In the context of eco-innovations or, in other words, new environmental technologies, a crucial role of a social awareness is being stressed in numerous studies – both in relation to consumers' behaviour as well as to firms' behaviour. The former relates to a so-called new, ecological consumer/consumption [2, 9] while the latter is a part of corporate social responsibility (CSR) [1, 4, 12].

Also, an issue of barriers for innovations is widely developed in literature, including the barriers/obstacles for innovation activities in SMEs [8, 10]. In Poland, for instance, SMEs complain about the cooperation, or a lack of it, with research organisations, banks, financial investors, other business environment institutions and local governments [6]. Frankly speaking, similar observations happen in the European Union as a whole. SMEs often struggle to convince financial institutions to invest in them or lend to them; they require a business-friendly environment to flourish.

According to Wrzesiewski and Miler [13], the Polish eco-innovation market/sector is in an initial phase of development; a relatively big role is being played by imported technologies; producers of environmental technologies have a weaker market position in comparison with their distributors. Only 26 Polish companies were registered within EMAS in 2010 [3].

There are numerous reasons for such a state of affairs – both on the demand side and on the supply side.

Too small the demand for eco-innovation is the result, among other things, of:

- too high the prices of ecological products, e.g. of eco-food,
- still low pro-ecological awareness among consumers,

[1] This is a revised version of the paper presented at the CAMOT 2012 Conference, Shanghai, 29–31 October 2012.

- a weakly expanded sustainable development *regime*,[2]
- high costs of exploitation of environment-friendly devices.

Among the reasons for too small the supply of eco-innovations are:

- a very small interest in EMAS among enterprises,
- various difficulties in the implementation of ISO 14001,
- insufficiently popularised CSR approach in industry,
- long periods of waiting for new environmental technologies being worked out in the Polish R&D sector.

However, a quick step forward has taken place in this field recently. Namely, within The Operational Programme 'Infrastructure and Environment', financed by EU Structural Funds and Coherence Fund, there is Action 4.3: Support for firms implementing the best available technologies (BATs). The enterprises introducing eco-innovations may gain a financial support from this source, although eco-innovation is not – unfortunately – a separate category entitled for grants.

According to the report based on a questionnaire research among 278 enterprises operating in the Polish eco-innovation market, numerous external (outside the firms) and internal (inside the firms) barriers were identified [13].

Three main external barriers mentioned by the respondents are:

- a growing competition in the sector, often a dishonest price competition,
- a difficult access to financial capital (tough bank credit conditions),
- difficulties in getting permits from local governments for installation of environmental devices.

Three main internal barriers are as follows:

- financial constraints, i.e. a lack of own funds,
- too weakly developed distribution channels,
- difficulties in finding demands for their products.

3 Tuzal Ltd.: A case study

One of firms operating in the eco-market in Poland is Tuzal Ltd. This is a small, family enterprise established in Warsaw in 1990. The firm employs three people permanently but used to employ, if needed, bigger groups of workers, often exceeding 20 people. Tuzal plays a double role of producer and distributor of environmental technologies, such as EcoDrain, ORTWE, FKJA/LAFT (see below). The firm's main market activities in the last decade and now have been as follows:

- to produce EcoDrain devices with Aikaterisil fillings for cleaning storm wastewater,
- to operate as the agent in selection of environmental protection technologies,
- to offer services for old chemical reagents, waste and hazardous solutions containing heavy metals and petroleum derivatives,
- to liquidate old, closed contaminated chemical facilities,
- to coordinate an international project SOILSTABSORBENT within the program EUREKA that resulted in elaboration of the ORTWED method sludge treatment plant, and
- to exclusively distribute the FKJA/LAFT method used to neutralisation of dilutions, wastewater and wastes from metal surface treatment, especially wastes from galvanisation processes.

The SOILSTABSORBENT project was established in 2002 within the EUREKA program (Project E!2695) as a result of studies of Polish–Danish research and development group. The aim of the project was to verify whether the oiled sludge, containing petroleum derivatives could be used as a stabilisation factor in the road construction process. To achieve the goal, the sludge was mixed with a highly reactive lime that came together with the water contained in the sludge in an exothermic reaction, so the dry hydrophobic granulate was obtained. The research on an environmental impact of the process were run in The Warsaw University of Technology and in The Road and Bridge Research Institute in Warsaw where the granulate was studied as a potential road stabilisation factor, and continued in The Chemistry, Oil and Coal Institute at The Wroclaw University of Technology where the granulate was examined as a toxic-gases absorber. There were 400,000 Mg petroleum derivative waste neutralised in the ORLEN Group facilities in Plock in 2001–2004, as a part of the project.

The next technology is the EcoDrain™ system with AikaterisilTM fillings. It is used as the rainwater treatment plant that is to be put directly into drains situated on roads, car parks, petrol stations and everywhere else where a problem of rainwater treatment occurs. The technology originates from Sweden, and TUZAL has an exclusive right for introducing it into the Polish market. The first such units were installed in 2003 in Plock. What is innovative in this technology is that it neutralises the wastewater at the very beginning of the pipeline system, in comparison

[2] Until recently, a coal being extracted in the country was called 'a black gold'.

to the classical methods, set on cleaning at the end of the drainage system. Moreover, because EcoDrain system is not connected to the ground, it does not need a building permit.

Tuzal has introduced several innovative modifications to the system of sterilisation of sludge using highly active lime. As a result, the ORTWED method was applied as the sludge treatment solution for municipal waste water treatment plants. The point of the process was to transform the sludge into a full-value fertiliser. A first such installation was erected in Glogow Malopolski, Poland in 2010. The idea of introducing this product into the market has arisen in the company due to the difficulties that municipalities had with treating sludge, especially after Poland was forced to meet the European Union requirements. Moreover, now we know that the method is suitable for many applications, such as municipal water treatment plants, biogas plants, food, herbal or animal production facilities.

TUZAL Ltd. is also the only representative/distributor of the FKJA/LAFT method both in Poland and abroad. This technology enables heavy and noble metals' recovery from wastewater in metal surface treatment facilities with simultaneous neutralisation of hazardous, toxic and dangerous chemical compounds like cyanides barium or arsenic derivatives. The technology has more than twenty Polish and global patents and utility designs. The major author who is also a founder of TUZAL Ltd. was several times awarded worldwide for this method which was applied more than 250 times all over the world.

At the moment, the company's strategy is to work hard on innovative technologies. It works on environmentally friendly, especially eco-innovative technologies. We believe that successful implementation of these technologies can increase the firm's income and competitiveness in the market. Moreover, Tuzal's goal is to come to an end with projects opened during last three years and, of course, to set up some new of them. There is a plan to employ young, energetic people in order to increase marketing activity.

Profits generated by Tuzal in 2007–2011 were: $24,300 in 2007; $16,000 in 2008; $13,200 in 2009; and $1200 in 2011 (in 2010, there was a small net loss). Provisional data for 2012 are very promising again.

In our opinion there were several reasons of this decreasing profit tendency. First of all, it is due to the international economic crisis that had an influence on lesser purchases, and extended period from the first contact to accomplishment of the project with a particular customer. The another reason was a significant increase in costs, including those borne on marketing that are due to a lengthening of the customer search process and to local administration decision processes, related with the lack of finance for innovation. The other factor that influenced the company's financial situation worsening was a termination, in 2010, of cooperation with a long-term customer for whom the company offered a big part of its works.

Nevertheless, the main sources of TUZAL Ltd. successes seem to be as follows:

- a belief in management capabilities to run the business and in the utility of technologies proposed,
- wide connections struck up by company employees as well with representatives of Polish and global companies as with local administration all over Poland,
- a continuous search of innovations and capability for selection of the most original and useful ideas,
- a broad professional experience and a specialist knowledge of the company's founder, Franciszek Tużnik, who has entirely used the wisdom gained during his university studies and work on the Ph.D. thesis,
- a persistence in aspiration to set up ambitious goals for the firm,
- a flexibility in searching of market opportunities and commissions as well as possession of wide range of technologies.

4 Barriers for eco-innovations

As many small enterprises in Poland, Tuzal encounters various barriers connected with market application of innovative technologies. They are analyzed below.

4.1 Problems in convincing customers to innovative solutions

Several generations of Polish people were downgraded by socialism and communism in innovative thinking. Instead of activity development, the society was learnt how to adopt and duplicate solutions invented somewhere else. TUZAL Ltd. finds this problem as the main barrier in reception of innovative technologies among potential customers in Poland who are much more distant to them than other European nations. When one chooses innovative solution he/she has to change his/her way of thinking or even entire approach to the problem. This lack of possibilities to directly compare innovation to something already known makes a big barrier.

Traditional marketing efforts, like advertisements in specialist periodicals and an attendance at fairs and confer-

ences, could be not enough to persuade customers to an innovative solution. To overcome this barrier TUZAL tries to introduce semi-technical installations that could constitute experimental models, useful for demonstration of the proposed solutions among customers.

A presence of the mental barrier is not optimistic. It is the fear of progression that made the Polish saying 'it will be somehow' very popular. The saying does not originate from nowhere. It is socialism that made our society so non-innovative, and that system is first to be blamed for such deprived reception of innovative solutions and irrational trust in old, often invalid technologies. That is also why many creative Polish people decide to emigrate to Western countries where they expect to successfully create and produce innovative solutions.

4.2 A specific nature of cooperation with local administration units

TUZAL Ltd. has broad business contacts with local administration units. Unfortunately, people working in these units often are not well prepared to their work, do not understand or even do not want to understand economic, ecological and social effects of using innovative solutions. This situation is caused due to the clerks' connections with certain political options or to an influence by strong lobby groups.

Moreover, in almost every single public tender the most important criterion is the lowest offered price. In such situation, many innovative solutions with higher investment costs are rejected, even if their further exploitation costs are much lower. That is why innovative products are not launched into the market while old, defective solutions are being installed. Such faulty technologies are very easy to be found in Poland where roads, motorways, municipal facilities are just at the beginning of the list.

Another problem is the social responsibility of the people employed in local administration units. If the proposed technology fails they are the first to be blamed for that. TUZAL Ltd. has several times faced a situation where the clerks were convinced to the offered method but they were afraid of introducing it. Also, a lack of appropriate funds for introduction of innovative technologies and long-lasting decision-making processes potentially make a serious problem in implementation of innovative methods.

To avoid these barriers, TUZAL tries to advertise and talk about innovative technologies at every level of the local or regional administration. Such debates, open for everyone involved in the decision-making process, can reduce the barriers among representatives of the unit and help convince them to a given solution.

4.3 Continuous changes in legal regulations

The inconstancy and incoherence of Polish legislation is a big problem in business activity. Most of all it is caused by clerks and ignorance of legislators as well as of a significant influence by lobby groups. These aspects also made it very hard to introduce innovative solutions. It is really not an accident that Poland is far away in business-friendly countries ranking.

In the conditions mentioned above, it is difficult to prepare long-term business plans and then to accomplish them on time and in accordance with already made decisions. Moreover, this situation requires constant actualisation of legal wisdom, often hard to be understood.

Another problem is followed by an inconsistency and misinterpretation of the legal acts. Whereas this practice causes incompatibility of legal forms and settlements which are obligatory for companies to prepare on a regular basis. This misinterpretation can even lead to obstruction or even elimination of smallest enterprises.

Moreover, more complicated, incoherent and ambiguous legal acts entail corruption, larceny and frauds. Together with the lack of responsibility for such delinquencies, many of those small enterprises decide to register abroad.

Although TUZAL Ltd. cannot do much about legislation, the company tries to fulfil its goals and even come up with new technological solutions. Several legal acts can intensify requirements amongst customers and so a chance occurs for the company to introduce innovations or achieve different marketing approach. Such situation requires an acquisition of constantly changing law.

4.4 An increasing market competition

In Poland, various market sectors have recently being taken over by several international corporations. Such market conditions are a real menace for small enterprises, like TUZAL. Many of those are forced to leave the market. Among others it often causes an activity obstruction or precludes the prevalence of their innovative solutions.

There are in fact two types of market competition from a view-point of small enterprises. One is a fair competition with other players from the same level (SMEs). The other type relates to a competition with the corporations that have a big financial and social power, making them able

to play the market game on their own rules. This often leads to a closing of any chances for smaller companies to introduce their new products or methods of production. What is more depressing, corporations have a big influence on authorities and legislation, so this barrier will only be stronger in the future.

The second problem connected with an increasing market competition is the appearance of much more, then before, substitutes in the market then before that lowers a market value of TUZAL's products, even those innovative. It is said that a normal solution here is to patent innovative units. In fact, it does not always bring an expected effect. Potential costs and long-term period of compensation often makes it impossible for small enterprises to initiate such cases. What is here sad, but true, is that patenting does not always mean protecting.

Both barriers – connected with corporations and with substitutes – are a significant problems. It looks like that there is the only one solution in such situation, i.e. a constant work on innovations and searching of technologies abroad to introduce them in local markets. TUZAL has chosen this way.

At the end, it is important to suggest some legal solutions to the mentioned problem. There is no simple, long-term support program for innovative enterprises in Poland. There is also needed some kind of assistance in creating partnerships between enterprises and research institutes. This should intensify Polish innovation movement for sure.

4.5 A lack of own funds for marketing

An increasing competition needs a bigger money support for promotion of products. A lack of funds is not a prosaic problem here. In fact, many enterprises like TUZAL, know how it is difficult to sell a product without a good marketing or even a chance to be present in mass-media. But in fact very often it is simply impossible.

In result, a little money support for promotion lowers the chance to eventually sell an innovation. Again, this situation is good for corporations that quite often retake from small enterprises the most attractive ideas for little money and introduce them as their own ones. This problem affects not only small entrepreneurs but also diminishes national revenues.

A basic plan here is to assign money from other business fields to spend for marketing. Because this solution decreases funds for other purposes, TUZAL tries to maintain contacts with research institutes and takes part in scientific publications where the company can also advertise its products.

This practice is rather a defensive activity, resulting from a lack of other perspectives. Only if decision-makers understand that boosting native innovation program gives a chance to strengthen national economy, there will be a view of some significant changes. Only a real marketing support for innovative technologies can help in expansion of them both in Poland and all over the Europe.

4.6 A generation gap and a retirement age of the company's owner

As mentioned, TUZAL Ltd. is a family enterprise and all firm's shares belong to the same family. Everyone tries to invest much energy and wisdom to make the company develop and expand in the market. It is the company's founder contribution who gives his knowledge and a practical expertise. His son, a representative of the young generation, has an economic and marketing knowledge and helps achieve the firm's goals.

It is normal that people from different generations have separate points of view and concentrate on different, often contrary activities. That is also why they have their own visions of how to lead the company. Luckily, this barrier was minimised in TUZAL Ltd. Internal partners accept others drawbacks and know how to use each other's advantages. They also know they can rely on each another, no matter what will happen.

It looks like a mutual understanding, and so trust is the chance for such a family enterprise to achieve any success. Only then a generation gap can bear fruits and does not stop the company's development.

To sum up, a generation gap in the company can be an advantage and a help for young generation. Wisdom and experience of old generation, together with broad education of younger co-owners can provide a presence in the market or even a chance to develop further and keep introducing innovations faster and with more chance to success.

5 Conclusions

We have identified six following barriers for eco-innovations in small firms:

- problems in convincing customers to innovative solutions,

- a specific nature of cooperation with local administration units,
- continuous changes in legal regulations,
- an increasing market competition,
- a lack of funds for marketing,
- a generation gap and a retirement age of the company's owner.

As seen, here there are barriers which:

- belong to both groups, i.e. external and internal ones,
- are typical barriers for technological innovation and those specific for eco-innovation,
- confirm at least some of the barriers mentioned at the beginning of this paper.

Legal and formal requirements, like obligation to present in national offices various certificates, permissions or to fill out not often necessary forms or reports, including those authenticated by a notary, have an influence on time, financial and tax commitments and lengthen technology implementation processes. This situation places Poland in the very far position on the list of business-activity supporting states and reduces operation opportunities for Polish companies. This fact has an influence on big number of bankruptcy among Polish micro-enterprises.

Having above in mind, one can come to the conclusion that all those barriers and requirements lead to economic slowdown that implies downward income tendencies in small enterprises like TUZAL Ltd. and influences economic slowdown on the macro-economic scale. In spite of all, Tuzal successfully tries to struggle with these adversities.

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THE OVERSIGHT OF FIRE PREVENTION IN AN ENTERPRISE

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Abstract: An efficiently working fire protection system in an enterprise, a work place or an institution guarantees the proper execution of fire protection duties. Its proper organisation is of key importance. The conditions of the proper organisation of the fire protection system in a given organisational unit are above all the universality in the scope of using applicable provisions, knowledge of applicable provisions, appropriately exercised supervision of usage of applicable provisions, orders and established rules of conduct. The aim of this paper is to specify the most important duties of owners, users or managers in providing protection against fire or other local risks. This results from the fact that given the variety of operating enterprises, the character of their activity, kind of production and used technology, size, fire risk, etc. it is not possible to determine a standard model of a fire protection system for a particular work place.

Key words: fire protection, fire safety, preventive measures, fire.

1 The duties of an owner, administrator or user of a building

Fire breaks out, above all, in places where the fire protection system is not well organised and where fundamental norms of the usage of the building and the area around it are not obeyed. If fire protection is to be effective, it is necessary to specify fire risk, provisions of fire protection and rules of conduct in case of fire for each building individually.

The most important legal act regulating issues related to fire protection is the Fire Protection Law[1] which says that fire protection consists of carrying out undertakings aiming to protect life, health, property and the environment against fire, natural disasters or other local risks.

The owner, administrator or user of a building, complex or area is obliged in particular to:

- obey technical-building, installation and technological fire requirements, equipping the building and the area around it with fire-fighting devices and fire extinguishers in accordance determined in the directive of the Ministry of the Interior,
- in a way guaranteeing their efficient and reliable functioning,
- maintain and repair fire-fighting equipment and devices, as well as fire extinguishers in a way that guarantees their efficient and reliable functioning,
- provide security to people staying in the building and in the area around it as well as a possibility of evacuation in case of fire,
- prepare the building and the area around it for a rescue operation,
- make the users of the building acquainted with fire safety regulations,
- determine norms of conduct in case of fire[2].

Owners and administrators are also obliged to:

- know fire safety regulations concerning the building and ensure that employees, lessees and users obey them,
- know the norms of conduct in case of fire, manners of raising the alarm and carrying out evacuation,
- make use of meetings with employees (or users of the building) in discussing issues of fire safety,
- make use of remarks and proposals related to the protection of the building against fire,
- maintain escape routes in a good condition and provide access to building,
- provide professional supervision of fire dangerous jobs,
- influence in an appropriate way those maintenance workers whose negligence may result in fire hazard,
- control carrying out of orders and train employees in fire protection[3].

Due to the fact that the knowledge of fire protection is extensive, activities, duties and supervision of fire protec-

[1] *The Fire Protection Law of 24 August 1991* (Journal of Regulations No 81, heading 351, with amendments)

[2] Ibid.

[3] K. Fiszer, A. Hetmann, D., Markiewicz, *A safe building,* Forum, Warsaw 2006, p. 56.

Table 1. The comparison of previous and current classification of buildings (*source: Cholerzyński W.: Components of building fire safety for…*[6]).

Category	Decree of the Minister of Infrastructure of 12 April 2002 (concerns a building or its parts constituting separate fire zones)
Occupancy-related fire hazard level I	Buildings with rooms intended for simultaneous occupancy of more than 50 people who are not their permanent users, but not intended for use to people with limited ability to move
Occupancy-related fire hazard level II	Buildings intended above all for people with limited ability to move, e.g. hospitals, day care centres, kindergartens, old people's homes
Occupancy-related fire hazard level III	Public utility buildings, not qualified as occupancy-related fire hazard level I and II
Occupancy-related fire hazard level IV	Residential buildings
Occupancy-related fire hazard level V	Multiple-flat residential buildings, not qualified as occupancy-related fire hazard level I and II

tion systems may be entrusted to a company or people having appropriate qualifications and experience.

People responsible for fire protection[4], that is prevention and spread of fire, who are not employed in fire protection units, ought to have tertiary education and complete a fire protection specialist training or be a major in fire safety engineering, or have a Bachelors Degree in Fire Safety Engineering, or should have their qualifications in fire safety engineering recognised.

The above-mentioned people responsible solely for operations related to providing fire security of the building should have at least secondary education and a fire safety officer training or the professional title of a fire safety technician.

2 Fire classification of buildings

Technical-building fire requirements for a particular building are determined depending on their purpose, height and the number of stored goods. Depending on their purpose buildings are divided into the following groups:

- classified as hazardous to people,
- buildings used for production and storage purposes,
- stocktaking buildings.

The elementary rule of classification is the main purpose of the building (occupancy, storage, production). What is important, this classification applied to buildings and their parts that constitute separate fire zones, defined as an occupancy-related fire hazard zone or a production and storage-related fire hazard zone.

Public facilities and boarding houses[5] are recognised in one or more categories of hazard for people (Table 1).

There is a separate classification based on the so-called fire load density for buildings intended for storage, processing and production, as well as garages.

Fire zones of garages, hydrophore plants, boiler houses, district heating substations, electrical switchboards etc. are subject to the same safety requirements as production and storage-related fire zones. Besides, fire zones may included in more than one category of hazard to people if buildings have 'mixed' purpose (e.g. office and multiple-flat residential buildings) or if these purposes change periodically. In such cases they should meet the requirements of each such category.

2.1 Building classification into height groups

Fire safety requirements change depending on the height of the building (both categorised as occupancy-related and production and storage-related fire zones). Height is measured from above ground level at the lowest lying point of the entrance to the building or its part that is on the

[4] *State Fire Service Act of 24 August 1991* (Journal of Regulations No. 88, heading 400, with amendments).

[5] *The Minister of Infrastructure's Regulation of 12 April 2002 of technical conditions of buildings and their location* (Journal of Regulations No. 75, heading 690, with amendments). Dz.U. nr 75, poz. 690, ze zm.

[6] Cholerzyński W. - *Components of building fire safety for auditors of qualification training of privates and non-commissioned officers of the State Fire Service*. National Headquarters of the State Fire Service, Education for Safety Foundation, Warsaw 2005.

Table 2. Building classification based on height (*source: Cholerzyński W.: Components of building fire safety for…*[8]).

Classification	Buildings	Residential buildings
Low (L)	Up to 12 m altitude above ground level	Up to 4 overground storeys inclusive
Medium high (MH)	From 12 to 25 m altitude above ground level	From 4 to 9 overground storeys inclusive
High (H)	From 25 to 55 m altitude above ground level	From 9 to 18 overground storeys inclusive
High-rise (HR)	More than 55 m altitude above ground level	

first overground stay to the top of the highest lying ceiling, including thermal insulation and its protective layer and excluding engine rooms or other technical facilities, or to the highest lying point of a flat roof or roof construction that is directly above the rooms intended for occupancy[7].

A significant change was introduced in 2009. In accordance with it top floor extensions and technical facilities. Table 2 presents building classification based on height.

The above-mentioned criteria concerns directly technical-building and fire requirements for particular buildings and affect the choice and type of fire-fighting devices and used elements.[8]

2.2 Evacuation

In case of fire the most important thing for people staying in the building is escaping from it safely. As a result in each building appropriate escape conditions enabling quick and safe evacuation from a fire zone or a zone covered by the fire must be provided. Such conditions need to take the following aspects into account: the number of people staying in the building and their physical fitness, and the construction of the building and its size. Therefore, the owner or the administrator of the building has to take care of technical fire protection measures. Their duties include among others:

- ensuring an adequate number and width of escape exits,
- keeping acceptable length, width and height of escape passages and routes,
- keeping escape routes and rooms safely sectioned,
- protecting escape routes listed in technical-building regulations against smoke and using devices and other technical solutions preventing smoke and removing it,
- ensuring emergency (safety and evacuation) and warning lighting in facilities in which it is essential to evacuate people,
- enabling passing warning signals and voice communications via audible warning systems in building in which it is required[9].

In case of fire general passageways in the building – horizontal (e.g. hallways and corridors) and vertical (e.g. stairs and stairways) can be used as escape routes. However, they have to be appropriately marked by safety signs and explicitly show the direction of escape. Evacuation can be carried out in three ways:

- directly outside the building,
- from horizontal (e.g. corridors) and vertical rooms (e.g. staircases, ladders) by escape routes outside the building,
- to an adjacent fire zone and then into another one or outside the building[10],
- life-threatening buildings.

The owner of the building is obliged to ensure appropriate fire protecti on conditions. This obligation can be – partially or completely – taken over by the administrator of the building, suitably to tasks and duties entrusted to them.

Buildings designed and built when various laws were in force often do not meet current standards. It also concerns buildings that have been converted, extended or overbuilt, or whose purpose has been changed. In such cases fire protection conditions need to be adjusted so that they meet current standards.

[7] *The Minister of the Interior's Regulation of 7 June 2010 of fire protection of building, other construction works and areas* (Journal of Laws of 22 June 2010).

[8] Cholerzyński W. - *Components of building fire safety for auditors of qualification training of privates and non-commissioned officers of the State Fire Service*, National Headquarters of the State Fire Service, Education for Safety Foundation, Warsaw 2005.

[9] *The Minister of the Interior's Regulation of 7 June 2010 of fire protection of building, other construction works and areas* (Journal of Laws of 22 June 2010).

[10] *The Minister of the Interior's Regulation of 24 July 2009 on fire-fighting water supply and fire escape routes* (Journal of Laws No. 124, heading 1030).

There is a necessity to adjust, or to be exact, eliminate some factors if technical conditions in the building are life-threatening for people. This happens if:

- the width of a passage, travel distance or a fire escape route, or the flight of stairway landing acting as a fire escape route is less than that determined by technical-building regulations by one third,
- the length of fire escape route or travel distance is 100% greater than that determined by regulations,
- a fire zone room is classified to occupancy-related fire hazard level I or II or belongs to a fire escape route:
- the facing of ceiling or suspended ceiling is made of flammable or dripping under the effect of flame or alternatively of flammable floor covering,
- wall coverings in the escape route are made of flammable material (in case two escape directions were not ensured),
- an appropriate escape route in a stairway of a high building other than residential building or a high-rise building has not been sectioned,
- fire escape routes have not been secured against smoke,
- there is no required warning lighting in the fire zone classified as occupancy-related fire hazard level I, II or V or on a fire escape route leading outside the building[11].

In case any of the above-mentioned situation takes place, measures aimed at improving it should be taken in accordance with technical-building regulations if possible.

However, sometimes it is not possible to make adjustments to building to make them meet regulations in force, e.g. if a stairway is very narrow and there is not a possibility to widen it or if the layout of the premises does not allow to shorten too long fire escape routes etc.

In such a situation the owner or the administrator of the building should apply for a permit to use other solutions compensating for building conditions that are impossible to improve. The permit is issued by the Provincial Commandant of the State Fire Service based on an expertise prepared by a research unit or a surveyor and a fire protection specialist[12].

[11] Conference proceedings, *The evaluation of fire outbreak risk and the analysis of ignition source in production and storage premises*. CS PSP 2007, p. 45.

[12] T. Laurowski, *The handbook of fire protection*. KaBe, Krosno 2010, p. 43.

3 Fire safety instruction

Owners and administrators of buildings are also obliged to prepare documentation of fire protection. The most important document is the Fire Safety Instruction containing the norms of conduct preventing fire and facilitating rescue action in case of fire.

The obligation to prepare such a document results from the article 6 of the Ministry of the Interior Regulation[13].

Fire safety instructions are supplied by owners, administrators or users of buildings or its parts constituting separate fire zones. That is why owners, administrators or users of buildings or its parts constituting separate fire zones, building intended for public utility functions, multi-flat residential buildings, production, storage and stocktaking buildings, supply and implement a fire safety instruction including:

- fire protection conditions resulting from the purpose of the building and its type of usage, used technological process, storage and technical conditions of the building, including the risk of fire outbreak;
- specification of which fire-fighting devices and extinguishers the building needs to be equipped with and how they should be maintained;
- norms of conduct in case of fire or other threat;
- manners of securing dangerous jobs in terms of fire;
- conditions and organisation of evacuation of people and practical means of their inspection;
- means of acquainting the users of the building, including employees, with fire regulations ant the content of fire protection instruction;
- tasks and duties of the users of the building as regards fire protection;
- building plans including their location and the location of the area around them with regard to graphic data relating particularly to:
  - surface area, height and the number of storeys,
  - distance from neighbouring buildings,
  - fire parameters of flammable substances present in the building,
  - fire load density found in a fire zone or fire zones,
  - the level of fire hazard zone, the expected number of people on each storey and in individual rooms,
  - location of rooms and outside surfaces classified as ex zones,
  - the classification of the building into fire zones,

[13] *The Minister of the Interior's Regulation of 7 June 2010 of fire protection of building, other construction works and areas* (Journal of Laws of 22 June 2010).

  - evacuation conditions indicating the direction of escape and escape routes,
  - location of fire-fighting devices and extinguishers, taps for main gas-fittings, flammability hazard materials and location of fire-fighting devices controls,
  - indicate access routes for fire brigade rescue crane,
  - outside fire hydrants and other sources of water,
  - fire escape routes and other travel distances, marking entrances to fenced areas;
- indicate persons or entities who drew up the instruction[14].

Fire safety instruction should be adjusted to the specificity of the building and/or technological processes used in an enterprise, company or institution. It is impossible to draw up a correct fire safety instruction without visiting the building. Work needed to draw up this document in a correct way depends on the level of building structure complexity and/or the complexity of technological processes (building type of usage). Professionally drew up and implemented fire safety instruction lowers the risk of fire, enhances the security of building usage, positively influences the possibility to negotiate a lower insurance premium, eases building management, ensures the owner's or administrator's comfort in terms of carrying out their legal duties[15].

Conditions of fire protection and the above-mentioned plans should be handed over to the Provincial Commandant of the State Fire Service with the aim of using them for planning, organisation and carrying out rescue operation. Storage of documents should enable to use them immediately in a rescue operation. The Provincial Commandant of the State Fire Service may absolve the owner, administrator or user of the building from handing over the above-mentioned document and demand to have them supplemented in justified cases. These documents can be handed over via e-mail[16].

In production, storage and stocktaking facilities a fire safety instruction may constitute a part of an operation and maintenance manual, and in facilities situated in a closed off area, state defence facilities and facilities situated in prisons and remand centres it may be a part of safety plan or rescue operation plans.

Fire safety instructions should be updated at least every 2 years, and after changes in the building type of usage or in technological process which affect fire protection conditions[17].

Fire safety instruction is not required for buildings or their parts if there are not any ex zones and if:

- gross building volume or its part constituting a separate fire zone does not exceed 1000 m^3 under the proviso of paragraph 2,
- gross building volume of a stocktaking building does not exceed 1500 m^3,
- the surface of the fire zone other than the building does not exceed 1000 m^2.

The fire protection instruction should be put in places available to rescue teams.

The fire protection instruction is not required if gross building volume or its part constituting a separate fire zone does not exceed 1000 m^3 and if the surface of the fire other than the building does not exceed 1000 m^2. This document should be supplemented with building plans with marked layout of escape routes, extinguishers and fire-fighting devices as it will ease evacuation in case of fire and make the instruction more legible.

The fire protection instruction should be prepared by people having appropriate qualifications because its preparation requires specialist knowledge of fire protection[18].

4 Hand held extinguishers: selection and purpose

Hand held extinguishers are portable devices initiated manually for extinguishing fire in the bud. When selecting and arranging hand held extinguisher in buildings the Minister of Interior Regulation of 7 June 2010 on fire protection of buildings, other construction works and areas (Journal of Regulations of 22 June 2010). In particular the following rules should be taken into consideration:

- facilities need to be equipped in extinguished meeting the requirements of Polish Standards concerning extinguishers,
- the type of an extinguisher should be adjusted to extinguishing those types of fire that can outbreak in the building:

[14] Ibid.

[15] H. Cieślak - *Fire safety instruction. Rules of preparation and examples*. Counseling and Human Resources Training Centre, Warsaw, 2009, p. 56.

[16] Ibid, p. 64.

[17] *The Minister of the Interior's Regulation of 7 June 2010 of fire protection of building, other construction works and areas* (Journal of Laws of 22 June 2010).

[18] Ibid.

  - A – solid materials usually organic ones and which normally burn producing glowing coals,
  - B – melting liquids and solid materials,
  - C – gases,
  - D – metals,
  - F – fats and oils in kitchen devices,
- a mass unit of fire-fighting agent 2 kg (or 3 dm^3) contained in extinguishers corresponds to (apart from cases specified in special provisions):
  - each 100 m^2 surface of a fire zone in the building that is not protected by a permanent extinguisher:
    - classified as occupancy-related fire hazard level I, II, III or V,
    - production and storage surface with the value of fire load density higher than 500 MJ/m^2,
    - including an ex zone,
  - each 300 m^2 surface of a fire zone not listed in 1, except for buildings classified as occupancy-related fire hazard level V.
- equipping warehouses in which liquid gas containers are stored and liquid fuel stations with extinguishers is specified by the Ministry of Economy's Regulation of 21 November 2005 on technical conditions that should be met by liquid fuel stations and depots, long-distance transmission pipelines carrying oil and petroleum products and their location,
- the place of threshing, regardless of required extinguishers, needs to be equipped with a water container with a capacity of at least 200 dm^3 ready to be used for extinguishing purposes with the use of a bucket or in an equivalent manner[19].

Fire extinguisher need to be placed in:

- easily available and visible places, especially:
  - by entrance of the building,
  - in stairways,
  - on corridors,
  - by exits,
- places that are not vulnerable to mechanical damage and subjected to heat (furnaces, radiators),
- in multi-storeys buildings – in the same place on each storey if conditions allow this[20].

The following requirements must be met when arranging fire extinguishers:

- the distance from each place in the facility where a person can stay to the closest fire extinguisher should not be greater than 30 m,
- there should be an access of 1 m in width to the extinguisher.

It should also be remembered that:

- meeting technical-building, fittings and technological fire-fighting requirements is understood as building a facility in accordance with regulations in force, the Polish Standards, equipping buildings in wiring, lighting and plumbing installation, ensuring and obeying the duration of their servicing by professional and cleaning flues and ventilation systems,
- equipping buildings, construction works and areas in required fire-fighting devices and fire extinguishers is understood as equipping them with dry powder extinguishers, compressed CO_2 extinguishers, liquid extinguishers, above ground hydrants and underground hydrant network used to extinguish fires from the outside of a building, fire hydrant cupboards in the interior hydrant network used to put off fire inside, fire alarm installation, permanent fire extinguishers and fire hydrants, fire alarms, fire blankets,
- providing maintenance of fire-fighting devices and fire extinguishers in a way guaranteeing their effective and reliable functioning is understood as ensuring they are serviced periodically and repaired in case of a necessity,
- providing security to people staying in the building, construction works and in the area around it as well as a possibility of evacuation in case of fire is understood as marking escape routes in areas, escape routes with exits in facilities, equipping facilities in safety and evacuation lighting, marking escape routes and exits in accordance with the Polish Standards, equipping escape routes in smoke dampers and sprinkler installations, ensuring the correct width of escape routes, escape routes with exits, ensuring order and condition of being passable to escape routes and exits and the possibility to open exits, preparing evacuation plans, organising fire drills to ensure safe and proper evacuation,
- preparing buildings, construction works or areas for rescue operations is understood as ensuring approach roads, entrance gates, water protection in the form of a fire hydrant network with above ground or underground hydrants, fire-fighting water containers, equipping facilities in fire switches, rescue ladders enabling rescue teams accessing the roof, equipping facilities in permanent fire extinguishers, smoke dampers, organising fire drills with fire service participation,
- acquainting employees with fire regulations is understood as acquainting them with issues in terms of fire protection, the division of fire service units, norms of conduct in case of fire or other local threats, norms of conduct during fire operations, equipping facilities with fire-fighting devices, using these in fire operations, obeying regulations when making use of wiring, light-

[19] *The Minister of the Interior's Regulation of 7 June 2010 of fire protection of building, other construction works and areas* (Journal of Laws of 22 June 2010).

[20] Ibid.

ing protection, smoke, ventilation or technological installations,

- defining norms of conduct in case of fire, natural disaster or other local threat is understood as preparing proper fire protection instructions, norms of conduct for wooded areas, safety reports for major risk of accidents enterprises, preparing fire emergency instruction for individual facilities and technological installations[21].

Summing up, it needs to be highlighted that based on an existing civil-law contract the administrator or the user of the building is fully or partially responsible for the fulfilment of the above-mentioned fire protection duties with respect to the building, construction works or the area. If such a contract has not been drawn up, the responsibility for fire protection duties lies with the actual administrator of the building, construction work or the area.

5 Responsibility for organising fire protection in an enterprise

Employers have a duty to appoint a person responsible for fire-fighting issues in the workplace. This duty was introduced by the Act of 21 November 2008 on amendments to the Employment Law (Journal of Acts No. 223, heading 1460), in effect since 18 January 2009 with later amendments moderating the qualifications requirements of such persons. The requirement concerning the necessity of completing the fire safety officer training (the practice of relating the Employment Law with the Fire Protection Act was abandoned). For the moments it is enough for the appointed employee to have a health and safety training completed as the training framework includes fire protection issues.

Employees need to be given the following personal details of these persons:

- surname,
- post,
- phone number,
- e-mail address[22].

Regulations introduce the obligation to appoint the number of such persons appropriate to the size and needs of the workplace, but do not specify it. However, it seems that companies operating in different sites should appoint one person in each location. If a company is big then appointing one person in each department is worth considering. After all, the point is to introduce a reasonable fire prevention and efficient evacuation in case of fire.

The person appointed to fight fire and evacuate employees who has only theoretical training (generally treated marginally) under health and safety training is likely to have problem with fulfilling their duties in case of real threat (such a person should visualise the responsibility for evacuation without any practical training).

Therefore it is important to carry out practical training of evacuation operation, making use of hand fire extinguishers and notifying fire service – at least for the appointed persons. Such training ought to be repeated at least every two years. Trial evacuations, on the other hand, should be repeated not less frequently than every two years. Practical examples should be worked out in a graphical form or demonstrated during a health and safety training or fire drills for employees.

It needs to be remembered that fire safety instructions (some companies are obliged to prepare them for facilities they occupy) should be announced to employees and verified every two years – signing the fire protection instruction does not mean that an employee will know how to behave in case of fire. Thus, it is worth conducting evaluation drills[23].

6 Training employees in fire protection

The Minister of Economy's directive of 27 July 2004 (Journal of Regulations 2004 No. 180, heading 1860 with amendments) obliges employers to train employees in health and safety, including fire protection[24].

It is the employer's duty to ensure that employees undergo training adequate to their post and providing them with information on and instructions concerning their post or their activity. Training may be organised and conducted by employees or by contracted or agencies having proper qualifications to conduct health and safety training (based on the Act on the Education System).

Health and safety training are conducted in the following form:

- initial training,

[21] T. Laurowski, *The handbook of fire protection*. KaBe, Krosno 2010, p. 98.

[22] *The analysis of causes of fire* International Conference Proceedings Poznań 2010, p. 32.

[23] B. Rączkowski, *Industrial safety in practice*, ODDK Gdańsk 2008, p. 342.

[24] *The Minister of Economy's directive of 27 July 2004 on health and safety training* (Journal of Regulations 2004 No. 180, heading 1860 with amendments).

- periodical training.

Initial training is conducted in a form of briefing in accordance with framework prepared for individual posts and includes:

- General initial training (general briefing) – for every new employees, students engaged in a student apprenticeship and vocational school students engaged in a vocational apprenticeship. The general briefing is conducted by a safety representative or a person fulfilling his duties in the enterprise or an employee appointed by the employer who possesses knowledge and qualifications to conduct briefing,
- On-site initial training (on-site instruction) – is organised before admitting a new employee to their workplace. On-site instruction is conducted by the manager appointed by the employer or by the employer if these people have proper qualification and professional experience and are trained in the methods of on-site instruction conduction.

Periodical training is completed by:

- employers and other people managing employees especially managers, masters and foremen,
- blue-collar workers,
- technical-engineering workers,
- office administration workers,
- health and safety workers and other people fulfilling their duties,
- office administration workers and other workers not mentioned in paragraphs 1–4, whose nature of job involves being subjected to serious detriments to health or health and safety responsibilities.

Periodical training of blue-collar workers is conducted in the form of briefings, not less frequently than every 3 years and in case of blue-collar workers whose health and safety are particularly at risk not less frequently than once a year. The Minister of Labour and Social Policy has established a general framework of initial and periodical training for all groups required to undergo training[25].

The organisers of training provide:

- framework of individual types of training prepared for individual groups of posts,
- framework of instructor training in the methods of instruction conduction – in case if such training is organised,
- lecturers and instructors having knowledge, professional experience and professional preparation ensuring proper completion of the framework of the training,
- proper local facilities where training can be conducted,
- professional equipment necessary to complete the framework of the training,
- proper course of the training and preparation of its records in the form of the framework of the training, registers, exam protocols and records of issued certificates (in accordance with the Minister of Education and the Minister of Labour and Social Policy's Regulation of 12 October 1993 – Journal of Regulations 1993 No. 103, heading 472)[26].

7 Duties of people in charge of fire protection in an enterprise

Every company engaging employees has to ensure their industrial and fire safety. That is why it should train one of its employees or employ a safety representative.

The safety representative should have the knowledge of:

- fire-fighting protection organisation,
- duties of legal persons, corporate legal persons, organisations and institutions in terms of fire, natural disasters and other local threats protection,
- fundamental rules of fire protection of devices and installations, buildings, facilities and areas,
- rules of evacuation of people and possessions,
- causes of outbreak and spread of fire and general rules of extinguishing fire,
- fire agents: their types, characteristics and their application possibilities,
- fire-fighting devices and fire extinguishers: their application in construction works, terms of maintenances and servicing,
- terms of conducting inspection of fire protection systems,
- organisation and conduct of fire training for workers,
- fire record-keeping,
- safety signs and fire extinguishers selection and arrangement,
- fire risk evaluation based on the behaviour of materials in a fire environment,
- preparation and carrying out of evacuation,
- how to prepare construction works and an area for a natural disaster and other local threat[27].

[25] *The Minister of Economy's directive of 27 July 2004 on health and safety training* (Journal of Regulations 2004 No. 180, heading 1860 with amendments).

[26] *The Minister of Education and the Minister of Labour and Social Policy's Regulation of 12 October 1993 on terms and conditions of qualifications improvement* (Journal of Regulations 1993 No. 103, heading 472).

[27] T. Laurowski, *The handbook of fire protection*. KaBe, Krosno 2010, p. 132.

8 Conclusions

The most important legal aspect regulating issues related to fire protection in an enterprise is the Fire Protection Law[28]. It says that fire protection consists of the implementation of actions aiming to protect life and health, possessions or environment against fire, natural disasters and other local threats. Due to the fact that the knowledge of fire protection is extensive, activities, duties and supervision of fire protection systems may be entrusted to a company or people having appropriate qualifications and experience. The aim of this paper is to specify the most important duties of owners, users or managers in providing protection against fire or other local risks. This results from the fact that given the variety of operating enterprises, the character of their activity, kind of production and used technology, size, fire risk, etc. It is not possible to determine a standard model of a fire protection system for a particular work place.

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[14] The Minister of Economy's Regulation of 27 July 2004 on health and safety training (Journal of Regulations 2004 No. 180, heading 1860).

[15] The Minister of Education and the Minister of Labour and Social Policy's Regulation of 12 October 1993 (Journal of Regulations 1993 No. 103, heading 472).

[16] The Minister of Infrastructure of 12 April 2002 on technical conditions of buildings and their location (Journal of Regulations No. 75, heading 690, with amendments).

[17] The Minister of the Interior's Regulation of 7 June 2010 of fire protection of building, other construction works and areas (Journal of Laws of 22 June 2010).

The Polish Standards:

[18] PS-92/N-01256/01 Safety signs. Fire protection.

[19] PS-92/N-01256/02 Safety signs. Evacuation.

[20] PS-92/N-01256/04 Safety signs. Technical fire-fighting measures.

[28] *The Law of 24 August 1991 on fire protection* (Journal of Regulations No. 81, heading 351, with amendments).

CROWDSOURCING AS A METHOD OF OBTAINING INFORMATION

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Abstract: The aim of this article is to analyse and describe a new trend in obtaining information and solving problems, which is crowdsourcing. Contemporary enterprises face enormous challenges, which are connected with omnipresent changes occurring in the functioning of societies and economies all over the world. Crowdsourcing is a very complex and constantly evolving phenomenon. It is an open subject of multiple discussions in which, due to its multiple factors and variable applications, it is being differently defined. Growing usage of this phenomenon prompts scientists for undertaking research and analysis of this issue as it is strictly connected with dynamically changing attitudes of, not only, entrepreneurs, but also their surroundings. The prime driving force behind undertaking this subject is a fast development of technology, Web 2.0, or globalisation. The mechanism of crowdsourcing's functioning has been known for ages; however, it was named as a tool for modern enterprises 10 years ago. During that short period of time crowdsourcing has gained the acceptance of a number of people all over the world. The challenge for the present research is, as well, to indicate advantages and underline the essence of proper managing of crowdsourcing in enterprises, what involves a number of aspects. The described solution is still gaining more and more proponents; however, planned inappropriately, may cause completely reversible effect than the desired one. In this article, descriptions of worldwide ventures, which apply crowdsourcing, in Poland as well, and the results of the newest research on the phenomenon were included.

Key words: crowdsourcing, innovations, Web 2.0, prosumerism, outsourcing.

1 Introduction

Modern enterprises function in constantly changing conditions. The acceleration in the production of goods based on knowledge, meeting expectations of more and more demanding clients determines the functioning of economic entities all over the world. According to the OECD's statistics, almost 1 billion USD is being spent on new knowledge every year. Nowadays, the manufactured products and offered services are more often distributed globally. As a result of the growing globalisation, the fragmentation of markets, which are strongly differentiated and dispersed, occurs. It causes far-reaching effects. One of them is the necessity to monitor not only the local market, but also the global one [1, pp. 37–38]. The Internet is not only a rich source of information, but also a way to communicate or distribute goods. The growing development of cyberspace conditions the functioning of enterprises and societies in almost every sphere of life. The activity of economic entities depends whether they will be able to find themselves in a new reality, what requires the application of modern technological solutions. Because of the increasing virtualisation of enterprises, the speed of operation and reliability are seem to be more meaningful than ever before [2, pp. 15–16].

Facing up the reality, requires possessing by enterprises such characteristics as innovativeness or elasticity. They allow to preserve the dynamic balance with the surrounding. Present organisations are aware of the intense competition and of how many new channels of distribution and promotion it operates with. Therefore, those entrepreneurs who want to achieve a success undertake innovative actions, which can provide them a competitive position on the market [3, p. 261]. Changes on our world lead us to a new era, which is characterised by intense participation of people in the global production. Forms of mass cooperation and co-creation change the existing business models. A widespread access to the Internet and modern technologies enable us to jointly undertake innovative actions [4, p. 28]. Nowadays, the consumers are not only the final recipients of goods and services, but they also take an active part in creating new products. They take over the role of the previous producers. The new type of a client, who actively participates in the production process, is named as the prosumer. The development of Web 2.0 is a perfect environment for the development of social platforms and, what follows, prosumerism. The Internet escalates the development of proactive attitudes in two ways. At first, it enables to contact everywhere and anytime; secondly, it is a perfect tool to share information and

Table 1. The comparison of crowdsourcing with outsourcing (*source: own elaboration based on:* [7, pp. 75–77; 8, pp. 1–34; 9, pp. 93–113]).

Crowdsourcing	Outsourcing
Global footprint – there is no fixed location, e.g. office, coworkers can be everywhere by participating only virtually.	Local footprint – operating only in some fixed locations, which fulfil certain requirements.
24/7 – virtual crowds can work not only everywhere, but also anytime. There are no fixed working hours. The only limitation is a deadline.	A fixed deadline and specified working hours.
Payment depends on the results of work – salary is given to a person whose work will be the best but cooperated with others. The final result is evaluated. There are no employed persons.	Payment for a certain job made for external company.
Cost-cutting – the cost is an award for the winner, which is estimated by a company; there are no legal recruitments.	The costs of a given job are for external company. Fixed costs are changed into variable costs.
Limited control – an entrepreneurship has got a limited control as the crowd working for it is anonymous and virtual. Only the access to the project may be somehow controlled. The final result is often unknown, there is an unlimited number of solutions, which are being chosen according to specific criterion.	An entrepreneurship does not have a complete control but it knows what is the expected result.
Crowdsourcing is a huge source of innovation. An unlimited number of people work on a certain problem or idea, which exceeds often all of the entrepreneur's expectations. The result is often very surprising or innovative.	Outsourcing does not favour innovations; there is only a certain work to be done, which is strictly described and the result shall not be surprising but it should meet some previous recruitments.
Very differentiated group of people works on the project. A crowd consists of experienced professionals, as well as, amateurs having a fresh creative look. As it results from many research conducted on a group work, variety gives valuable effects so that a number of aspects for solving the problems occurs.	A group of professionals and specialists in their fields works on the project.
Certain jobs are usually devoted to aspects connected with solving a given problem or searching for ideas (B + R).	There may be ordered works from the field of IT, ancillary operations, as well as, logistics.

multimedia resources [5, p. 26, 27]. Prosumption is one of the driving forces in the changing world of business, which is not based on the complete number of products, but on creating the ecosystem of innovations. Users shall not be perceived only as clients, but rather by partners. The present consumer is much more educated and well-oriented, therefore, he or she wants to have more intense influence on future which he or she co-creates. Entrepreneurs, in order to compete and develop successfully, must accommodate the prosumers, take the initiative, and benefit from surrounding possibilities [4, pp. 212–217; 6, pp. 170–174].

2 The essence of crowdsourcing

The 21st century cooperation is undoubtedly crowdsourcing – the model of solving problems and developing products and services with the use of virtual crowds. Organisations establish the cooperation with an unidentified crowd by uploading in the web 'an open call' in order to work on a specific project. Creators of the best solutions are usually somehow awarded. A company becomes the owner of an idea and uses it in practice, simultaneously benefiting from [7, pp. 75–76]. Crowdsourcing consists of three components, such as virtual crowd, outsourcing of some previous inside organisational processes, and applying Web 2.0. Crowdsourcing is the model of out-

sourcing which is located in the middle of outsourcing and advanced Internet technologies (Table 1) [8, pp. 1–3].

The term 'crowdsourcing' was first used by J. Howe and M. Robinson in June 2006 in 'Wired' magazine. They defined this phenomenon as a new model of business based on web, using creative solutions invented by virtual societies which answer open questions. In other words, an entrepreneurship announces in web that it searches for a solution to a given problem and an unlimited number of individuals offer solutions for it. The best idea is awarded and used [10, pp. 1–4]. Crowdsourcing enables entrepreneurships not only to find solutions for their problems, but also to acquire new ideas outside the company and, in the same time, limit the involvement of resources and save the time spent on the development of the idea from its bases.

Crowd and the Internet technologies create Web 2.0 – websites, which were constructed after the year 2001 and in which the main role is played by contents made by the users of a given website. Web 2.0 is not new World Wide Web, but a new way of using its resources. Web 2.0 websites have changed the way of interaction between their owners and users, giving, in the same time, more space in creating contents to the hands of the users. The essence of Web 2.0 has an important influence on the development of social media, the Internet's applications, or blogosphere. Web 2.0 enables the users to interact and integrate more freely. The Internet users visit personalised websites and become, somehow, their co-creators by providing contents (among others, pictures, videos, links to other Internet sites, etc.) and building the users' societies, which cooperate with each other [11, pp. 1–4].

Nowadays, enterprises are using more often Web 2.0 in order to improve their internal processes and establish cooperation with the environment – clients, suppliers or partners. Every Web 2.0 website enables to interact with others in a new way, namely it goes beyond standards, offering the clients a new quality. It is possible to publish and share information, creating, at the same time, a website from its contents to the projects of almost everything connected with life (e.g. the virtual world of Second Life) or products of the favourite brand, or any other organisation which is present in the Web. The user, with the help of the above services, may be included to the process of creating the product in its initial phase (creating the idea of the product), as well as in its final phase (marketing or distributional). Research carried out in The McKinsey Global Institute proves that the enterprises applying Web 2.0 on a large scale, achieve better economic results and higher position in the market. The number of enterprises using virtual social websites has been still rising. Therefore, entrepreneurs gain a series of advantages, such as growth of the accessibility to knowledge or external/internal professionals, as well as, minimise the way to introduce novelties to the market and reduce costs. Adopting the technology of virtual societies facilitates, most of all, the flow of information inside the company, as well as in its surroundings. Furthermore, organisations using Web 2.0 adopt the attitude of learning organisations, what is an unavoidable factor for a proper functioning in hipercompetitious reality [12, pp. 117–120].

The meaning of crowdsourcing is strictly connected with a fundamental orientation on innovations. Presently, entrepreneurs build up a competitive vantage, creating innovativeness not only based on their own sources (in contrast to the past – based only on own research and development resources). Today, an effective method to achieve a success is to seize the outside opportunities through involving external entities in processes of creating and implementing innovations. Entrepreneurs are aware of the fact that they are unable to employ only the best workers and there is often a need to engage employees from outside of the company. Nowadays, it is possible to establish a cooperation with excellent external professionals. The role of such cooperation is emphasised due to a very simple reason, namely, there is no organisation which possesses all sources to achieve a stable market vantage [13, p. 156].

Crowdsourcing is an answer to the occurring doubts and needs of entrepreneurs, as well as, users. It provides enterprises an access to knowledge, information, readymade solutions and establishing relationship with the environment; whereas, clients are assured with the possibility to have a real influence on creating products and services. Knowledge and abilities of people from all over the world may serve to the economic practice and the overall development.

The power in crowdsourcing is reflected in three main perspectives. First of all, it is cost saving. A task, which is expensive to be done inside of the company and is connected with employing extra people, or other expenses, is given for an external consideration. Publishing a problem outside not only saves the time spent for the task realisation, but also costs of employment and conduction of a research. Secondly, the effectiveness of work is increased through employing a large number of people. People engaged in the project are frequently clients who are well acquainted with a product, service or brand. They see them from a different perspective – other than the one of a company's workers. Applying modern Internet plat-

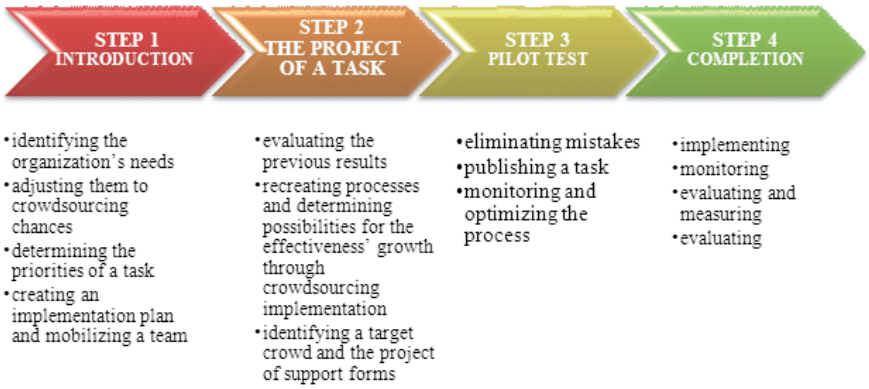

Figure 1. The process of crowdsourcing implementation [16, p. 12]

forms shortens also time of a tasks' completion. Opening a company for a cooperation with the environment has, as well, many advantages connected at least with its image. An enterprise gains an opinion of an innovative company, bearing in mind the needs of a client, and engaged in a dialogue with the environment. Worth mentioning is the third perspective connected with the global labour market, which establishes a cooperation with the best professionals from all over the world without the necessity to employ them permanently [14, pp. 1–2].

Crowdsourcing, as every other model of business, must be properly planned and managed. The below scheme presents the most important steps, which are to be undertaken in order to implement the process (Figure 1). Organisations willing to use the crowdsourcing must distinguish tasks which would provide them the largest advantages on an attractive level of effort. Therefore, the first step is to search for tasks which fulfil this criterion. Then, tasks must be precisely described and specified in order to find those which could take the advantage of an elastic supply and they shall be published outside of the company's frames. Managers shall consult on every decision with all the interested parties which will have an influence on the effectiveness of crowdsourcing. In this manner, a construction of the new process is being created. Next step is a project of the task. Here, it is important to remember that the task will be available for everyone, participants may be from different trades or countries; therefore, it is necessary to prepare profiles of our target groups, define informative needs, accomplish exhaustive descriptions, share as many as possible important data, as well as, define the criteria for the tests' evaluation. A pilot test is the next step to take. It shall be available only for a limited number of users and shall verify the accuracy of the prepared material or formulations. A test of the Internet platform and the prepared support tools is also important. The last but not least steps are to provide a proper management of the overall process, designate people responsible for the communication with a crowd, ensure the supervision of the sent solutions or current clarification of disputes through implementation of Frequently Asked Questions (FAQ) [15, p. 13].

In 2012 a report on using crowdsourcing, 'Crowdsourcing Industry Report', was written and published. Results of the Massolution company reveal that its main forerunners are large organisations those incomes are over 1 billion USD. Nine out of ten global brands from the ranking of Interbrand – 'Best Global Brands 2012' (one of the most generally admitted ranking of the worldwide brands) implement crowdsourcing. Global companies were using this model as, for example, a tool for acquiring a feedback from the users, what improved the existing products (Google), helped to create new products and services (IBN), as well as, created marketing campaigns (Coca Cola). Furthermore, sector, which specialises in crowdsourcing solutions for enterprises, maintains an intense upturn [16].

The model of crowdsourcing is constantly evolving. It is a novelty which intrigues and prompts to conduct a research. Motivations of people – 'crowd', which answers to the *open call*, are unknown. The undertaken research indicates that these motivations are influenced by a number of factors, starting from financial gains, award, the level of a task's complexity, the connection with interests, the probability of winning, but also the possibility to self-develop, the improvement of one's abilities, appreciation and satisfaction resulting from completing the task [14, p. 3].

The present model, as any other, is burdened with particular limitations and threats. With the growing popularity, the controversy rises as well. Critics state that it consti-

tutes a danger for specialists employed in a company and it can be demotivating, finally influencing also on aspects connected with salary or hiring certain employers. There are also limits when it comes to tasks being shared with a crowd; a risk connected with publishing certain information or managing a large number of solutions, their selection and choosing the best one. A threat occurs also in terms of lack of interest between virtual societies, insufficient resources for adequate planning of the project (including a proper platform, the manner of communication with a crowd, award for the winner or the lack of the final solution or a practical inability for its implementation). A problem appears also in connection with the lack of employee–employer relationship, insufficient control and the influence on the society, which results from the absence of direct relations or written agreements [15, pp. 3-4].

Nevertheless, crowdsourcing is the trend which means constantly rising. A growing number of entrepreneurships implementing it in practice prompt to become more acquainted with it. For this reason the next section is devoted to its practical usage.

3 The practical use of crowdsourcing by present companies

Crowdsourcing is an innovative way for searching solutions for modern enterprises. The largest worldwide companies use it willingly in practice. More often, coauthors of crucial ideas are clients, suppliers, partners, as well as, people from down under who are not at all connected with an organisation. The present trend was used by the founders of the innovation exchange InnoCentive who have built a platform which integrates entrepreneurs searching for innovatory solutions with the initiators. It happens that the originators of the best ideas may win even 1 million dollars. One of the InnoCentive's mottos is – *A breakthrough idea can come from every place all over the globe.* A web portal unites entrepreneurs, nongovernmental organisations or national institutions. Entities, which search for innovation in their fields, upload on the web their offer, in which, except of a detailed description of a problem, information on a financial award for the founder of the most interesting solution is included. So far, over 40 million dollars have already been given to the hands of the originators. An award for the most complex problems reaches even from five thousand to one million dollars. The popularity of the web, started in 2001, is proved by a constantly rising number of users, which exceeded 300 thousand. The portal gathers presently users from almost 200 countries, who work every day to fulfil the largest needs of nowadays economy. Over 1650 offers have been already published in the portal, which gained altogether 40 thousand answers. It is worth mentioning about the high percentage of solved problems – even 85% of them find a satisfactory answer. The platform InnoCentive breaks large grounds before the worldwide economy – few hundreds of people would work on innovations or even few thousands of scientists at the same time. Professionals, registered in the portal, can not only help to overtake the competitors, but also find the best solutions for certain problems of the entrepreneurs [17].

The general director of GoldCorp Inc. was also guided by the idea of crowdsourcing. Rob McEwen, the CEO of that time of an enterprise dealing with extracting gold, was facing the threat of bankruptcy. The company was struggling with a number of problems, starting from its growing debts, the exhaustion of exploitable for 50 years resources of gold, ending with strikes. The manager, in spite of criticism and disbelief of coworkers, undertook almost a suicide attempt to rescue the company. At the meeting with geologists, he announced that he is up to find gold in the deepest and the most unavailable parts of the mine and that he will devote for this aim 10 million USD. Gathered at the meeting geologists had very sceptical attitudes toward the decision of their supervisor. Nevertheless, they decided to undertake the task and, surprisingly, they found that resources in this area are 30 times larger than those exploited previously. The discovery turned out to be a phenomenon; however, in spite of good intentions of geologists, they were not able to estimate the precise abundance of reserves and their location. McEwen, inspired by the example of Linux, decided to follow the steps of Linus Torvalds. He wanted to take the advantage of people outside of the company. He gathered all the accessible information about the reserves, saved them in files on computer, and published. Geologists employed in the entrepreneurship were not pleased about this idea and expressed their sceptical attitudes. Mining is an industry, in which information is extremely precious and usually carefully protected. The director admitted that his decision was very controversial and dangerous. In the year of 2000 the project 'Goldcorp Challenge' was announced. Its total award was 575 thousand USD for people who will describe the best estimations and methods of exploitation. Information spread immediately and in few weeks solutions from 50 countries were sent. Solutions were created not only by geologists, but also by mathematicians, physicians or graphic designers. The open call provided in-

formation which was extremely surprising and revealed previously unknown possibilities. Participants specified a number of places which were not taken into consideration ever before. What is more, in more than 80% of new areas, they encountered rich reserves of gold. McEwen estimated that he had saved from 2 to 3 years of hard and expensive exploration works. The project influenced on the phenomena that the entrepreneurship worth 100 million USD struggling a number of problems, is now in value of about 9 billion USD and became the second, in view of its capitalisations, biggest corporation mining gold in the world. Furthermore, previously undeveloped mining region of Northern Ontario became one of the most innovative and profitable area in this branch. The strategy applied by Rob McEwen has ruined the stereotypes functioning in the mining business, lead the company out of a deep crisis, and is a perfect example of using crowdsourcing, thanks to which sharing an organisation's particular part of intellectual property enables to reveal enormous potential of a group genius [4, pp. 23–27; 18].

Another perfect example of applying the power of virtual societies is the brand called Threadless, which is said to be the symbol of resourcefulness in the creativity sector. Cofounders, Jake Nickell and Jacob DeHart, did not have business intentions at first. In times of starting up Threadless they were both students. From its beginning they treated the project as a way of integrating the design societies from all over the world. Many other events took part along with the project, as Jake's winning in a competition for the best T-shirt organised by New Media Underground Festival. They were starting with only 500 USD in their pockets. The first 2 years of Threadless functioning were connected with investments – in a new series of T-shirts. The founders wanted to create a design virtual society where authors' projects were verified by potential clients, who were given the possibility to evaluate the best T-shirts, up to date. The post popular and the best evaluated (from 1 to 5 points) were then printed by Threadless. At the beginning, Jake and Jacob printed one series per month. After 4 years this number grew to one series per week and the next year six series per week. Each year the company and its societies brought new events. In this case, it took 6 years to find an investor who was interested in the development of Threadless. The undertaking of the two students is not only producing T-shirts, but it is mostly about original projects. Over the time, Threadless' scope of functioning connected with design spread further. They also organised monthly meetings in the Art Institute 'Anonymous Federated' of Chicago with virtual designers, who were telling their stories to the gathered crowd. Threadless are mainly contents, such as: 'Threadless Select' (organised since 2008 with the cooperation with the Rhode Island School of Design), 'Loves Tree', and 'Bestee Award' (which award was higher than 100 thousand USD in 2007). The authors of project come from different continents. Threadless may be described as a Web 2.0. company, where consumers create products which then they buy. Winners receive 2000 USD award, 500 USD to spend in the Threadless shop, and their name is printed on T-shirts with their projects. The undertaking exists thanks to the use of social media. Nowadays, Threadless is a society with over 2.5 million people from all over the world and the number of projects reaches over 500 thousand [14, p. 4; 18].

The iStockphoto, a first Internet portal offering pictures, multimedia and design elements on the principle of royalty-fee (a single payment), founders also based their business on crowdsourcing. Stock photos are ready pictures, which can be legally used in commercial and promotion materials. The company was set up by Bruce Livingstone in May, 2000. Originally, iStockphoto was a free website; however, over the time, it was changed into a model of micropayments and from 2001 it has been a profitable business. Clients searching for pictures to use in the Internet sites, booklets or business presentations, pay 1 USD for, so-called, credit and they can start buying pictures. The costs depend on the resolution; the best quality files may be priced up to 50 points. Artists, designers, photographers from all over the world register in the portal in order to create, work and learn. IStockphoto portal started its functioning in 2000 with a collection of only few photos. Today, it offers vector graphics, video files, music compositions and sound effects. Millions of users enjoy inexpensive and high quality files from the iStockphoto collection. Photographers receive 20% of the cost price when their picture is being downloaded. Some of the most committed participants of online society may earn through signing an agreement with iStockphoto company and receive 40% of the cost price of their projects. The founders of iStockphoto involved, hereby, in their entrepreneurship the artistic industry, sharing with millions of users millions of files from a large number of the registered authors. A basic idea is still the same: everyone can freely join the portal; these are not only designers – professionals, but also amateurs, who want to sell their original works, and clients buying necessary digital media [7, pp. 79–80; 19].

The development of crowdsourcing has its beginnings abroad, where a very fast progress of it is observed. However, there are also examples of its usage on the Polish market. One of them is bank BZ WBK and its 'Bank of Ideas' platform. The Bank of Ideas is a place where the Internet users, being clients or only sympathisers, can upload their opinions and ideas about the functioning of the bank. A virtual crowd suggests what shall be improved in the bank. The freedom of expression and uploading ideas was also extended to the possibility to vote for the best solutions. Finally, bank BZ WBK implements in practice those ideas which are the most beneficial for their clients, improving, in the same way, their level of service. The Bank of Ideas is, therefore, a perfect form of introducing the dialog with clients, as well as, a valuable source of information. It was created in 2009 and, as for this moment, it implemented 546 ideas, whereas, 41 ideas are partially implemented, 8 are in the process of implementation and 7 are being consulted in the bank. They are concerned with almost every category of bank services – starting from individual accounts to a company's services. Currently, 7515 users, who have altogether uploaded 4389 ideas, are logged in. They have generated over 9816 comments. In 2010, the BZ WBK platform was awarded in the content 'A good design 2010' organised by the Institute of Industrial Design. The Bank of Ideas is a pioneer of the crowdsourcing's tools in Poland. This year, the Western Bank WBK awarded by a prestigious honour – the title of the Company of a Year 2012 [20].

Not only large companies, but also small enterprises or organisations may benefit from implementing crowdsourcing. An example is a regional Touristic Organization. It announced a contest which aim was to acquire new, unconventional souvenirs' projects promoting the Lower Carpathians voivodeship. They shall be connected with cultural traditions of the region, as well as, those modern inspirations [21].

Aretech is a Polish enterprise from MSP sector, which based its model on crowdsourcing. They test software through organisation and management of the tests' processes carried out by real users in their own environments. The project is run with the use of the Internet portal named Testuj.pl. It is the first crowdsourcing testing website, creating testers' society ready to verify every application for desktop and mobile platforms. In this way, with the cooperation of virtual society, the company offers services which control the functionality, usability and safety of applications [22, 23].

Under the motto 'Only Good Ideas' crowdsourcing platform Sprinet.pl works. It is the first marketing platform in Poland, which aim is to link brands with a creative Internet society. As a result, innovative solutions are created mainly in the field of marketing. Sprinet.pl is a site of social character, which was created in 2012 thanks to the financial support from the Operational Program of Innovative Economy. The main aim is to focus the society involved in the process of crowdsourcing, thus, the activity of enterprises, institutions or organisations, willing to improve their products, will be supported. This platform enables to share ideas which are to influence on an organisation's development, as well as, help to solve its problems. Personalised profiles and set of research tools, such as surveys, questionnaires or open questions, involve, additionally, the Internet users in a number of categories from widely understood social life (e.g. media, governmental institutions, health care, computer and electronic industry, investing in cities, education, etc.) in part of which different innovative solutions may be realised. Sprinet is still a young undertaking, however, accomplishing its first projects, such as the contest 'The taste of the region – like at home'. A three-stage competition organised by the Restaurant under the Town Hall in Rzeszów, in part of which one might submit his/her proposition of a regional dish. The winners of four dishes with the highest scores received in-kind prizes. There are 209 users currently registered in the portal, 154 ideas have been submitted as part of 19 projects, from which 7 were accepted. In time, there will be more of such projects. Participating in crowdsourcing undertakings combines pleasure with business, in the same time, offering the possibility to create the reality. The founders of the platform use their activity other than Web 2.0. services, where the newest information about contents, events or ideas are uploaded [24].

The application of crowdsourcing is still developing. More and more complex problems can be solved. A key concept in the process of crowdsourcing is the fact that a well-organised action promotes itself and the Internet users take over some of the ambassadorial responsibility. As a result, message reaches the receivers in very differentiated manners – through channels, which are not used in traditional campaigns. Another important factor is a fresh look, which the receivers often possess. In Poland, crowdsourcing constitutes still a novelty, a new Internet mode; therefore, because of the adopted technique, with a proper use of PR tools, a campaign becomes interesting for media and bloggers. From the conducted observation of the adopted actions, at least two areas may be classi-

fied as problematic. Cooperating with a company offering outsourcing services for entrepreneurships, one may significantly control the transfer of confidential information through signing additional confidential information agreements or entrusting them only to reliable clients. Using crowdsourcing it is more difficult to preserve the confidentiality of information. If these are tasks with a high confidentiality level, which were previously protected from competition, then crowdsourcing is not the best solution (especially its basic form published to everyone). An option may be extra protection, which is given by some particular platforms, such as hidden content or private one.

From the perspective of a company using crowdsourcing solutions, one has to be aware of the fact that the solution which gains the highest number of users may not be proper for an organisation. An example of an action, which turned out to be a failure, is the project of Henkel company – a contest for the best package of a dishwashing liquid Pril. Users sent projects of packages and then they could evaluate particular solutions, creating, in the same way, the projects' ranking. Henkel company announced that 2 out of 10 best projects will be chosen. In weeks' time the Internet users submitted over 50 000 projects. Henkel company, realised that many of the projects having the highest scores, are not the ones that they were expecting. They intervened and, at their own discretion, changed the results. They informed the users about the manipulation of results in an official statement. As a result, the virtual crowd rebelled against the behaviour of the company and extensive discussions on the situation took place in the Internet. All the events caused more damage than benefit. Participants of crowdsourcing are particularly sensitive about injustice, lack of transparency, and clear rules. An example of a company having problems with image is Moleskin – an Italian notebooks' brand, which decided to give an offer to design a logo for Moleskin's blog through an open contest. Regulations of the action turned out to be very unfair for the participants of the contest. The main organiser reserved the copyrights of all the projects submitted in the content. In Poland, such contest would be illegal, as all copyrights may be subscribed only to the winning project. Undertaking crowdsourcing research and realizing them through a content needs to clarify the rules: how the winner will be chosen? who is the owner of copyrights of the winning project? and what is going to happen with remaining projects? Conditions and rules of the contest, as well as, the overall process from its beginning to the end, must be clearly formulated. It is enormously important to think the undertaken actions over when using crowdsourcing in marketing. However, it is worth to remember that crowdsourcing brings number of advantages but, as an effect of inappropriate decisions or communication, it may harmfully influence on the image of the company. Nowadays, companies dealing with crowdsourcing services are developing and they will probably become more specialised.

The quoted examples allow to formulate few conclusions on crowdsourcing. They confirm the fact that it provides a new way of solving problems with the emphasis on model which may be over generalised in different branches of industry for solving a variety of tasks. Crowdsourcing is the Internet model, which may be a strategic way to conduct an enterprise, effectively attracting interested people, who, appropriately motivated, are able to provide the solutions of the highest quality and in a large number. A committed crowd creates solutions and products, working faster and using less workforce than even the greatest minds in their area. Trends observed on worldwide markets enable to state that this strategy will still develop.

4 Summary

This article constitutes an introduction to an extensive subject, which is crowdsourcing, through illustrating pioneers and creating an outline of its factors. Crowdsourcing may be defined as a wisdom of the virtual crowd; however, it is not only another mode of the Internet, but an effective tool to gather talents, using cleverness with a simultaneous limitation of costs and time, which were previously necessary to solve a problem. Crowdsourcing is possible only with the application of modern technologies and, for this reason, it is an extremely up-to-date challenge, which develops dynamically and is attractive from the point of view of researchers and entrepreneurs.

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OMEGA-PSIR: FROM THE REPOSITORY TO THE RESEARCH KNOWLEDGE BASE EXPERIENCE OF WARSAW UNIVERSITY OF TECHNOLOGY

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Abstract: This paper is devoted to a solution for building a research knowledge base for the university. An experience in developing a specialised software for building such a knowledge base is presented. We present the functionality of the system, as well as, sketch applied AI technologies aiming at providing features attractive for the system beneficiaries. It is shown that although a classical repository is the main part of the system, the essential value of the solution is in providing analytical tools for the 'research management'. First lessons learned from deploying the software at Warsaw University of Technology are also discussed. The platform has been developed under the SYNAT project, aimed at building nation-wide scientific information infrastructure.

Key words: digital library, knowledge base, scientific resources, repository.

1 Introduction

In 2010, a dedicated project, SYNAT, has been launched in order to address deficiencies of scientific information infrastructure in Poland. The main SYNAT construction is based on three levels of scientific repositories, its ultimate goal is to ensure the dissemination of the Polish scientific achievements and to improve integration and communication of the scientific community, while leveraging existing infrastructure assets and distributed resources. The three levels of scientific repositories are shown in Figure 1.

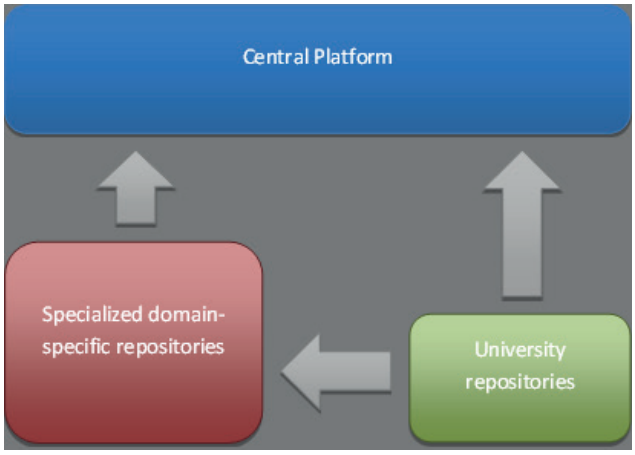

Figure 1. General SYNAT architecture

- the central level (the SYNAT platform and the INFONA portal),
- the domain level (specialised domain-specific repositories),
- the university level (repositories held by the universities).

More information about the research concerning SYNAT can be found in [2, 3]. In this document, we focus on the university level and postulate that it should be more of a knowledge base rather than just a repository. The purposes of the university 'Research Knowledge Base' is to provide:

- an entry point of the entire scientific information (together with full texts) concerning research performed at the university, with accordance to the principle that the information about publication, research project, etc., is entered to the system in the place where the research was performed. This ensures that this information is correct and up-to-date,
- an access point to this information with limiting factors depending on the access type (logged user, access from university, access from the world), and the publishers' copyright policies,
- an easy way to store cleaned, unambiguous and interconnected information of various types, e.g. researchers, institutions, conferences, journals, book series, projects, publications, diplomas etc.,
- administrative tools for reporting and evaluating scientific achievements of the university as a whole, the university institutions, as well as, individual researchers, according to the requirements of the university executive level, State authorities (Ministry of High Education), non-governmental bodies, etc.,
- interoperability, i.e. both side communication channels with various university services and systems (e.g. homepages, system supporting diploma processes, report generators, employee database) and various external services like Google Scholar, publishers' websites, etc.

We have been developing such a 'knowledge base' for almost 2 years now. The project originated from analysing the needs of Faculty of Electronics and Information Technology, and was first implemented to suit one faculty requirements, but soon it became clear that the system should become an university-wide one. Hence, it is now under deployment at the whole university.

The paper consists of three sections. In Section 2 we present general features of the software. Then in Section 3 we present special developments for improving data acquisition processes. In Section 4 we briefly present novel technologies incorporated within the software, making more valuable information retrieval parameters, as well as, analytical functionalities of the system.

2 Ω-Ψ^R Software

2.1 General assumptions

The last decade has shown an increased interest of many universities around the world in the systems concerning research data management and access to publicly funded research information. Also in Poland, at universities various approaches can be observed – some has been very enthusiastic in building infrastructure for research repositories storage, some other rather reluctant in supporting academic staff in meeting more demanding requirements for research practice, quite often due to lack of idea on how to provide suitable motivation on one side, and assistance on the other, leading to a successful university research knowledge database. It turns out that important success factors are harmonising solutions concerning both organisational issues, as well as functional features of the software.

The starting requirements for the university knowledge base were rather typical, focused on the repository functions. The main aim of the repository was to build institutional publication repository services, based on the open access idea to the most possible extent. However, since the very beginning it was clear that the system cannot be limited to the repository functions only. The university's research knowledge base should cover a vast and heterogeneous repertory of data concerning various aspects of the research activities, and the knowledge base should be a central entry point for information about researchers and their activity records, including inter alia the projects run at the university, along with various project documents and data, but also presentations, patents, etc., as well as various level diplomas and theses, starting from B.Sc. through M.Sc. to Ph.D. theses. All these data types should be strongly interconnected, building a semantically rich database. With such variety of the content in the university knowledge base, the software should be flexible enough, so that demands for new object types and new relationships would be fairly easy to implement. The flexibility should be reflected in providing administrative tools that enable defining new data structures, and then for the new objects make it easy to define new data entry worksheets and new search screens. As a result of a thorough evaluation of the needs of various levels of the academic community, the fundamental features of the implemented software are as follows:

- the system provides an easy way for:
  - storing any typed metadata along with digital content,
  - an easy way for defining custom types of stored metadata,
  - defining relationships between records of different types,
- with the defined data structures (rich in relationships between various objects), there are simple yet powerful means for the maintenance and control of the semantic data network stored in the knowledge database,
- the system is able to preserve 'historical values' of linked objects in the course of changes,
- the system provides multiversioning of the data,
- an efficient full-text search capabilities in both metadata and digital objects is available,
- the system provides means for automatic generation of highly ergonomic and customisable GUI,
- the system provides means for an easy integration with external systems and exposure for external search engines,
- the system provides means for extensive access control mechanisms,

With all the features above, the last but not least, is the multilinguality of the system.

Bearing in mind dynamics in changing the users' needs, all the tools of this kind have been implemented within the system in such a way that in most cases the system development does not require programmers' intervention. With the use of the implemented software, we have built the University Research Knowledge Base, which has following functionalities:

- storing of the university organisational structure,
- storing knowledge resources metadata and their correlation, among others:
  - publications (books, articles, etc.),
  - patents,
  - diplomas (B.Sc., M.Sc., Ph.D.),

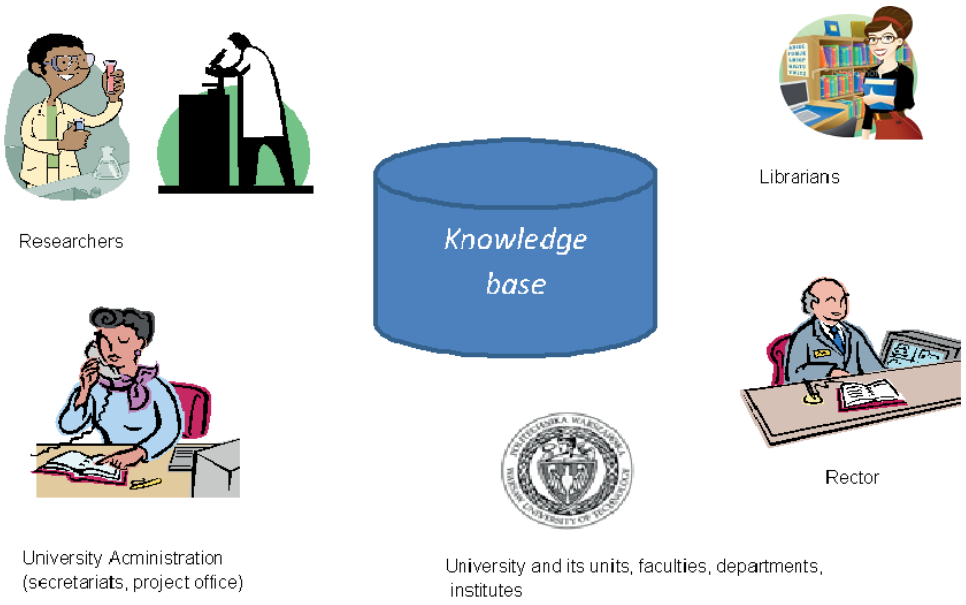

Figure 2. System beneficiaries

- research projects, along with the project documents, multimedia presentations, as well as research data, benchmarks, etc.,
- other scientific documents (reports, reviews, etc.),
- information about authors and their affiliations (CVs, other external and/or internal activities),

- storing employees data together with their achievements,
- evaluation of employees and organisational subunits,
- reporting for the internal purposes and for the purpose of the authorities,
- import/export in various formats.

Clearly, with the flexibility feature of the system it is fairly easy to define other objects within the knowledge base.

2.2 Users and beneficiaries of the system

The groups of the foreseen system users and beneficiaries are very heterogeneous. The first classification splits the users into the external and internal ones. As for the internal users, we can distinguish the following groups (Figure 2):

- researchers,
- students (graduates, undergraduates),
- university administration,
- scientific bodies (faculty councils, senate, promotion commissions, etc),
- university leaders, responsible for the research strategies.

For the external users, the role of the system is also multifold, though a bit different. The system integrates various functions, but the main function that should be emphasised are:

- provide a complete and up-to-date information about the research areas of the university researchers, and their strength to the potential external partners for building scientific cooperation links,
- provide means to the governmental authorities concerning the research potential of the university, and the currents achievements, inter alia for the evaluation and assessment reasons,
- provide complete and up-to-date information about the research areas of the university researchers, and their strength to the international evaluating bodies.

2.3 Main functionalities

In this Section we briefly present the functionality of the system.

2.3.1 Repository functions

With any defined object in the knowledge database it is possible to predefine various ‘digital attributes’. The digital attributes are devoted to store digital objects, which then are accessible by a unique ‘object identifier’. The text objects are subject to indexing, so that the index for full-text retrieval is built automatically with the new objects added to the database. Also the updates of text documents are automatically reflected in the indexes. The repository functions are implemented by means of the JCR [1] programming tools.

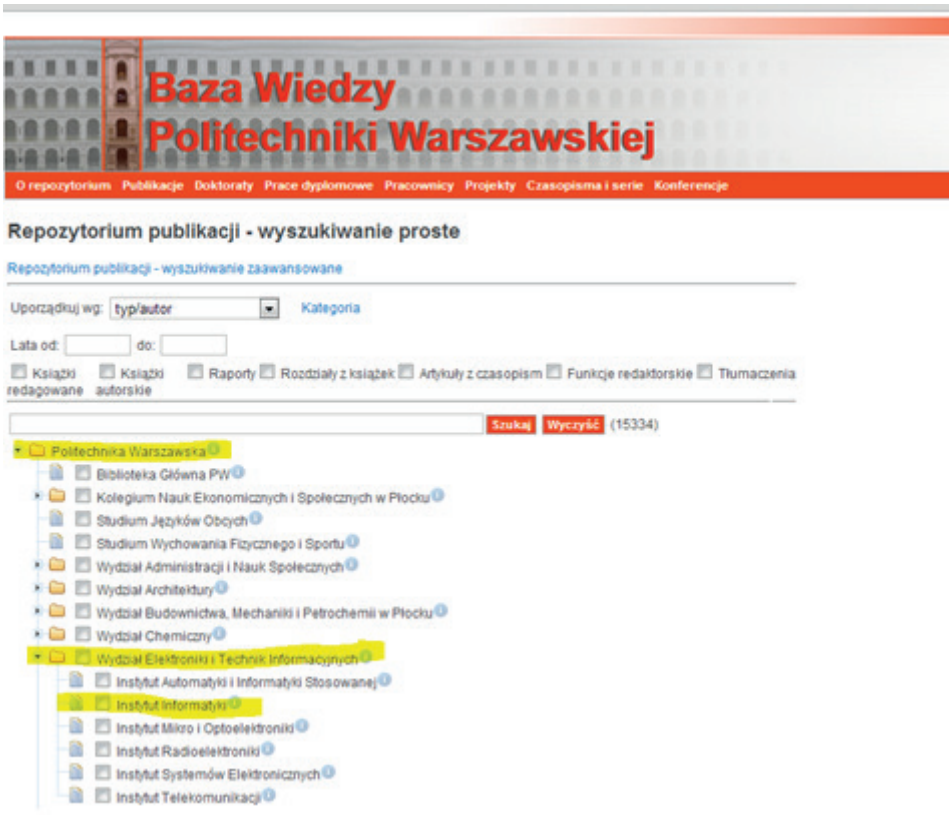

Figure 3. A search screen for a central retrieval point

2.3.2 Information retrieval

As Jackrabbit implementation of JCR uses Lucene [6], the powerful full-text retrieval capabilities of Lucene become a standard way to access the text objects and accompanying digital objects. The digital objects are 'values' of the digital attributes, so that if a document being value of an attribute of a given record fits to a query, the record is classified as relevant to the query. Among the objects' attributes, there are usually the attributes entered by the data entry clerk (or imported from external sources), or the ones, which are 'automatically' generated as a result of 'text mining' (automatic classifications/categorisations of the objects). Also the 'automatically' filled attributes are used for building the search index, and then used for information retrieval. For building the information retrieval screens, special tools have been implemented within the system. An example of the search screen is presented on Figure 3.

2.3.3 Multilinguality

Multilinguality is implemented in two layers:

- the GUI layer,
- the data layer,

For the GUI layer, in order to build a screen the system uses a dictionary for a given language, replacing the 'coded' messages/texts into the proper language equivalents. For the data layer, one has to foresee some attributes that are language-related, so that for a specific interface language appropriate values can be displayed.

2.3.4 Reporting

The system has a variety of tools to 'define' specific reports. Two ways of reporting are foreseen:

- building a simple report from a search result,
- building an aggregate report from a search result.

Both ways of reporting can be 'defined' in such a way that no reprogramming of the software is needed. It is just a repository of reports stored in the system base, and for a given GUI page we can invoke a predefined report.

2.3.5 Interoperability

The interoperability of the system is reflected by means of the following functions:

- data import,
- data export,

- harvesting tools for the external servers,
- linkages to the external resources.

Data import can be done in many ways. There are database administrator possibilities to import bulk of data for a startup loading of given objects, there are also means for the data entry clerk to import a BibteX file for loading some bibliographic records. What is very important, any kind of the data import is performed in such a way that the imported data cannot spoil the 'semantic network' stored in the knowledge base. To this end the following functionalities have been developed:

- the import controlled by the system for duplicates,
- the imported data are automatically 'linked' to appropriate objects, for example the new publication is linked to the author(s), relevant journal, conference, etc.

The data import is a part of the acquisition functionality. For the importance of this functionality for the system, it is described in more details in Section 3.

Data export is also provided in various ways. There are possibilities just to dump a part of the database in the form of the XML (in a proprietary format). Additionally there are tools for end-users to export from the system data in the form of BibTeX or Excel.

The harvesting functionality has been implemented for exposing the knowledge base data to the harvesting processes of the external systems. The external systems can harvest data from the knowledge base by means of OAI PMH [11] (in the Dublin Core format) or by means of the system proprietary services.

Another important form of interoperability is the connectivity to the resources of other systems. In particular, while presenting the bibliographic results, the system provides a link to the Google Scholar record. Additionally, whenever available, the DOI value provides an easy access to the publisher version of the publication. In the case of missing DOI, the data may contain URL links to the external digital contents.

2.3.6 System flexibility and configuration

As mentioned above, with a variety of the content in the university research knowledge base, and difficulties in defining all the software needs at the design phase, the software should be flexible enough, so that demands for new functionalities would be fairly easy to implement. The main idea behind this requirement was to provide easiness in defining custom installations and make possible expanding to the system in course of its life, without the need of (re)programming the software. The flexibility should be reflected in providing administrative tools that enable defining new data structures, and then for the new objects make it easy to define new data entry worksheets and new search screens. The proposed solutions for an upgraded flexibility of the system moved further. Actually, the system additionally provides scripting means for:

- validation tools supporting data entry process quality,
- means for visualising search results, custom views, defining sorting rules, etc.,
- means for defining analytical views,
- access rights rules, defining access to various objects, as well as synthetic information that can be obtained from the system.

All the tools of this kind have been implemented within the system in such a way that in most cases the system development does not require programmers' intervention. More details concerning the administrator tools are presented in [13].

2.3.7 Access control/protection

Another issue tightly coupled with the organisation structure is access control and users privileges. The system provides means for controlling access to the functions, as well as to the digital resources. There are some levels of protection, depending on the user role and its affiliation. The privileges control has been implemented by introducing to the metadata the attributes storing the 'record owner' and its 'affiliation'. Additionally there are special means implemented for controlling access to the digital resources. For specifying the privileges various metadata attributes can be used. The metadata and the user defined accessibility parameters are then combined within business rules that compute access rights. The rules can be easily modified, as they are kept in a separate configuration file. The administrative means for the access control are presented in more details in [13]. Below we provide an example, which illustrates how the rules can be built:

Example

A user that has 'dataentry' or 'superdataentry' role assigned can modify and delete his/her own records. Additionally, if the user enters a publication co-authored with an author from another institute, the other institute will also have access to the record modification (except deletion).

```
rule DataEntryAndSuperDataEntryCanAd-
dCanDeleteAndModfiyItsOwnRecords
when
  check: PermissionCheck(granted
==false,action ==”edit” ||
action==”delete”)
  role: Role(name == ‘dataentry’ ||
name==’superdataentry’)
  identity:Identity(name:principal.
name, affiliation:affiliation)
  entity:Entity(owner==name,affilia-
tionowner==affiliation)
then
check.grant();
end
rule DataEntryCanModifyPublications-
OfOwnedAuthors
when
  check: PermissionCheck(granted
==false,action ==”edit”)
  role: Role(name == ‘dataentry’ ||
name==’superdataentry’)
  identity:Identity()
  art:Article()
  a:Author(affiliation
!=null,affiliation.
accronymPL==identity.affiliation) from
art.author
then
check.grant();
end
```

2.3.8 Knowledge base functions

As a result of integration of various types of information under one system, quite new and powerful functionalities can be implemented. The most spectacular are the possibilities to perform:

- looking for expert,
- aggregating and visualising knowledge area for researchers, and/or for the university units,
- providing statistics about the research activities.

Below we present the first two functions

Looking for expert

One of the interesting features implemented within the system is the functionality of looking for experts, potential candidates for the teams and projects, within the university, as well as for the external partners who are looking for the cooperation.

The applied search is not based on what the staff declares or writes to the CV. Instead, it is based on what the knowledge base contains concerning various activities of the researcher. It means that the implementation of the functionality makes sense if the following conditions are satisfied:

- the knowledge base represents a kind of ‘semantic network’ by means of variety of interconnected objects, such as publications, patents, projects directed and/or participated, expert’s involvement in the conference program committees, etc.1 ,
- the knowledge base is as much complete as possible.

The expert search is based on the following components:

- major fields of the expertise suggestion; there is a module which extracts the main areas of expertise from the publications data (keywords provided by the authors), tags extracted automatically from the papers contents (by semantic processing of the objects, see the next subsection), the research maps2, which are built based on journals subject area, assigned to the papers by the Ontology for Scientific Journals (see [12], and the next subsection), as well as the researcher’s affiliation description, which in turn can also contain area tags, aggregated from the tags of publications, assigned to the ‘affiliation’ unit,
- search engine: this relies on the Ω-Ψ^R search engine, build on top of the Apache Lucene library; it provides full-text search and a rank on the basis of the well-known TF/IDF measure,
- a ranking module, which is definable by the system administrator with a special scripting language; such a module can implement a very specific rank algorithm, which can provide specific weights to the particular evaluation elements (e.g. impact factor of the journals, number of citations, special ranks for managing projects, etc.); one can have many ranking algorithms defined, so that the end-user can specify the ranking, depending on his/her specific needs; for example, a student looking for his Ph.D. supervisor can provide a search for experts in a given domain but then can sort them by number of supervised theses,
- result presentation: the results are presented in the form of table with the authors portfolios, containing all the details about the authors activities; the results are enriched with the ranking score bar.

---

[1] This information is planned for being applied when the acquisition process based on web mining is extended on searching for the involvement into conferences PC.

[2] For the internal needs, the module presents the tags in the form of a vector, and it visualizes it for the end-users as a word cloud. The word cloud can be “calculated” for the authors, and for the affiliations by aggregating cloud vectors assigned to the papers, supervised theses, run projects etc. This helps the user to pick the most probable area of expertise rather than test the casual phrases

The ranking algorithm can be roughly presented as follows:

- all the knowledge base resources are searched with a specified search phrase (formulated the same way as for searching publications, theses, etc.),
- for all the result items returned, the persons being the publication authors, theses supervisors, project leaders, etc. are extracted and a table for authors is built with all the 'achievements' for each person (publications, theses, projects, affiliations, etc.),
- for each 'achievement' record for each person in the table the score is calculated according to the selected algorithm,
- for each author the calculated achievements scores are added and the final 'authors score' is provided,
- the table is sorted by the final scores and presented as output.

A simple example for calculating the one 'achievement record' score is given below[3]:

Multiply the following parameters:

- the Lucene relevance score,
- the author role weight ('article author', 'book author', 'book editor', 'phd author', 'phd supervisor', 'bachelor author', 'bachelor supervisor', 'master author', 'master supervisor', 'project member', 'project leader', 'author profile'),
- impact Factor (IF) of the journal (for the journal papers), IF for the book series (for the chapters or books), a defined value for a book chapter or book if the IF are not known.

Aggregating the research activities

The main advantage of integrating various aspects of research activities of the researchers is a possibility to aggregate all the activities, so that the presentation of a department, faculty or an institute can be provided with the aggregated values summarising various activities. The aggregated 'activity vector' can be then visualise in the form of a table or as a 'word cloud' of research areas. Examples of visualising research areas are presented in Figure 4.

2.4 Functionally defined users

For running the knowledge base, a number of roles have to be assigned to the users. In this respect the system is also flexible and it is possible to make it in various ways, depending on the organisational conditions and human resources.

In general, in addition to the actual beneficiary end-users one can distinguish the following 'functional groups' of users:

- data entry staff,
- administrators of the database(s),
- system administrators,
- exploitation and maintenance staff.

Data entry: At WUT the data entry functions are assigned to the specially trained staff, usually to faculties. The decisions in this respect depend on the faculties and deans. In some cases the roles are dedicated to the institutes, in other, to the faculty librarians. It is however also expected that in smaller units, the data entry role can be assigned to the researchers directly. For such cases, special control of data quality will be given to the Main Library staff. The data entry role is limited to the role scope: as a rule, the user can correct and modify its own record, only the user with special privileges can update records of 'subordinated users'.

Administrators of the database(s) (DBA): The database administrator role provides the functionality which makes possible to change the values of 'central databases', like the journals base or conferences. At WUT, only an assigned librarian will have rights to (re)define the scores assigned to the journals (based on the Ministry scoring system), control the conference database (flagging on and off the conferences with the Web of Science flag). The other functions of the DBA cover, i.e.:

- assigning/changing privileges to the users,
- controlling the statistics of the database contents,
- generating special reports for decision makers,
- controlling data quality,
- verifying data entry (cataloguing) rules,
- maintaining the contents of auxiliary dictionaries (languages, countries, affiliations, and the university structure).

In Figure 4, a screen for searching for an expert and the result screen are provided.

System administrators (SA): The system administrators have at their disposal a number of functions that make possible changes to the software without programming. The system administrator can change the system configuration (switching on or off some functionalities), add new reports to GUI, change the rules for the users privileges. The other changes of SA cover:

[3] This algorithm causes that publications where the keyword occurred frequently (for example in full text, extracted paper keywords, journal name, journal keyword) are scored higher, moreover the journal impact factor increases the ranking.

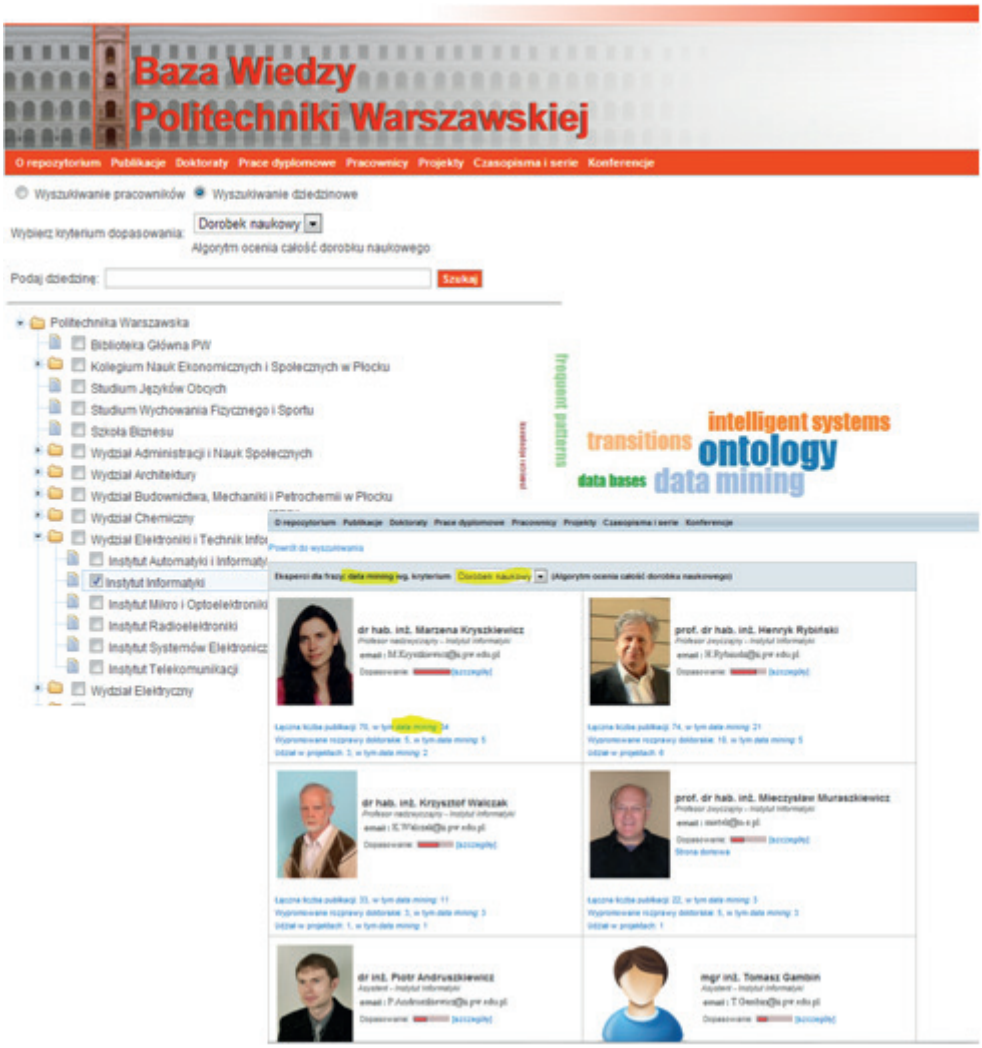

Figure 4. A search for experts in a domain and the result page

- defining new data objects and modifying structures of the existing ones,
- defining new screens (data entry, search, results) and modifying the old ones,
- defining new sorting rules, reports, etc. and modifying the old ones,
- defining/modifying validation procedures,
- additionally the database administrators can add new or change the existing scoring algorithms for the criteria of the research quality assessing.

Exploitation manager (EM): The EM is responsible for the correct work of the system environment and smooth work of the system. In particular, EM is responsible for:

- checking the CPU workload of the processor,
- usage of the disk space,
- backing up the information resources and the system,
- planning reorganisation/maintenance breaks and recovering the system after breaks,
- traffic control and statistics of the usage of the system,
- controlling the network parameters.

2.5 Architecture

The architecture of the system is schematically presented on the Figure 5.

One can distinguish here the following components:

- Application – the framework applied, Seam (http://seamframework.org/), makes easier building ergonomic GUI, and simplifies an overall integration of the system;
- Data – the data system is based on the XML formats. The data structure is verified by the XML Schema Definition (XSD). Such XML data are then converted to the object model by means of the JAXB technology (http://jaxb.java.net/). The data persistency is gained by means of the repository system Jackrabbit (http://jackrabbit.apache.org/), compliant with the standard of Java Content Repository (JSR 170 and JSR 283). The JCR standard provides *inter alia* the following functionality:

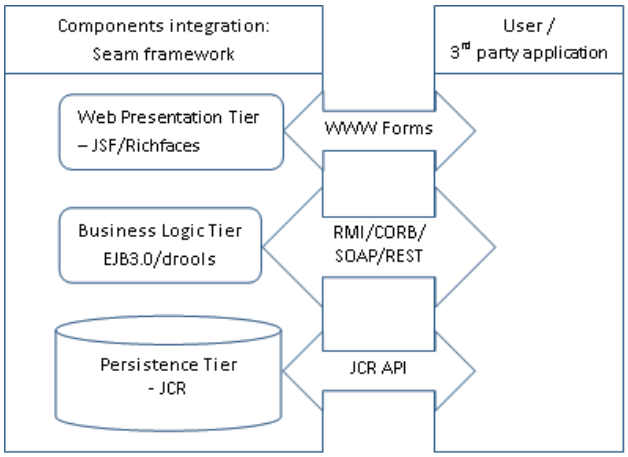

Figure 5. System architecture

- indexing,
- versioning,
- access control
- integration on the data level,
- control of the changes of the contents,
- a fairly simple switch to another technology provider.

For technical reasons, the system also uses a typical relational database, mainly for storing addresses of remote repositories as well as keeping data necessary for the users' authorisations.

- Presentation layer – this layer is supported by the technology provided by Java Server Faces, with the use of the library RichFaces (http://www.jboss.org/richfaces), which is based on the AJAX approach. The basic user interface is automatically generated, based on the XSD definitions, then it can be freely adopted/tuned to specific needs of the particular functionalities. More details are in [13].
- Business logic layer – it is based on the components of EJB 3.0 (see http://jcp.org/aboutJava/community process/final/jsr220/), so that transactionality of the system is guaranteed. Additionally, it simplifies exposing the system to the other (external) systems.
- Run environment – the system is run under the control of a virtual Java machine, ver. 6, and the application server JBoss[4].

The system Ω-Ψ^R has been implemented in such a way that it can applied as a central system, or in a distributed environment. As at a given point it has been decided that at WUT we apply a centralised version. This solution is in general much cheaper and easier to maintain.

[4] If needed, it can be replaced by another product compliant with the Java Enterprise Edition standard.

Figure 6. Data acquisition process

3 Data acquisition

This section presents a solution for automatic acquisition of bibliographic entries from the web. This process consists of three steps, depicted in Figure 6:

- searching for publications,
- extracting bibliographic metadata and finally,
- merging entries into university knowledge base.

The first step is realised by the Ψ^R module. The module can be seen as a focused web crawler. It delegates user-given queries to various search engines, executes them in a periodical manner and consecutively refines them to improve precision and recall of results. We use it to search the Internet for the publications of the WUT authors. Besides publications acquisition, the Ψ^R module is going to be used to retrieve up-to-date information about conferences and journals.

The second step is performed by the Zotero software [14]. Zotero is a free and open-source Firefox extension, which helps managing bibliographic data and related research materials. Notable features include automatic detection of bibliographic entries on websites, retrieving these entries and converting between many formats e.g. BibTex, MODS, RefWorks. Zotero supports bibliography detection in a variety of sources including publishers' databases, like Springer, Scopus or IEEE, as well as, publication search engines like Google Scholar or CrossRef.

It is worth mentioning that the system Ω-Ψ^R itself is supported by Zotero as well. In particular, for the purpose of data acquisition we implemented the Zotero-based web server, named bib2py. We use it to convert websites containing information about WUT publications into BibTex format. As Zotero was developed as a browser extension, it was not straightforward to build the web-server applica-

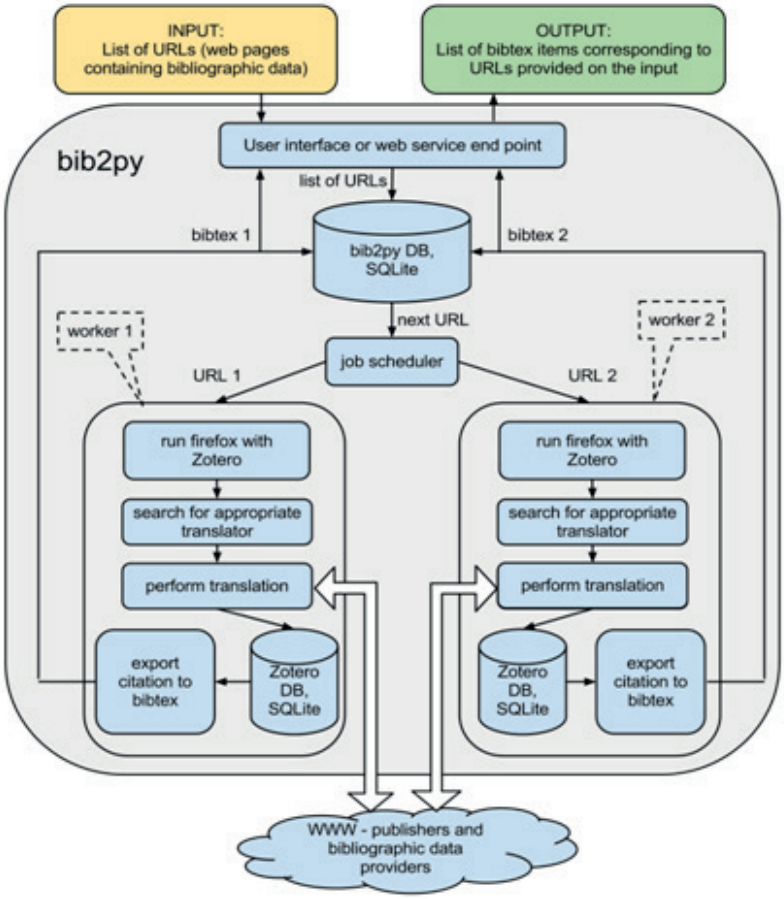

Figure 7. Zotero as a server – bib2py architecture

tion on the top of it. Several changes in the Zotero source code were made in order to automate the process of bibliographic data extraction and to eliminate the necessity of the user interaction. Moreover, in our web-server we utilised a plugin to Zotero, named 'Scaffold', which is a Firefox extension designed for developing and testing the Zotero translators.

The bib2py module provides the functionality that enables user to manage the process of bibliography extraction from the predefined collection of research resources. The service takes as an input either a single URL or the list of links that point to the websites containing bibliographic data, e.g.: http://link.springer.com/chapter/10.1007/978-3-642-32826-8_40, or http://dx.doi.org/10.1016/0306-4379%288 4%2990025-5.

For each URL, it tries to extract the bibliographic metadata existing on the webpage using an appropriate Zotero translator. When the bibliographic data are successfully extracted from the website, they are exported into the specified citation format (e.g. bibtex). The details of the bib2py architecture are presented on Figure 7. Note that in order to speed up the bibliographic data retrieval we can process different resources in parallel.

The last step, i.e. importing BibTex into the repository, is performed by the Ω-Ψ^R software. It converts BibTex into a native XML format, which represents publications in the form of a tree-like structure (see Figure 8). The tree nodes represent bibliographic elements, which might be shared between many publications, e.g. authors, books, journals, series.

Each tree node might have its own properties (e.g. title, name, surname). As mentioned earlier, the repository data structure (based on the JCR data model) is composed of objects (or nodes). Therefore, while importing an XML tree, the tree nodes are stored in the repository independently (like objects), so that they can be reused in linking to other publications, as well as, they can be embedded locally in the 'document tree', so that to allow keeping 'historical data'. The splitting of 'global data' from the local ones makes possible to modify data on either site, e.g. authors affiliation change or surname change can be performed at a global level of the PERSON object, whereas the local author subtree at a given publication tree stores the historic value of the affiliation). During the import, every element of the tree has to be matched against the contents in the repository, then merged and integrated

Koperwas Jakub Janusz, Skonieczny Łukasz, Rybiński Henryk, Struk Wacław: Development of a University Knowledge Base, w: Intelligent Tools for Building a Scientific Information Platform: Advanced Architectures and Solutions / Bembenik Robert *[i in.]* (*red.*), Studies in Computational Intelligence, vol. 467, 2013, ISBN 978-3-642-35646-9, ss. 97-110, DOI:10.1007/978-3-642-35647-6_8

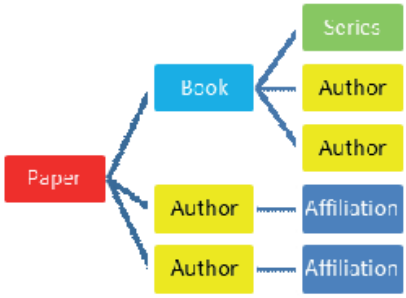

Figure 8. Bibliographic entry and its tree-like representation

with the existing 'objects'. We have implemented a number of general methods for the tree matching, as well as specific matching methods for identifying publications and authors.

It is worth noting that the presented data acquisition functionality does not cover all the possible functions of the module Ψ^R. This functionality addresses two main needs:

- it can be used to gather missing publications from web and load a bulk to the system,
- it can be used as a tool for the staff to perform a very easy data entry for their new publications; actually, with the use of ZOTERO the data input received from the publisher side is of a very high quality, and the obtained BibTeX file can be loaded automatically to the system. As the import of data is controlled for duplicates, there is no risk to spoil the repository.

4 Semantic processing server

Semantic processing in the WUT Knowledge Base is thought as a process aiming at enriching the objects by adding semantically meaningful descriptions and/or modifications. The processing is performed on the repository documents (publications, theses, patents, etc), and it consists in:

- scientific domain classification – adding subject tags that classify the objects to given scientific domains,
- extraction of semantically meaningful descriptors from the text and assigning them to the 'semantic description' field,
- identifying synonyms, relevant acronyms and other close meaning terms based on the semantically meaningful descriptors,
- looking for translations of the extracted descriptors and acronyms (from the English texts to Polish, from the Polish texts to English).

The target goal of those activities is manifold, the most important reasons are: the processing (1) is mainly used for building maps of research areas for individual researchers, and then, with the use of their research characteristics, for propagating the researchers interest to the affiliation related university units descriptions, and building the research maps for these units (from laboratories to faculties); the processing (2) and (3) are also used for building interest vectors of the researchers (used for building the word clouds), but mainly they are used for improving the search parameters, such as precision and recall; The processing (4) is used to improve multilingual information retrieval.

In the system Ω-Ψ^R the semantic processing is using two special semantic resources:

- ontology for Scientific Journal [12] (in the sequel OSJ), mainly used for performing task (1) above,
- the Wikipedia resources, mainly used for the tasks (2–4).

Below we describe the usage of the resources in more details.

4.1 Publication classifier

Scientific domain classification is the task consisting of providing a publication with one or more relevant tags, assigning the publication to one or more scientific classes. In Ω-Ψ^R we have decided to use the OSJ ontology as a classification schema. OSJ is a three level hierarchy, ended with the leaves on the last (fourth) level, which are simply scientific journal titles, so the path in OSJ from the root to a leaf (i.e. a journal title) assigns domain tags to the papers from the journal. The OSJ classification schema covers 15,000 peer-reviewed scientific journals, and it is translat-

ed by more than 22 international experts who volunteered their time and expertise, making the tools available to worldwide scientists. The levels in the OSJ hierarchy are respectively domain, field, and subfield. For example the journal 'Artificial organs' in OSJ is classified as follows:

- domain – *Applied Sciences*,
- field – *Engineering*,
- subfield – *biomedical engineering*.

Clearly, OSJ can be used straightforward for assigning tags to all the papers published in the journals that are present in the OSJ list. The problem appears for the publications out of the OSJ journal lists, as well as theses, publications being conference papers, chapters in the books, etc. To this end, we have designed and implemented Bayesian classifier, which was trained on the OSJ papers. So, the science domain classifier works as follow for each document:

- if the document is a paper from the OSJ list, take the tags assigned by OSJ to the journal,
- otherwise, use the Bayesian classifier on the available metadata, preferably including title, keywords and abstract, and use the result tags to classify the document.

The classifier provides only the tags from the second level of the ontology[5]. While experimenting, we verified two solutions: one classifier for all the OSJ fields or a tree of specific classifiers, each node representing a 'specialised' classifier. The experiments have shown that the solution with the tree of 'specialised' classifiers outperforms one common classifier. The tree of classifiers is a hierarchical structure with the depth 1, where each node represents a specialised classifier. The root is a classifier for the first OSJ level, its children are composed by six classifiers at level 2 (for each OSJ domain there is one fields classifier constructed). An average accuracy (10-fold cross validation) in a tree mode has reached 85%, whereas in the case of a single classifier for all the OSJ fields the accuracy was about 60%.

4.2 Semantic indexing

For implementing semantic indexing, special semantic resources, like domain ontologies, or thesaurus, play a crucial role in enhancing the intelligence of Web, mainly by means of enterprise search and in supporting information integration. Nowadays, most of the semantic resources cover only specific domains. They are created by relatively small groups of knowledge engineers and are very cost intensive to keep up-to-date with the domain changes. At the same time, Wikipedia has grown into one of the central knowledge sources, maintained by thousands of contributors. Bearing in mind that the whole university research domain cannot be covered by one specific domain ontology, we have decided to apply Wikipedia (Polish and English) as a semantic knowledge resource and implement Wikipedia-based semantic indexing of documents in the Ω-Ψ^R system information included in Wikipedia.

Wikipedia contains 30 million articles in 286 languages, including over 4.2 million in the English part. Additionally, it extensively uses ontology called DBpedia, which is a crowd-sourced community effort to extract structured information from Wikipedia and make this information available on the Web. DBpedia allows one to ask for sophisticated queries against Wikipedia, and to link various data sets on the Web to Wikipedia data. Since a few years, both Wikipedia and DBpedia are used in research in many areas involving natural language processing, in particular for information retrieval and information extraction (see e.g. [4, 5, 7]). Below we present how we use Wikipedia for the needs of semantic processing in the Ω-Ψ^R system.

Wikipedia articles consist of free text, with structured information embedded, such as *infobox tables* (the pull-out panels that appear in the top right of the default view of some Wikipedia articles, or at the start of the mobile versions), categorisation information, images, geo-coordinates and links to external Web pages. This structured information can be extracted and arranged in a uniform dataset, which can be queried. In our project we use Wikipedia in two approaches – *term oriented* and *text oriented*. The first one describes a given term by other words, which come from the Wikipedia content. The module responsible for this task is named WikiThesaurus. The text oriented approach consists of extracting keywords from a text using dictionary of terms (defined as Wikipedia article's titles). The module responsible for extraction is called WikiKeywordsExtractor. Both modules are working on a previously prepared database, built from the Wikipedia content.

WikiThesaurus is a module providing semantic information about an analysed term. It is inspired by the Milne and Medelyan works [9, 10]. It processes data in two steps. First, given a term extracted from the processed

[5] The first level of OSJ is too general, it has six broad categories: Natural Sciences, Applied Sciences, Health Sciences, Economics and Social Sciences, Arts and Humanities and General, whereas the third level is too detailed, and there is a problem with finding out a training set with a uniform distribution of categories and representative number of examples per category.

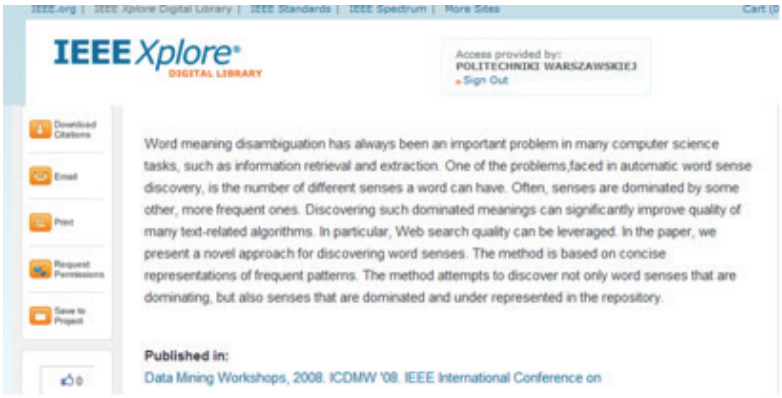

Figure 9. The example of abstract used in keywords extraction process

document, it searches for an article with the title equal to or at least containing this term. Then, the found article is processed in order to extract its labels[6], senses, translation or first paragraphs. In order to retrieve related topics to a given term we retrieve all the articles that are siblings in a domain, links-in and links-out. The functionalities provided by WikiThesaurus are as follows:

- retrieving senses for a term,
- retrieving short description for a term,
- retrieving alternative labels for a term,
- retrieving translations for a term,
- retrieving related topics to a term.

WikiKeywordsExtractor is used to extract keywords from a text using knowledge included in Wikipedia. The main idea and some partial solutions come from [7]. The module processes the input text in three steps:

- text preprocessing,
- terms filtering,
- terms evaluation.

4.2.1 Text preprocessing

KeywordExtractor processes the input text in such a way that for each term it looks in the Wikipedia preprocessed base for anchors, i.e. links to other articles or proper names. With the found anchors it builds a list of candidate keywords.

4.2.2 Term filtering

KeywordExtractor filters the candidates in order to remove the irrelevant terms (like articles describing pronunciation), or solve the polysemy problems. The latter one refers to the terms referring to the articles being the disambiguation pages, containing multiple meanings of the given term. For this case, the module has to choose only one meaning. The decision depends on categories matching, and the number of other candidates having link-in/out to a given meaning. The cleaned list of candidate articles is passed to the final phase.

4.2.3 Term evaluation

KeywordExtractor ranks terms (being candidate titles) using measures based on the common descriptors. Each candidate article is described by a bag of words (bow in the sequel), constructed from titles of related articles (as siblings, links-out, links-in). In the same way we describe the analysed text – a bag of words is built from terms, which are titles of candidates returned from the filtering phase. Next, each candidate is compared to the bow of the analysed text. The final measure is a derivative of cardinality of the intersection of the two sets (see Formula 1).

$$\text{Rank (candidate, text)} = \frac{|Bow(candidate) \cap Bow(text)|}{|Bow(text)|} \quad (1)$$

where *Bow(candidate)* is the set of terms describing the candidate article, and *Bow(text)* is the set of terms describing the analysed text.

Generally, those candidates, which have higher cardinality measure, are ranked higher[7]. Finally, only the candidates ranked above a given threshold are accepted. The titles of those candidates are the final list of keywords.

The example of keywords extraction is demonstrated in Figure 9.

[6] They are manually edited, and assigned to the articles by Wikipedia editors.

[7] Other similarity measures are now under tests.

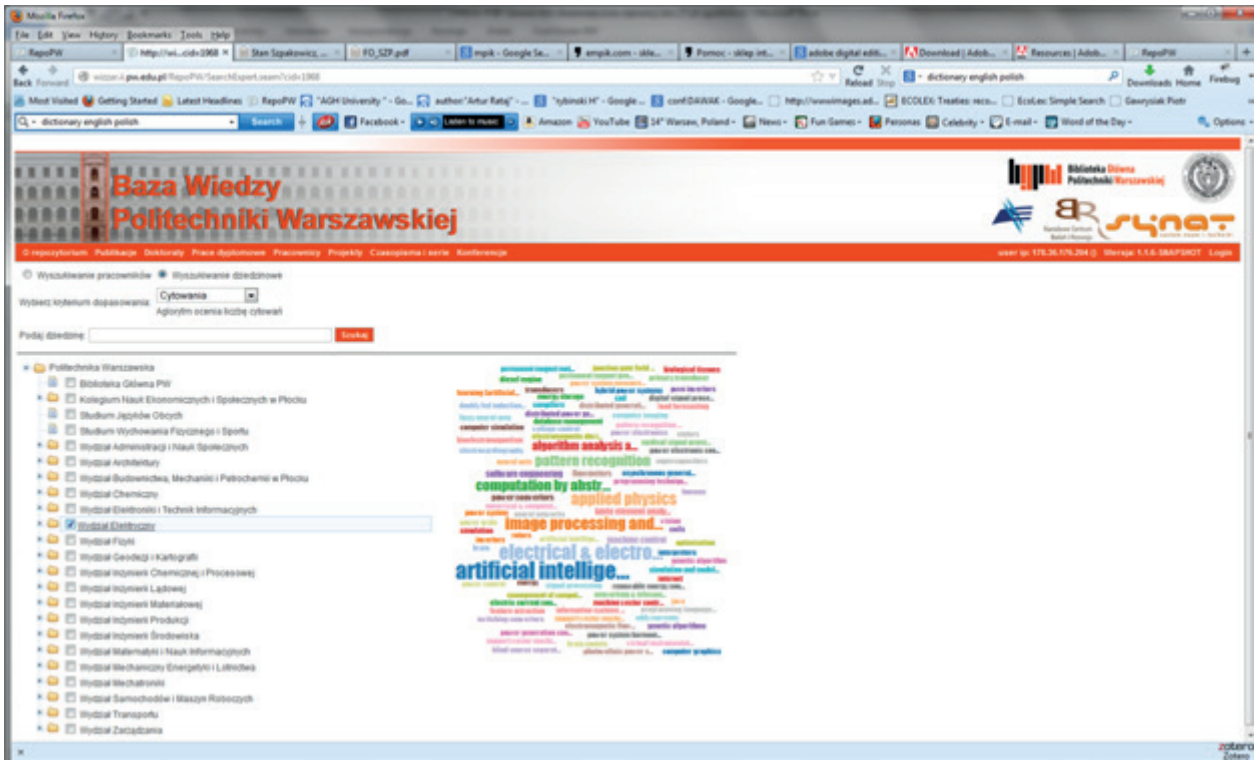

Figure 10. A map of the research areas for a selected faculty

The input text is the abstract from Figure 10. The extracted keywords are: *information, information retrieval, web search engine, computer science, word sense, World Wide Web.*

The extracted keywords are used to create research maps which facilitate expert search described in previous section. Publication keywords are aggregated on the authors' level and further on the affiliations' level creating cloud of words which visually depicts research areas of interests for the given person or institution. An example of a research map for a faculty and a researcher is presented in the Figure 11.

5 Conclusions

First, a simpler version of the system was deployed only at the Institute of Computer Science and was used only for scientific publications. Then, it was implemented at the Faculty of Electronics and Information Technology (FEIT), and it has been used for more than 2 years. In the meantime it gained the development level suitable for building the university knowledge base and the functionality of the current version of Ω-Ψ^R. As such, a year ago the system has been moved to the university level, and after a series of courses and training it starts working for all the faculties.

It turns out that the WUT Knowledge Base installation is positively accepted by the university faculties. Especially, as the functionality of Ω-Ψ^R goes beyond the typical functionality of institutional repository, providing appropriate means for many various groups of users it has chances to become a central knowledge source about the university research activities, the more that, due to applied intelligent tools (acquisition tools, reporting functionalities), the maintenance efforts of Knowledge Base are essentially reduced compared to the typical solutions.

The efforts devoted to the dissemination of university scientific achievements start bringing initial results. The usage statistics of WUT Knowledge Base show increasing interests from visitors from all around the world, especially Western Europe and North America. It is expected that those effects could be enforced after some time, when the database contents reaches a certain level. In order to speed up the saturation processes, the system will provide in the near future more crowd-sourcing features, in particular making possible uploading full texts by the authors themselves providing social media integration etc.

It also turns out that the Ω-Ψ^R software system itself is very successful and attracting much attention. In particular, the system was presented to other Polish universities, who requested the possibility to evaluate the system and are seriously considering using it. Installing the system on more than one university could enable cross-university

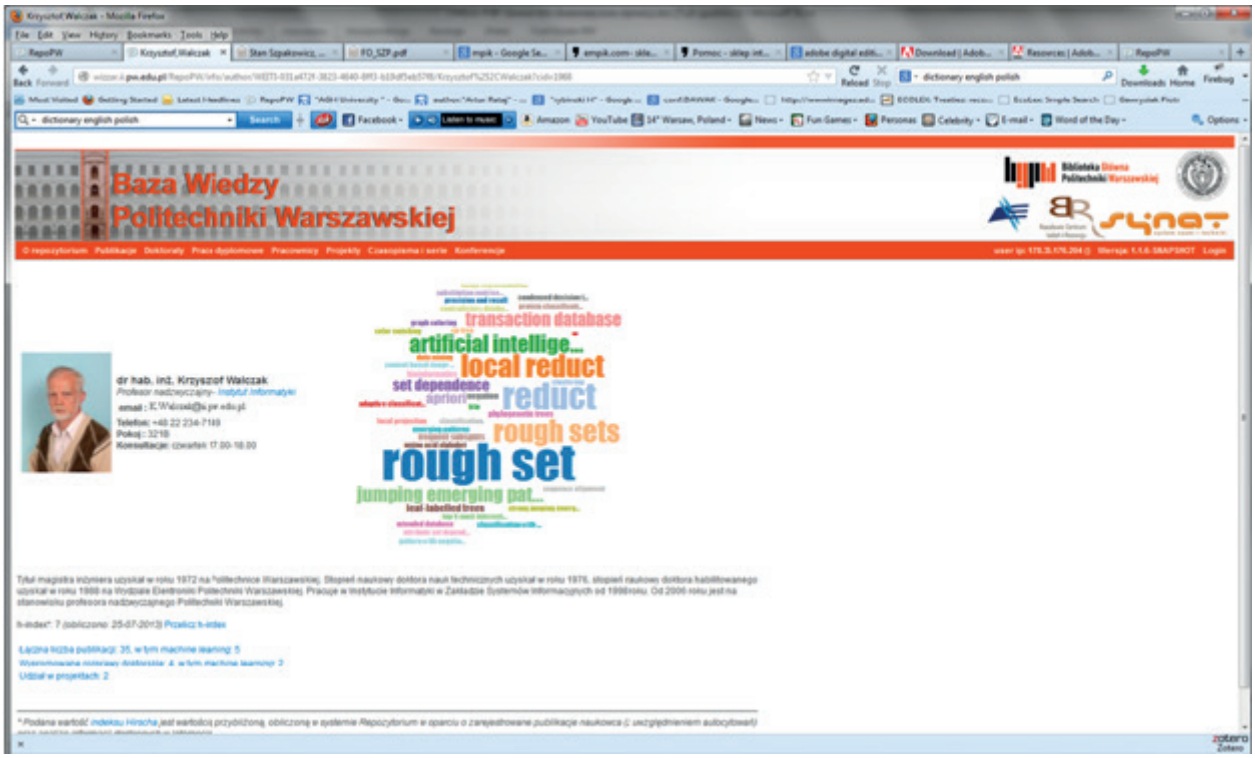

Figure 11. A map of the research areas for a selected faculty staff

resources sharing, and thus could lead to the development of completely new functionalities increasing synergy in Polish science. For instance, quick access to peers work from the universities network will be possible. In addition, the functionalities of looking for a team will eventually help building project teams consisting of researchers from various universities. Some comparative statistics would also be possible, which would stimulate the competitiveness.

Both, the Ω-Ψ^R system and its implementation as the WUT Knowledge Base seem to significantly contribute to the irreversible global trend of aggregating and sharing the scientific achievements. The initiative of the universities in Poland in implementing the university level research knowledge bases will provide means for building a modern nation-wide scientific information platform.

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USE OF THE PN-EN ISO 9004:2010 STANDARD FOR IMPROVEMENT OF COMPETITIVENESS OF THE FOOD INDUSTRY ENTERPRISES

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Abstract: Food industry companies, functioning in an ever-changing and uncertain environment, look for ways to increase their competitiveness, including the improvement of effectiveness and efficiency of the implemented food safety management systems. Directions that can be used for this purpose are provided by the PN-EN ISO 9004:2010 standard. In the first part of the elaboration presented the requirements for the food safety management system included in the PN-EN ISO 22000:2006, and then the guidance of the PN-EN ISO 9004:2010 standard for providing the enterprise management system in order to achieve a sustained success in the turbulent environment. Followed by compared the guidelines and requirements of these two standards in order to evaluate the possibility of their combined use in the food industry enterprises. Next presented this guidelines of the PN-EN ISO 9004:2010 standard, which have no references to the requirements of the PN-EN 22000:2006, and are discussed how they can be helpful for enterprises in the food chain in the process of improvement of effectiveness and efficiency of the implemented food safety management systems.

Key words: food industry, PN-EN ISO 9004:2010, PN-EN ISO 22000:2006, quality management system, food safety management system.

1 Introduction

The primary goal of any enterprise is to achieve sustained success. The matter of competition on the modern market can be represented by the offers of individual companies that compete for the opportunity to effectively provide the finished products to their prospective buyers [2]. The competition applies to the market acceptance of the offer by purchasers [15]. The products are even more competitive, the greater extent to which they meet the requirements of customers in terms of price, quality or other features affecting the selection decision.

Also in the case of food, nowadays consumers look for food products that meet their needs and expectations as much as possible.

The requirements of food may refer to its various features such as: the organoleptic, nutritional, stability and convenience in use. However, the most important requirement for goods, resulting in food law, is its safety, conditioning the health of consumers. The European Union prefers the free flow of goods and services, but in the case of food it must be unconditionally secure [3]. While the organoleptic and nutritional value can be evaluated by the consumers at the time of the selection and purchase of food products, so far the assumption that the products are safe for consumers must be accepted only on the basis of the manufacturer's declaration [5]. Meanwhile, the successive food safety crises published in media, including: dioxin contamination of animal feed, spread of serious animal diseases, such as bovine spongiform encephalopathy and avian flu, result in the decrease of consumer confidence in the quality and safety of traded food, and thus the loss of confidence to its manufacturers and distributors.

These food safety crises, as well as rapidly changing environment where the food industry enterprises function, along with the needs and expectations of consumers, forcing companies to change the current approach to the safety of produced and marketed food toward its assurance, within the enterprise management system. These changes are also the result and consequence of the reform of the EU food law, implemented in line with the 'White book of the food safety', published in 2000, that imposes on the enterprises from the food chain[1] the requirements to ensure food safety under the Hazard Analysis and Critical Control Point – HACCP [14].

One of the sources of competitive advantage of the food industry companies is therefore the safety of marketed food. In order to prove consumers their ability to produce food that is safe and meets their requirements, companies implement and submit to certification of the food safety

[1] The food chain notion can be interpreted as sequence of the stages and operations involved in the production, processing, distribution, storage and handling of a food and its ingredients, from primary production to consumption. The food chain also includes the production of materials intended to come into contact with food or raw materials [10].

management systems, in accordance with the requirements of the PN-EN 22000:2006 standard. Performed tests show that the information on the implemented system, placed on the food product or its packaging, is essential for consumers and affect purchasing decisions. Also in the evaluation of enterprises, the implementation of the food safety management system affects the growth of their competitiveness [3].

However, in the era of increasingly certified and implemented standardised management systems, in order to ensure the competitiveness of enterprises the implementation of the system is already inadequate – it is necessary to take measures in order to continuously enhance its effectiveness and efficiency. Therefore, the food industry enterprises seek for solutions that enable them to improve the effectiveness and efficiency of their food safety management systems, so that they can be the source of their competitive advantage. Guidelines that can be used for this purpose are provided by the PN-EN ISO 9004:2010 standard, designed for organisations of various types, which provides guidance helping to achieve sustained success through the use of the quality management system, functioning in the enterprise.

This article is a review. Its purpose is to determine, on the basis of the analysis of literature and standards for quality management and food safety, the extent to which the guidelines of the PN-EN ISO 9004:2010 standard can be used by the food industry enterprises in developing their competitive advantage.

2 Food safety management system in accordance with the PN-EN ISO 22000:2006 standard

In order to standardise and harmonise the various standards and regulations for food safety in 2005, the International Organization for Standardization published the ISO 22000:2005 standard, the so-called 'Food safety management systems: Requirements for any organisation in the food chain' (introduced in Poland by the PKN in 2006). The main goal of this standard is that the most effective system in the area of food safety, bringing maximum advantages for both the company and all its interested parties is the system that is established, maintained and updated as a part of a comprehensive management system and is included in the total number of activities related to the management of the organisation [10].

In the PN-EN ISO 22000:2006 standard, one specified requirement for the food safety management system that can be implemented in organisations carrying out activities at any stage of the food chain, wishing to demonstrate their ability to supervise food safety hazards and thus a consistent safety of food supplied to consumers [10].

The PN-EN ISO 22000:2006 standard specifies the requirements for the food safety management system in the following areas [10]:

- food safety management system, which specifies the general system requirements and the requirement for the documentation,
- management responsibility, including the requirements for management commitment, food safety policy, food safety management system planning, responsibility and authority, communication and management reviews,
- resources management, including human resource requirements, infrastructure, work environment,
- planning and realisation of safe products, including the requirements for pre-requisite programs, risk analysis, the HACCP plan, planning the verification of system and control of non-conformities,
- validation, verification and improvement, including the requirements for the validation of control measure, control of monitoring and measuring, verification and improvement of food safety management system.

The PN-EN ISO 22000:2006 standard may be the basis for certification of food safety management system. System certificate confirms that all food safety hazards are identified and assessed by the company and are controlled in such a way that the marketed products do not negatively affect the health of consumers.

3 The guidelines of the PN-EN ISO 9004:2010 standard

One of the well-known and internationally recognised tools of a system approach to the enterprise management of the quality-oriented products and services provided to customers is the quality management system, built on the basis on the requirements and guidelines of the ISO 9000 standards. These standards are aimed at supporting the organisation, regardless of the size and nature of its activities, in the implementation, maintenance and continuous improvement of an effective management system that ensures compliance with customer needs and expectations, and as a result provides confidence to our products or services [11].

One of the standards included in the ISO 9000 series is the PN-EN SO 9004:2010 standard, the so-called 'Managing for the sustained success of an organisation: A quality management approach'. It was developed in

order to provide the guidance to help organisations to achieve a sustained success[2] in demanding and constantly changing environment,[3] through the use of the organisation's quality management system [12]. In contrast to the PN-EN ISO 9001:2009 standard, which sets out the requirements for the system and can be the basis for the certification, the PN-EN ISO 9004:2010 standard has the status of the guidelines, so it is not intended for certification purposes. In comparison to the PN-EN ISO 9001:2009 standard, targets for customer satisfaction and product quality were extended in the guidelines of the PN-EN ISO 9004:2010 standard, so as to include the satisfaction of all interested parties of the organisation. In addition the PN-EN ISO 9001:2009 standard focuses only on the effectiveness of the quality management system, while the guidance of the PN-EN ISO 9004:2010 standard provides guidance on the continuous improvement of the effectiveness and efficiency of the entire organisation, including more comprehensive approach to its operation, as they in fact relate to the strategy management [7, 13].

The guidelines of the PN-EN ISO 9004:2010 standard have been included in six areas [12], i.e.:

- managing for the sustainable success of an organisation,
- strategy and policy,
- resource management,
- process management,
- monitoring, measurement, analysis and review,
- improvement, innovation and learning.

Their use is a step toward the implementation of the Total Quality Management (TQM) to the organisation.

In accordance with the guidelines of the PN-EN ISO 9004:2010 standard, a continued success of the organisation is achieved by its ability to meet the needs and expectations of not only its customers, but also other interested parties in a constantly changing environment (business, environment, community, society and country, abroad) for a long time and in a balanced way [7].

Like all the ISO 9000 standards, the PN-EN ISO 9004:2010 standard is intended to be applicable to all organisations, regardless of the type of business. Thus, it can be used also by the food industry enterprises, especially those that have implemented the food safety management system, in accordance with the requirements of the PN-EN ISO 22000:2006 standard, as a tool to enhance competitiveness.

4 Comparison of the guidelines of the PN-EN ISO 9004:2010 standard and the requirements of the PN-EN ISO 22000:2006 standard

In order to evaluate the possibility of using the PN-EN ISO 9004:2010 standard in the food industry enterprises, owing the food safety management system in accordance with the PN-EN ISO 22000:2006 standard, one carried out a comparative analysis of the guidelines and requirements contained in these two normative documents (Table 1).

The analysis shows that almost all the guidelines of the PN-EN ISO 9004:2010 standard are reflected in the requirements of the PN-EN ISO 22000:2006 standard, although the requirements for the food safety management system, corresponding to the guidelines of the PN-EN ISO 9004:2010 standard have much narrower range. In fact they focus only on one aspect of the operation of the food industry enterprises, which is the food safety, and do not include other aspects being decisive to their success in the market.

The guidelines of the PN-EN ISO 9004:2010 standards, which have no references to the requirements of the PN-EN 22000:2006 standard, include the guidelines on:

- achieving sustained success,
- management of financial resources,
- commitment and motivation of the people,
- cooperation with suppliers and partners,
- management of knowledge, information and technology,
- natural resource management,
- self-assessment,
- use of benchmarking,
- learning.

These guidelines (discussed further) may be used by the food industry enterprise to improve the effectiveness and efficiency of their food safety management systems, making perfect the performance of enterprises, and as a result the increase of their competitiveness.

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[2] According to the guidelines of the PN-EN ISO 9004:2010 standard, the sustained success notion shall be interpreted as result of the ability of an organisation to achieve and maintain its objectives in the long term [12].

[3] PN-EN ISO 9004:2010 standard defines the organization's environment as combination of internal and external factors and conditions that can affect the achievement of an organisation's objectives and its behavior toward its interested parties [12].

Table 1. Relationship between the guidelines of the PN-EN ISO 9004:2010 standard and the requirements of PN-EN ISO 22000:2006 standard (*source: own study based on* [10, 12])

Subclause in PN-EN ISO 9004:2010	**Subclause in PN-EN ISO 22000:2006**
4.1. (Managing for the sustained success of an organisation) General	4.1. (Food safety management system) General requirements 5.1. Management commitment
4.2. Sustained success	—
4.3. The organisation's environment	7.3.4. Intended use 7.3.5. Flow diagrams, process steps and control measures 5.6.1. External communication
4.4. Interested parties, needs and expectations	5.7. Emergency preparedness and response
5.1. (Strategy and policy) Generals	5.2. Food safety policy
5.2. Strategy and policy formulation	5.2. Food safety policy
5.3. Strategy and policy deployment	5.3. Food safety management system planning 8.5.2. Updating the food safety management system
5.4. Strategy and policy communications	5.6.2. Internal communication 5.6.1. External communication
6.1. (Resource management) Generals	6.1. Provision of resources
6.2. Financial resources	—
6.3. People in the organisation 6.3.1. Management of people	6.2. Human resources
6.3.2. Competence of people	6.2.2. Competence, awareness and training
6.3.3. Involvement and motivation of people	—
6.4. Suppliers and partners **6.4.1. General**	—
6.4.2. Selection, evaluation and improvement of the capabilities of suppliers and partners	—
6.5. Infrastructure	6.3. Infrastructure 7.2. Pre-requisite programmes (PRPs)
6.6. Work environment	6.4. Work environment 7.2. Pre-requisite programmes (PRPs)
6.7. Knowledge, information and technology	—
6.8. Natural resources	—
7.1. (Process management) Generals	4.1. (Food safety management system) General requirements
7.2. Process planning and control	7.1. (Planning and realisation of safe products) Generals 7.2. Pre-requisite programmes (PRPs) 7.6.1. HACCP plan 8.2. Validation of control measure combinations 7.9. Traceability system
7.3. Process responsibility and authority	5.4. Responsibility and authority
8.1. (Monitoring, measurement, analysis and review) Generals	8.1. (Validation, verification and improvement of the food safety management system) Generals 8.3. Control of monitoring and measuring
8.2. Monitoring	7.6.4. System for the monitoring of critical control points 8.4.2. Evaluation of individual verification results
8.3.1. (Measurement) Generals	8.4. Food safety management system verification
8.3.2. Key performance indicators	7.6.4. System for the monitoring of critical control points 8.4.2. Evaluation of individual verification results
8.3.3. Internal audit	8.4.1. Internal audit

Subclause in PN-EN ISO 9004:2010	Subclause in PN-EN ISO 22000:2006
8.3.4. Self-assessment	—
8.3.5. Benchmarking	—
8.4. Analysis	8.2. Validation of control measure combinations 8.4.3. Analysis of results of verification activities
8.5. Review of information from monitoring, measurement and analysis	5.8. Management review 5.8.1. General 5.8.2. Review input 5.8.3. Review output
9.1. (Improvement, innovation and learning) Generals	8.5. Improvement 8.5.1. Continual improvement 7.10.2. Corrective actions 5.7. Emergency preparedness and response 7.2. Pre-requisite programmes (PRPs)
9.2. Improvement	8.5. Improvement 8.5.1. Continual improvement 7.10.2. Corrective actions 5.7. Emergency preparedness and response 7.2. Pre-requisite programmes (PRPs)
9.3. Innovation	7.3. Preliminary steps to enable hazard analysis 7.4. Hazard analysis 7.5. Establishing the operational pre-requisite programmes (PRPs) 7.6. Establishing the HACCP plan 8.4.2. Evaluation of individual verification results 8.5.2. Updating the food safety management system 7.8. Verification planning 8.2. Validation of control measure combinations 5.6.2. Internal communication
9.4. Learning	—

5 Managing for the sustained success of the food industry enterprise

In accordance with the guidelines of the PN-EN ISO 9004:2010 standard, the meeting of the needs and expectations of all its interested parties contributes to the lasting success of the organisation [12]. Comparison of actual results with the expectations, through the perspective of the requirements of different interested parties, is the essence of assessing the level of the competitiveness of the enterprise [15].

The PN-EN ISO 9004:2010 standard defines an interested party as a natural or legal person, which adds a value to the organisation and/or has an impact on its activity and results achieved [12]. In the case of the food industry enterprises, they mainly include food consumers, but also all organisations in the food chain (Figure 1).

Interested parties by the food chain may specify different requirements (Table 2).

Because the needs and expectations of interested parties and enterprises can be dynamically changed and be in conflict of interests with the requirements of the other party, the PN-EN ISO 9004:2010 standard promotes their performance in a balanced way. To make this possible, the enterprise shall [12]:

- plan in a long-term perspective,
- systematically monitor and analyse changes in its environment,
- identify interested parties, their needs and expectations and the impact on their operation and success,
- systematically engage interested parties, provide them with information about their activities and plans and establish mutually beneficial relationships,
- balance the competing needs and expectations of interested parties by applying different approaches, such as mediation, negotiation,
- identify and eliminate the risk of short- and long term perspectives affecting the achievement of a long-term success,
- predict future resource needs,

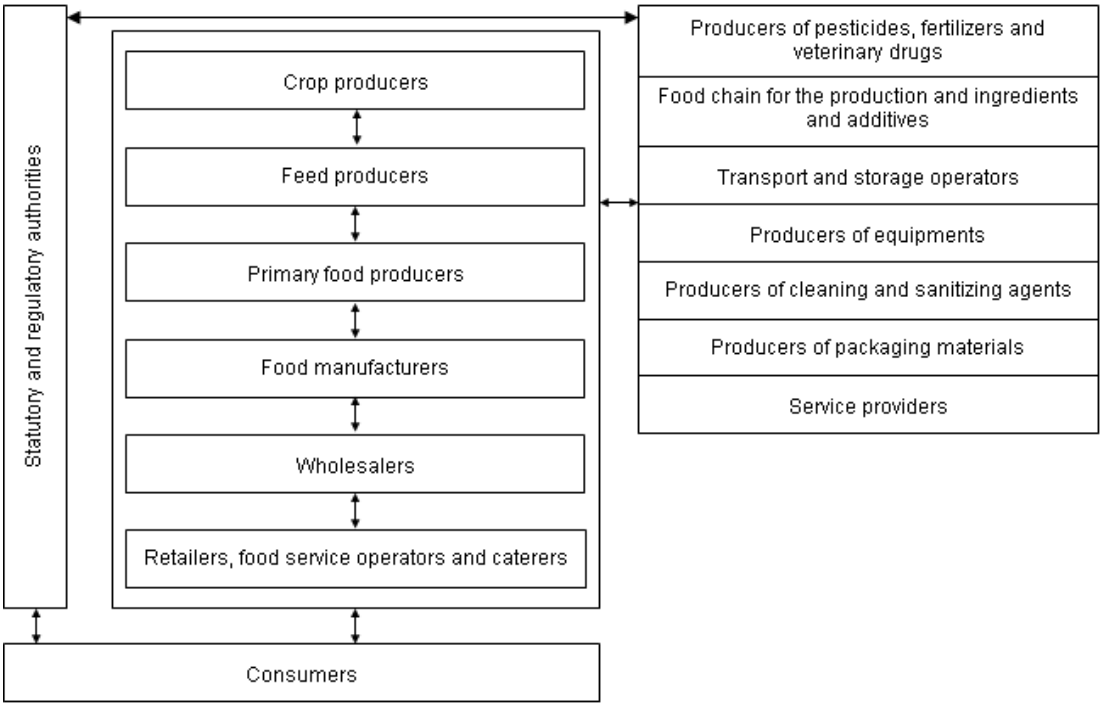

Figure 1. Interested parties by the food chain (*source:* [10]).

- systematically assess its compliance with current plans and identify the needs for any corrective and preventive actions,
- provide employees the opportunity to learn the benefit for themselves and the enterprise,
- implement the processes of innovation and continuous improvement leading to a sustained success.

6 Strategy and policy of the food industry enterprise

The basic document of the food safety management system, built on the basis of the requirements of the PN-EN 22000:2006, which sets out the obligations and directions of the company operation relating to food safety, is its policy of the food safety. The policy shall be appropriate to the nature of the company and its place in the food chain, in accordance with the requirements of the customers' food safety, communicated, implemented and maintained at all levels of the organisational structure of the company, viewed in terms of its usefulness and validity, and a framework for setting and reviewing objectives of the food safety [10].

The PN-EN 22000:2006 standard does not specify requirements for the formulation of the mission, vision and strategy of the enterprise. However, it is possible to formulate and implement the food safety policy without prior definition of the mission, vision and strategy in this area. Thus, under the guidance of the PN-EN ISO 9004:2010 standard, the food industry enterprise that wants to achieve sustained success in the market shall establish and maintain vision, mission and shared values with regard to food safety, which will be understood, accepted and supported by all the staff of the enterprise, as well as all the interested parties [12]. They shall be determined taking into account the requirements of all interested parties (the company shall anticipate the potential conflicts arising from the different needs and expectations), the requirements of the food law, strengths and weaknesses, opportunities and threats.

In accordance with the guidelines of the PN-EN ISO 9004:2010 standard, the implementation of strategies and food safety policy requires [12]:

- to translate them into measurable objectives relating to the food safety,
- development and implementation of the schedule to achieve the objectives,
- to provide the resources necessary to achieve the objectives,
- assessment and elimination of the risks associated with the implementation of the objectives,
- implementation of the activities necessary to achieve the objectives.

Implemented activities shall not only be effective but also efficient – in order to optimise the use of the related resources [7].

Table 2. Examples of interested parties and their needs and expectations (*source: own study based on* [12]).

Interested party	Examples of needs and expectations
Consumers of food	Safety, quality, price and delivery terms of food Compliance with the food law Effective notification on food safety hazards Proper response to crises related to the food safety
Statutory and regulatory authorities	Compliance with the requirements of the food law Effective notification on food safety hazards Proper response to crises related to the food safety
Owners/ stakeholders	Stable profit Transparency of the organisation activities Compliance with the requirements of the food law
People in the organisation	Suitable work environment Job security Recognition and reward of achievements
Suppliers and partners	Mutual benefits and business continuity Effective notification on the food safety hazards
Community	Environment protection Ethical behaviour Compliance with the requirements of the food law and other requirements Effective notification on the food safety hazards Proper response to crises related to the food safety

Following the recommendations of the PN-EN ISO 9004:2010 standard, the enterprise shall implement its strategy and policy as well as obtain feedback from all interested parties in order to quickly and flexibly respond to changes in the environment in which it operates.

Policy and strategy of food safety shall be translated into processes implemented in the food safety management system. For this purpose, the enterprise shall [7, 12]:

- determine the relationship between their organisational structure, implemented system and various processes carried out in the system,
- identify potential problems in the interaction between the processes,
- provide resources for the implementation of priority improvement activities related to the food safety,
- provide an organisational structure for the establishment and implementation of a long- and short-term food safety plans at all levels of the enterprise.

7 Resource management

The competitive possibilities of the enterprise are significantly affected by the quality of their resources and the ability to use them. The entirety of the tangible and intangible resources, which shall be the property of the enterprise in order to be able to use them to build, maintain and strengthen its competitiveness, is the potential of the competitiveness of the enterprise [15]. Resources, in addition to the organisational structure, processes and procedures are also one of the elements of the food safety management system built on the basis of the requirements of the PN-EN 22000:2006 standard. These resources include human resources, infrastructure and work environment [10].

In accordance with the guidelines of the PN-EN ISO 9004:2010 standards, thanks to the appropriate resource management, organisations operate effectively and efficiently and achieve sustained success. Therefore, the food industry can be used in the processes of production of the safe food and to the activities of the current operation.

7.1 Management of financial resources

The PN-EN 22000:2006 standard does not include requirements for the management of financial resources, because its requirements are focused on ensuring the effectiveness of the food safety management system. However, the decisive factor for the competitiveness of the food industry enterprises is the system that is not

only effective, and thus ensures the implementation of the objectives of food safety, both short- and long-term, but is also efficient and so the results obtained by enterprises exceed the costs of those inputs. Improvement of the effectiveness and efficiency of the system may in fact have a positive impact on the financial results of the company [12].

Efficiency of the food safety management system can be measured in financial terms, and therefore food industry enterprises can use the guidance of the PN-EN ISO 9004:2010 for the management of their financial resources. The standard recommends that while managing financial resources the enterprises shall determine the needs and sources of these resources in order to ensure their availability for present and future activities. Businesses can use two mechanisms to improve the efficiency of the food safety management system and its operation in financial terms [12]:

- interior, based on the reduction of interferences in the process (especially: any deviation from established critical limits in identified critical control points), reduction of non-compliance with the requirements of food produced (consumers, regulations, product specifications, product standards) and reduction of wastage of raw materials and time,
- exterior, based on the reduction of non-compliance with the requirements of food produced following its delivery to consumers, their damage, the cost of complaints and the cost of lost customers and markets.

Management of financial resources in an efficient food safety management system shall include the monitoring, controlling and reporting of information on the efficiency of the allocation and the use of these resources, related to the implementation of the strategy, policy and food safety objectives. The enterprise shall also review its financial results in order to identify ineffective and inefficient activities and take appropriate improvement actions.

7.2 Commitment and motivation of people

The most important resource of any organisation is the staff, as its awareness, commitment and competence are decisive to ensure the effectiveness and efficiency of its operation. Human resources are also essential to ensure the effectiveness of the food safety management system, and therefore the PN-EN 22000:2006 requires that the staffs executing actions in the system was aware of how these activities contribute to the assurance of the food safety and be competent on the basis of education, training, skills and experience [10].

In the management of human resources, food industry enterprises may use standard guidelines of the PN-EN ISO 9004:2010 for motivation of the staff (which are not included in the PN-EN 22000:2006 standard). According to these guidelines, the increase of commitment and motivation of the staff can be achieved by [7, 12]:

- improvement of the process of sharing knowledge and skills,
- introduction of the system of recognition and reward on the basis of individual assessments of the staff,
- establishment and implementation of a rating system of the professional appraisal and planning the staff career,
- systematic study of satisfaction, needs and expectations of the staff,
- providing both mentoring and coaching opportunities.

7.3 Cooperation with suppliers and partners

One of the resources that can determine the market success of the food industry is supplier (e.g. raw materials, semi-finished products, packaging and ancillary services) and partner[4] (e.g. institutions including technical, financial, governmental and non-governmental). Type of relationships with suppliers and partners and the way of their management can have a significant impact on the performance of the enterprise. The PN-EN 22000:2006 standard does not specify the requirements in this respect, however, the company that wants to be competitive shall maintain a positive relationships with their suppliers and partners, based on a common strategy, knowledge sharing, as well as gains and losses [12].

Using the recommendations of the PN-EN ISO 9004:2010, the food industry enterprises shall manage the cooperation with suppliers and partners in such a way to ensure improvement of their ability to deliver products and services that meet the requirements of the company. Thus, companies shall [12]:

- optimise the number of their suppliers and partners,
- provide a two-way flow of information on the needs and requirements of each party,
- ensure cooperation in the validation of the process capabilities implemented by suppliers and partners,
- monitor their ability to supply products in accordance with the requirements of the company,

[4] The partnership notation can be interpreted as agreement of two or more parties involved in the design and implementation of an object, the joint work to ensure its successful completion, by which they reach their goals, under conditions of reciprocity [8].

- share the knowledge with suppliers and partners in order to effectively and efficiently improve the process of delivery,
- involve suppliers and partners in the identification of needs for improvement of purchases and development of a joint strategy to ensure the food safety,
- evaluate, recognise and reward the achievement of suppliers and partners,
- analyse and eliminate the risks associated with cooperation, in particular those having impact on the food safety offered by the enterprise to the consumer.

The organisation shall also encourage their suppliers and partners to a mutual and continuous improvement of their management systems and to participate in joint initiatives in the area of improving, maintaining a balance between the objectives of short- and long-term objectives [7].

7.4 Management of knowledge, information and technology

A key resource in the organisation functioning in the knowledge-based economy is information. Intellectual capital is becoming increasingly important as a factor determining the competitive advantage of enterprises [2].

Information is considered to be basic resources necessary to continuously improve the knowledge of the organisation and its lack is a barrier to a continuous improvement of both the food safety management system and the performance of the enterprise [9, 17]. The PN-EN 22000:2006 standard does not specify requirements for the management of knowledge, information and technology, but any food enterprise shall specify the principles for identification, preparation, maintenance, protection, use and assessment of these resources. Companies shall also share knowledge, information and technology with their stakeholders, especially in the context of the need for effective flow of information about dangers of the food safety throughout the food chain.

Enterprises that want to achieve success in the market, shall manage:

- external information, such as the food law, results of controls carried out by the official food control authorities, results of audits of the second and third party,
- internal information, such as the results of the monitoring of critical control points in the process, results of testing of raw materials, semi-finished and finished products, consumer satisfaction survey results, results of internal audits and audits of suppliers, system verification.

In accordance with the guidelines of the PN-EN ISO 9004:2010 standard, information management shall include [12]:

- identification of the information needs of both internal and external sources of information,
- acquisition of knowledge and experience of the enterprise staff,
- acquisition of knowledge from business stakeholders,
- processing of information into the knowledge necessary to make decisions related to the improvement of the implemented food safety management system and the functioning of the enterprise,
- use of data, information and knowledge in defining and implementing the strategy and objectives of the food safety,
- evaluation of the benefits of using information in order to improve the management of information and knowledge,

The decisive factor for the competitiveness of the food industry enterprises is also the technology they have. Thus, following the guidelines of the PN-EN ISO 9004:2010 standard, companies shall consider and make a choice of technological options that enable an increase of effectiveness and efficiency in the areas of product making, marketing and customer relations [7]. This shall include the assessment of the current level of technology, costs and benefits associated with it, the risks associated with changes in technology, environment and opportunity to respond to changing customer requirements [12].

7.5 Management of natural resources

One of the types of resources that are crucial to the operation of the food industry enterprises are natural resources. In the case of these companies, natural resources can significantly affect the safety of the food produced, and thus achieve a long-term success. Natural resources can thus determine the competitiveness of the enterprise, and often are outside its direct supervision [17]. Therefore, in accordance with the guidelines of the PN-EN ISO 9004:2010 standard, companies shall systematically analyse the risks associated with the availability of these resources and have contingency plans to ensure their availability and their replacement with others [12].

As mentioned before, the success of the enterprise depends on its compliance with the requirements of all stakeholders. Because one of these requirements may be the protection of environment, in the management of natural resources the enterprise shall take into account the

environmental aspects throughout the life cycle of food produced, from design through manufacture, distribution, up to the disposal of the packaging. Therefore, companies can integrate the food safety management systems with the environmental management systems, for example using the requirements of the PN-EN ISO 14001:2005 standard.

8 Self-assessment

In order to identify the elements of the food safety management systems for improvement, which is necessary for the proper planning and the implementation of improvement activities, enterprises shall be subjected to a systematic assessment of both their effectiveness and efficiency. Both internal audits and management reviews, conducted in accordance with the requirements of the PN-EN 22000:2006 standard, provide enterprises with information on the effectiveness of their systems, but this information, however, is limited mostly to the degree to which systems can meet the requirements of the PN-EN 22000:2006 standard and other requirements of companies, inter alia, according to provisions of the food law, product standards and system documentations. They do not provide any details on the efficiency of the systems, which is one of the determinants of the competitiveness of the food industry enterprises. Hence, it is necessary to use additional methods of assessment that will provide companies comprehensive and precise information on the strengths and weaknesses of their systems, enable them to determine priorities for improvement in this area and provide an incentive to improvement activities.

The PN-EN ISO 9004:2010 standard recommends that enterprises shall evaluate the implemented management system, using the self-assessment. The concept of self-assessment is to understand a systematic, comprehensive and complex review of organisational activities and its outcomes (...), aimed to identify the strengths and areas for organisational improvement, providing the possibility of prioritising the planned follow-up activities that can be regularly monitored [4]. Self-assessment can be carried out in relation to the management system or a model of excellence [12]. It can therefore be carried out in relation to the guidelines of the PN-EN ISO 9004:2010 standard or a selected model of the organisational excellence, as defined in the criteria for regional, national or international awards for quality. The scope of self-assessment can be flexibly adapted to the objectives and priorities of the enterprise, and so each of them can develop its own model of self-assessment in relation to any management system. Therefore, the food industry enterprises may also carry out the self-assessment with regard to the requirements of the PN-EN 22000:2006 standard.

The self-assessment shall be the basis for any action taken by the food industry enterprise, regardless of its size, organisational structure, type of food supplied to consumers. It is impossible, however, to efficiently and effectively manage and undertake systematic and continuous improvement activities, without information resulting from the self-assessment of information on the results achieved by the enterprise. Thus, the self-assessment shall be the basis for planning and monitoring of the strategy and policy for enterprises in food safety and implementation of any tools for use of their enterprise resources [1]. In order to enable the monitoring of the performance of enterprises at the time, the self-assessment shall be carried out systematically [13].

While carrying out the self-assessment, the food industry enterprises can assess the level of maturity of its food management system and identify the needs as well as set the priorities for their improvement. Because it is not possible to improve all areas of the functioning of the enterprise at the same time, only on the basis of analysis of the strengths and weaknesses, the management can set goals and priorities in this field [16].

In the food industry enterprises, the self-assessment does not have to be limited to the evaluation of their safety management systems; companies can comprehensively cover their whole system of management. The self-assessment may in fact be used to [7]:

- establish priorities and action plans enabling the enterprise to achieve sustained success,
- implement the improvements and innovations in processes, products and organisational structure,
- monitor and improve the financial performance,
- collect input data for periodic review of the effectiveness of the enterprise management system and evaluate its competitiveness.

The PN-EN ISO 9004:2010 standard proposes two types of the self-assessment [7]:

- The overall self-assessment, providing information on the level of maturity in six key areas of management, listed in the standard;
- The detailed self-assessment, providing information on the organisational performance in relation to the recommendations of various subsections of the chapters of the PN-EN ISO 9004:2010 standards.

The overall self-assessment shall be performed by the top management of the enterprise, while the detailed

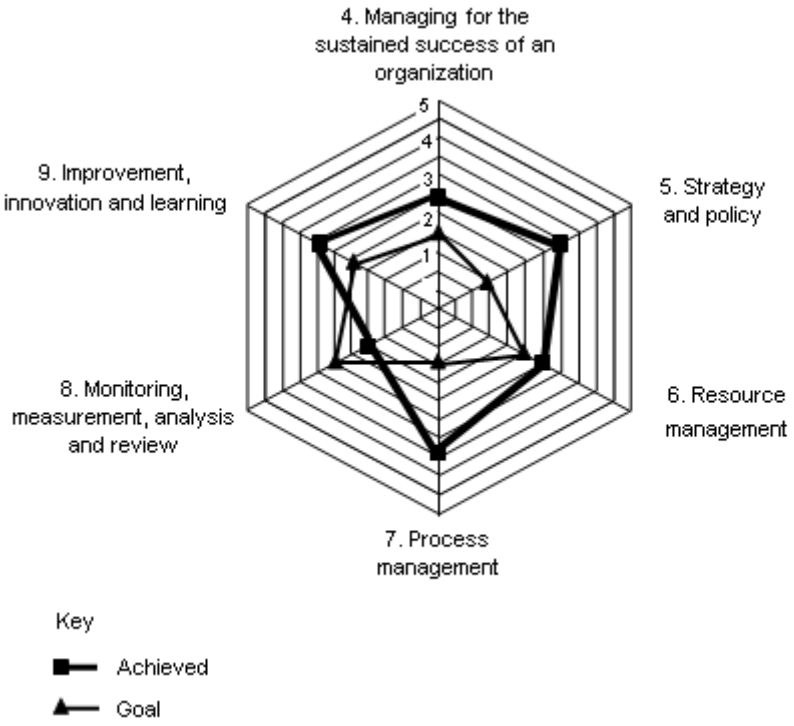

Figure 2. Example illustration of the results of a self-assessment (*source:* [12]).

self-assessment shall be performed by the operational management. In both cases, the assessment may be carried out at a five scale of maturity levels proposed by the PN-EN ISO 9004:2010, or customised to suit the needs of the enterprise [12]. Self-assessment results shall be related to the objectives set out by the enterprise in order to achieve them in each area (Figure 2), while the results of the analysis of the differences between the goals pursued and the results obtained shall be used to identify, plan and implement the improvement activities.

9 Benchmarking

In accordance with the guidelines of the PN-EN ISO 9004:2010 standard, in the improvement of the food safety management systems, necessary to increase the competitiveness of the food industry enterprise, can be used for the benchmarking, defined as a method of measurements and analysis, enabling the search for best practices in the enterprise and beyond it, in order to improve their own management [12].

Using the guidelines of the PN-EN ISO 9004:2010, the food industry enterprises may carry out the benchmarking, including [12]:

- internal, including procedures implemented in the food safety management system (competition between organisational units is not market-oriented, but has an effect on the growth and decline in the competitiveness of enterprises [15]),
- external, including developments and processes carried out by rival enterprises in the food chain,
- general, by comparing the strategies, activities or processes with unrelated organisations.

Companies can submit to the benchmarking the strategies and policies for the food safety, processes implemented in the food safety management system, individual food products offered to consumers, as well as organisational structures.

10 Learning

While using the guidelines of the PN-EN ISO 9004:2010 standard, the food industry enterprises can improve the effectiveness of the implemented food safety management systems through a learning process, defined as the collection and analysis of information from various sources, including the events on the successes and failures.

The ability to learn, providing a quick access to knowledge and its use, is one of the factors that determine a company's ability to achieve sustainable success. Enterprises shall learn through a combination of knowledge, patterns of thinking and patterns of behaviour of people with the values of the company, on the basis on teamwork, interacting and creative sharing of knowledge, both inside and

outside the company [7, 12]. The learning process shall be supported by the top management of the enterprise, through the recognition and rewarding of the excellence of the staff and the creativity appreciation [12].

11 Summary

Since joining the European Union, Poland has become a part of the single market of food, which is characterised by an intense competition to win the consumer, for whom an essential matter is the safety of purchased products. The fulfilment of the requirements of the PN-EN ISO 22000:2006 standard ensures the safety of the food produced by the enterprise, however, it may be insufficient to achieve the business success. In order to make the food safety management systems the source of competitive advantage, the food industry enterprises shall continuously improve their effectiveness and efficiency.

Competitiveness may be defined as the ability to adapt the company to the changes in its environment. Enterprises are even more competitive, the greater their ability to immediately respond to these changes. The PN-EN ISO 22000:2006 standard provides only the identification and meeting the customer requirements for the food safety. However, the use of the guidelines of the PN-EN ISO 9004:2010 standard ensures not only the identification and meeting all current needs and expectations of each party interested, but also provides a fast and flexible adaptation of the requirements to these changes.

The requirements of the PN-EN ISO 22000:2006 standard are much narrower in scope than the guidelines of the PN-EN ISO 9004:2010 standard. The PN-EN 22000:2006 standard focuses on the most important, but only on one aspect of the functioning of the entities in the food chain, which is the safety of food supplies to consumers, regardless of all other aspects of enterprise management. Its main objective is to ensure the effectiveness of the food safety management system, without specifying the requirements for its efficiency. However, the PN-EN ISO 9004:2010 standard establishes the guidelines for a comprehensive, strategic, both effective and efficient organisational management system. Thus, the combined use of the standards of the PN-EN 22000:2006 and the PN-EN ISO 9004:2010 may be helpful for enterprises in the food chain to maximise the use of implemented food safety management systems to strengthen their competitiveness. The integration of these two approaches to the organisational management ensures that the food safety management system is an integral part of a comprehensive enterprise management system, ensuring an effective and efficient implementation of the adopted strategy and objectives.

Food industry enterprises, wishing to improve their food safety management system, resulting in the increase of their competitiveness, can in particular use the guidelines of the PN-EN ISO 9004:2010 standard, for:

- balanced meeting of the needs and expectations of all its interested parties, concerning the food safety and other requirements for enterprises, as well as a flexible respond to changes in business environment,
- formulation and communication of strategies and policies for the enterprise, taking into account the objectives of the food safety, as well as its effective and efficient implementation,
- assurance, monitoring, supervision and analysing the financial resources, necessary to ensure the effective and efficient functioning of the food safety management system and the functioning of the enterprise,
- development, implementation and improvement of the system to engage and motivate the staff,
- closer cooperation with suppliers based on the principles of creation of the value for both parties,
- management of intellectual capital and technology of the enterprise, providing an effective and efficient execution of processes,
- analysis of the risks associated with the availability of natural resources and taking actions to reduce the risk, as well as minimise the negative impact of enterprise activities on the environment,
- use of complex methods to assess the organisational management system, a part of food safety management system, such as self-assessment and both internal and external benchmarking.

The PN-EN ISO 9004:2010 standard provides versatile solutions that can be successfully used by companies throughout the food chain in order to obtain the best results and sustainable business success. Each company that wants to achieve tangible benefits of its use shall be translated into concrete, practical actions.

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EFFECTIVENESS OF THE MANAGEMENT SYSTEM IN ACCREDITED LABORATORY AS A TOOL TO ENHANCE COMPETITIVENESS

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Abstract: The situation on the market of laboratory services in Poland is growing rapidly. In order to stay in this difficult market, one shall convince potential customers to his/her competences and quality of services. Testing or calibration laboratories, wishing to assert its position in the market, introduce the management system based on the PN-EN ISO/IEC 17025:2005 standard, the so-called 'General requirements for the competence of testing and calibration laboratories', and then apply for the certificate of accreditation in the Polish Centre for Accreditation (PCA) [14].

In order to maintain accreditation, as well as to maintain a competitive advantage, laboratories must prove that the management system is effective, which is the matter of this article. The first part presents the analysis of concepts on the effectiveness of the quality management systems and their improvement, in particular those set out in the standards of ISO 9000 series, as well as in the ISO/IEC 17025 standard (in the past and present). In the following part one identified and described the PN-EN ISO/IEC 17025:2005 standard on the effectiveness of the management system in the accredited laboratory (including the involvement of top management and quality policy, internal audits, corrective and preventive actions, evaluation of the effectiveness of training, quality control tests). Then one showed how to assess the effectiveness of the management system, which shall or may be used by the accredited laboratory (i.e. internal audit, self-assessment, management review, surveys and financial appraisal).

Key words: accredited laboratory, ISO/IEC 17025, quality management system, effectiveness of the management system.

1 Introduction

In the increasing competitiveness, more and more enterprises look for new ways to gain an advantage on the market and new opportunities for income generation. The management of different types of organisations is generally aware of the need to meet customer expectations, which determine the position of the company among its competitors. In order to develop a competitive advantage and efficient implementation of customer requirements, more and more organisations implement management systems [26]. This also applies to laboratories that play a significant role in the control parameters of raw materials, semi-processed and finished products. Laboratories shall ensure the quality of their work as well as reliable and accurate symbol and study results [12] and for this purpose they implement the management system on the basis of the PN-EN ISO/IEC 17025:2005 standard, specific to this type of activity. On this basis, laboratories shall be accredited to the selected test methods. However, for the system management in the accredited laboratory actually fulfilled its task, it must be, above all – effective. Issues on the effectiveness of the quality management system are discussed most often in the context of the ISO 9000 standards, but they apply equally well to professional management systems, including those implemented in laboratories. Moreover, the PN-EN ISO/IEC 17025:2005 standard itself is based on the principles adopted in the ISO 9001 standard. This means that if the accredited laboratory operates in accordance with the requirements of the EN ISO/IEC 17025 standard, then it simultaneously carries out its testing and calibrations, in accordance with the principles of the quality management system, compliant with the PN-EN ISO 9001 standard (however the accredited laboratory cannot declare that it meets the requirements of the ISO 9001 standard) [21].

Research on the effectiveness and efficiency of the management system in accredited laboratories are becoming more important, because one observes more intense competition in the market for accredited services. Currently, the list of accredited testing laboratories in the Polish Centre for Accreditation, according to the PN-EN ISO/IEC 17025:2005 standard contains over 1160 active laboratories, which shall take improvement actions, aimed at increasing the competitiveness on the market.

The quality management system is particularly useful in business activities, where the motives of the implementation of this system are internal, and the implementation

of the system is treated as a part of the strategy of the company [4]. Furthermore, the very effectiveness of the quality management system is defined as its ability to achieve the objectives contained in the strategy of the organization. Therefore, the objective of this article is to analyse the literature and standards for the interpretation of the effectiveness of the management system and the methods of assessment of the effectiveness of the system in accredited laboratories.

2 Defining the effectiveness of the quality management system

The issue of effectiveness of actions is discussed in many different fields of science, including psychology, praxeology, science of organization and management [27]. It is most widely and most often discussed in the management, namely quality management. In the terms relating to the quality, the PN-EN ISO/IEC 17025:2005 standard refers to the standard glossary of ISO 9000. According to the existing standard of PN-EN ISO 9000:2006, the quality management means 'coordinated activities to direct and control an organization with regard to quality' [18], where the management and supervision, according to A. Hamrol, usually involves the establishment of a quality policy and objectives on the quality, quality planning, quality control, quality assurance and quality improvement [6]. In turn, A. Iwasiewicz defines the purpose, for which the quality management applies, and defines the phenomenon as a process. According to him, 'the quality management process is a series of coordinated actions to enhance, or at least stabilize, the market position of the company' [7].

An inherent element of the quality management is to improve the quality, which is '*part of quality management focused on increasing the ability to fulfil quality requirements*' [18]. The quality management system requires a continual improvement, i.e. '*recurring activity to increase the ability to fulfil requirements*' [18]. They can be described by two main factors, which are:

- effectiveness ('*extent to which planned activities are realized and planned results achieved*' [18]) and
- efficiency ('*relationship between the result achieved and the resources used*' [18]).

Continual improvement is a fundamental principle of the ISO 9001 standard, which is also reflected in the PN-EN ISO/IEC 17025:2005 standard. This concept encompasses all aspects of the organization. Striving after 'perfection' requires time and one shall be aware that this perfection is never reached. Each business, including laboratory, must change and improve all the time, because the environment changes. An excellent system is one that allows you to quickly and effectively respond to the changing environment of the organization and situations that take place within it. Excellent system is the ultimate goal, but in practice it is unattainable. Its perfection really comes from the effectiveness in improvement [27].

Considering the standards of the ISO 9000 series on the quality management system, they refer the issue of the effectiveness to the activities, processes and the quality management system in the organization. The very concept of efficiency has been discussed in previous standards from the 1990s, but only modern editions strongly emphasize the importance of creation of the efficiency in order to continuously develop and improve the quality management system.

The standard glossary in the field of the ISO 8402 standard quality from 1996 devoted very little attention to efficiency. This standard mentioned the efficiency only in the 3.8 point [23], where one defined the quality management as: '*actions taken throughout the organization to increase the effectiveness and efficiency of activities and processes in order to provide added benefits to both the organization and its customers*' [23]. Thus, the effectiveness referred to all activities and processes, and improvement of its level would be the result of the quality improvement. However, the concept of efficiency was not defined [27].

Much more attention was given to the effectiveness of the ISO 9004-1:1996 standard [24], despite the fact that the term itself was used in a very ambiguous manner. On the one hand, the standard presented the need to ensure the effectiveness of achieving the desired goals of the quality; on the other hand the effectiveness was showed as one of the objectives of the quality, for example: uniformity, aesthetics, cycle duration, cost, etc. The adoption of these two approaches of effectiveness resulted in the fact that it could be considered as a measure of itself, which was not logical [27].

The standard also proposes the determination of effectiveness of the quality management system as a result of audit performance. This proposal had its justification in the ISO 10011-1 standard that defines the quality audit as '*systematic and independent examination to determine whether quality activities and related results comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve objectives*' [22]. K. Lisiecka explained the merits of determining the effectiveness of the quality system in the audit process in such a way that if one of the factors in-

spiring the development of the system shall be '*a systemic study of the effectiveness of the activity and accompanying documentation of the production sphere*' [11], then given that the purpose of the audit is to develop a system, the audit shall include an examination of the effectiveness of the system. According to an earlier edition of the ISO 9004 standard, the results of internal audits and the '*total effectiveness in meeting the guidelines of the ISO 9004 standard and the quality policy as well as objectives established by the organization*' [24], were the subject of the assessment at the time of review.

The most important source of information for the verification of an effective quality system was to be accurate records, both operated and maintained. In the standards from 1996, one pointed out two particular groups of activities in respect to which one said about the effectiveness, these included both corrective and preventive actions. Usually, however, these standards presented the information on the effectiveness with the reference to the quality system, and not to activities or processes, and at the same time in the ISO 9001:1996 standard one particularly rarely emphasised the concept on the effectiveness of the use of these matters.

At last in the revised standards of the ISO 9000 series from 2000, one paid more attention to the issue of effectiveness, and what is more, it became one of the key elements of the quality management system assessment. According to the current standard of PN-EN ISO 9000:2006, the effectiveness is defined as the extent to which one implemented the planned activities and achieved the planned results [18]. This standard presents also the definition of effectiveness, which eliminates the possibility of interchange ability of use of these terms.

Amendments to the ISO/IEC 17025 standard, dedicated to laboratories, evolved towards underlining the importance of an effective management system. The ISO/IEC 17025 standard from 1999 did not significantly stressed this issue, but its amendment from 2005 was to ensure its compliance with the ISO 9001:2000 standard, including the scope of the system effectiveness. The main changes, made to the ISO/IEC 17025 standard in 2005, present amendments to the requirements for the management, particularly in order to further enhance the responsibility of top management, the need to demonstrate commitment to the continual improvement of effectiveness of the management system and taking into account an increased focus on customer satisfaction.

The effectiveness can be seen in four dimensions, including [27]:

- organization,
- quality management system,
- process,
- action.

Each of these issues has a different degree of detail. In this connection that the effectiveness itself applies to activities, by analysing the effectiveness of the organization, system or process, each of these structures is a bigger or a smaller group of operations, which cannot be identified individually. The study of the effectiveness evaluates the result of all the activities, included in the organization, system or process [27].

The standards of the ISO 9000 series state that in order for the organization to function effectively, it shall identify and manage numerous, interrelated and mutually interacting processes [18]. It shall therefore follow the recommended process approach, which is a means to achieve the desired results. Ways to continual improvement shall be looked for by the top management of the organization, which will help to achieve better results and avoid potential problems. The condition for the effective functioning of the organization is also the identification of a number of interrelated activities that occur within the processes and their management.

The PN-EN ISO/IEC 17025:2005 standard does not relate directly to the use of the process approach, however, many accredited laboratories accept them in the course of development, implementation and improvement of effectiveness of their management system. By using this approach in an implemented system, one emphasizes the importance of receipt of the results on the operation and effectiveness. The improvement of effectiveness of the management system shall be carried out by the laboratory in a continuous manner, and the top management shall provide evidence of its commitment to its systematic improvement [29].

3 The requirements of the PN-EN ISO/IEC 17025:2005 standard on the effectiveness of the management system

The PN-EN ISO/IEC 17025:2005 standard for accredited laboratories determines the requirements for the development of the system, its implementation, but also the conditions that must be met in order for the competences of the laboratory to be found due to carry out the tests [15]. This standard involves the implementation of the management system that includes quality systems, administrative systems and technical systems for the management of the lab-

Table 1. Management system in the laboratory – activities and evidence of a continuous improvement [26]

Organizational management system	Quality management system	Management system in the technical area
• refers to the top management in the laboratory • assigning the responsibility and authorities for all levels of management • identification of the resources necessary to carry out the duties • processes of communication and communication in relation to the effectiveness of the management system • commitment to continuous improvement • maintenance of the integrity of the management system in the course of the implementation of changes	• declaration of the quality policy and quality objectives • actions taken by the quality manager • use of tools arising from the quality system • obtaining information from customers – both current and future • active involvement: internal audit, management review, preventive and corrective actions • storage of records of the activities carried out	• improvement of effectiveness of the system in relation to: - Personnel, - Resources • support of these activities through other 'components of the management system'

oratory. The PN-EN ISO/IEC 17025:2005 [21] standard has been divided into two parts. The first one contains the requirements for a proper management (Chapter 4), while the second one describes the requirements for technical competence within tests and calibration (Chapter 5). The chapter on the management presents the requirements including, among others: organization, management system, documents and records control, subcontracting of tests and calibration, purchasing services and supplies, customer service and management reviews [15]. If it comes to the technical requirements, one contained those concerning factors that may affect the accuracy and reliability of tests performed, and these include [21]:

- human factors,
- accommodation and environmental conditions,
- test and calibration methods and method validation,
- equipment,
- measurement traceability,
- sampling,
- the handling of test and calibration items.

According to the PN-EN ISO/IEC 17025:2005 standard, the laboratory shall continually improve the effectiveness of its management system, using [21]:

- quality policy,
- quality objectives,
- results of audits,
- results of the analysis of data,
- results of corrective and preventive actions,
- results of the management review.

Table 1 describes the distribution of responsibilities and actions for the improvement of effectiveness of the management system, broken down into systems, including: organizational management, quality management and management in the technical area [26].

The development and a continual improvement of effectiveness of the management system in the laboratory is the responsibility of the top management. The requirements of the PN-EN ISO/IEC 17025:2005 results in the commitment of the top management in this regard. Therefore, the top management shall [21]:

- provide the evidence of its commitment to the development and implementation of the management system and continual improvement of effectiveness of the system,
- inform the organization about the importance of meeting customer demands as well as statutory and regulatory requirements,
- ensure that the integrity of the management system is maintained in the planning, implementation and changes to the management system.

According to the PN-EN ISO/IEC 17025:2005 standard, the laboratory shall document its policies, systems, programs, procedures and instructions to the extent necessary to ensure the quality of test results. One of the main obligations that must be included in the policy statement of the quality of the accredited laboratory is the labora-

tory management statement to continuously improve the effectiveness of the management system. In addition, the top management shall ensure that appropriate processes in the laboratory will be established and that communication takes place regarding the effectiveness of the management system.

Information on the effectiveness of the management system is collected under the internal audits carried out in the laboratory. In order to confirm that the activities of the laboratory shall continue to comply with the requirements of the management system and the PN-EN ISO/IEC 17025:2005 standard, the laboratory shall periodically and in accordance with the program and procedure carry out internal audits of its activities. The internal audit program shall address the elements of the system, including the activities of the study. If the audit results raise doubts about the effectiveness, accuracy or reliability of the results, the laboratory must take corrective actions and notify customers, if it had an impact on the results. In accordance with the requirements of the standard, one shall made records for audited area, findings of the audit and subsequent actions [21].

The effectiveness of the management system implemented in the laboratory is also provided through corrective and preventive actions. In accordance with the requirements of the PN-EN ISO/IEC 17025:2005 standard, the laboratory shall establish a procedure and give the power to implement corrective actions in the case of nonconforming work or deviations from policies and procedures in the system of management or technical activities. The procedure for corrective actions shall start with determination of the root cause of the problem, and corrective actions shall be adapted to the size of the problem and the associated risk. In further activities, the laboratory shall [21]:

- monitor the results of corrective actions in order to determine their effectiveness,
- ensure that appropriate areas of activity will be subject to an additional audit if the identified non-compliances or deviations justify doubts as to whether the proceedings are compliant with the policies and laboratory procedures,
- perform additional audit in order to confirm the effectiveness of corrective actions (if it is warranted – for example, when one found a serious problem or the interest of the laboratory is in danger).

On the other hand, with regard to preventive measures, in accordance with the PN-EN ISO/IEC 17025:2005 standard, the laboratory shall [21]:

- determine the necessary improvements and potential sources of non-compliance, both technical and on the management system,
- develop, implement and monitor action plans in order to reduce the likelihood of such non-compliances and take advantage of opportunities for improvement.

Procedures for preventive actions shall include the initiation of activities and use of surveillance in order to ensure their effectiveness.

Furthermore, in order to continuously improve the effectiveness of the management system in the laboratory and meet the requirements of customers as well as their satisfaction, the laboratory shall determine and provide the necessary resources, in particular financial ones, which shall be planned, shared and monitored by the management. The issue of effectiveness is often considered in conjunction with human resources. In the PN-EN ISO/IEC 17025:2005 standard, one recommends to perform the tasks by the personnel qualified on the basis of appropriate education, training, experience and /or demonstrated skills. The laboratory management shall ensure the competence of anyone, who [21]:

- operate specific equipment,
- perform tests,
- evaluate the results,
- sign test reports.

Assurance of competences is promoted by further education and training of employees, which shall be assessed in terms of impact on the effectiveness and efficiency of laboratory activities. Therefore, the laboratory management shall formulate objectives for education, training and skills of the laboratory personnel, and training programs shall be targeted to current and anticipated tasks of the laboratory [21]. The PN-EN ISO/IEC 17025:2005 standard presents the requirements for the laboratory to evaluate the effectiveness of activities concerning training, and to determine the personnel competences, independently of the kind of employment. Emphasizing a human factor in the standard is the most understandable, because both deliberate and conscious actions of employees to the greatest extent shape the processes and quality management systems.

The confirmation of effectiveness of the management system in the accredited laboratory is mostly determined by the results of monitoring the validity of tests and calibrations undertaken. In accordance with the PN-EN ISO/IEC 17025:2005 standard, the laboratory shall have quality control procedures just in order to be able to monitor the validity of the study. In addition, the data obtained in the

monitoring process shall be saved so that it is possible to track their changes. One of the key elements of monitoring of the quality of laboratory operations are proficiency testing. They are fundamental tools for external quality control tests performed in the laboratory as well as an objective and independent verification of the results. Proficiency testing is defined as '*evaluation of participant performance against pre-established criteria by means of inter-laboratory comparisons*' [3]. The main feature of proficiency testing is that they include a comparison of the results obtained by one laboratory, with the results obtained by other laboratories involved in the program [12]. The results can be used for self-assessment of the laboratory, presentation to customers or other interested parties, i.e.: accredited bodies, as an independent proof of the quality of the results obtained in the laboratory, which can also be translated into the management system effectiveness. Participation in proficiency testing programs and analysis of the results perfectly complements internal quality control procedures in the laboratory, by providing an external, competent assessment of laboratory testing opportunities [12].

The statement whether the management system implemented in the laboratory is appropriate, adequate and effective is the goal of management reviews. The PN-EN ISO/IEC 17025:2005 standard presents the requirements concerning the top management to carry out their view of the management system and testing activities [21]:

- periodically (usually every 12 months),
- according to a predetermined schedule and procedure,
- in order to ensure a continued responsibility and effectiveness of activities,

And the input data to the management review shall include [21]:

- the suitability of policies and procedures,
- reports of managerial and supervisory personnel,
- the outcome of recent internal audits,
- corrective and preventive actions,
- assessments by external bodied,
- the results of inter-laboratory comparisons or proficiency tests,
- changes in the volume and type of the work,
- customer feedback,
- complaints,
- recommendations for improvement,
- other relevant factors, such as quality control activities, resources and staff training.

In addition, the PN-EN ISO/IEC 17025:2005 standard contains the requirement for storing and maintaining the records of the reviews and subsequent actions and assurance by the management that those actions were carried out in appropriate and agreed terms [21].

4 Methods for assessing the effectiveness of the management system

The effectiveness that is created in the process of continual improvement of the management system shall be evaluated on a regular basis, which is one of the tasks of the top management of the laboratory. Basing on the standards of ISO 9000 series and the ISO/IEC 17025 standard, one may determine the following methods to assess the effectiveness of an implemented quality management system [27]:

- internal audit,
- self-assessment,
- management review,
- surveys,
- financial appraisal.

Internal audit is considered essential and best way to carry out the study and evaluate the effectiveness of the quality management system. The current term for audit, included in the PN-EN ISO 19011:2012 standard, is defined as '*systematic, independent and documented process for obtaining audit evidences and evaluating it objectively to determine the extent to which the audit criteria are fulfilled*' [17]. The standard defines an audit as a process. Its main objective is to obtain audit evidence (records), and thus the confirmation of existing facts or other information, as suggested by the point 3.3. of the ISO 19011, concerning the evidence of conducted audit. Only after the assessment of the evidence, the definition suggests the fulfilment of the quality criteria, which are in accordance with the point 3.2 – i.e. procedures, quality policy and requirements. They provide information about the effectiveness and condition of the implemented quality management system [27].

Auditing enables the identification of the effectiveness of the actions taken in the laboratory, but just like any other method it has some drawbacks that can affect the image of the implemented system. In this case, one shall also look for other alternative methods for testing and evaluating the effectiveness of the management system, which will be both – objective and independent in the course of auditing.

R. Barcik draws attention to some shortcomings that accompany the auditing, i.e. [1, 27]:

- sense of observation is an essential tool for auditors,
- the whole process of auditing depends on the first impression of the auditor,
- auditor's work is largely based on feelings,
- auditor draws a lot of attention to the order which prevails in the workplace, order or its lack to a large extent shape the attitude of the auditor,
- if the auditor is an employee of downstream and audited person takes a higher or managerial position, then the audited one tries to outrun such an employee,
- rigid adherence to the content of documents is a common abnormality, the auditor who obtains answers in the form of formal quotations.

Alternative thought is introduced by the authors of another book, edited by R. Leist, who argue that '*in the course of auditing the system, the study is not subject to the person, but the effectiveness of the system*' [10], hence the '*people satisfied with the fact that well-known weak points have not been identified during the audit, prove not a weakness, but a lack of self-motivation, which threatens the future of the company, in which they work*' [10].The authors recognize the passive attitude of audited people, which is due to the caution and very limited sincerity of the personnel involved in the process [27]. The laboratory management must pay particular attention to the creation of such a working environment in order to eliminate such hazards.

Self-assessment is one of the methods of evaluating the effectiveness of the system, and the information resulting from the self-assessment on the results of the organization can be used for an efficient and effective management, as well as a systematic and continuous improvement. One of the existing models of self-assessment is a model recommended in the course of the latest edition of the ISO 9004:2009 standard (the PN-EN ISO 9004:2010 standard). The self-assessment can be a basis for any action taken by any organization, regardless of its corporate purpose, size or structure. It is the basis for planning and monitoring of strategies, policies, implementing all the tools for the use of resources [2]. It may also be used by accredited laboratories that have implemented a management system in accordance with the PN-EN ISO/IEC 17025:2005 standard. Organizations, including accredited laboratories, can use this tool to determine their strengths and weaknesses. The biggest advantage of self-assessment is both – simplicity and ease in use. Unfortunately, on the other hand, its disadvantage is determination of the effectiveness on a very general level. Although the self-assessment method is pretty much promoted in the standards of the process approach, it is not aimed at assessing the effectiveness of the processes identified in the system, but the evaluation of the effectiveness of the implementation of various points of the standard. The use of a very simple method of assessment by the employees, i.e. the five-point scale, frequently used in the assessment of all issues, can cause the formation of the risk of 'score syndrome', which is characterized by the fact that the emphasis may be placed on highlighting the strengths and hiding the weaknesses. It leads to the weakening of objectivity and accuracy assessment of the system [27, 28].

Another method to assess the effectiveness of the quality management system is a management review. The concept of review is defined as '*activity undertaken to determine the suitability, adequacy and effectiveness of the subject matter to achieve established objectives*' [18]. The top management is responsible for conducting management reviews at planned intervals and their documentation. Management review is a secondary method in comparison with an internal audit and self-assessment, because in order to evaluate the effectiveness of the system it uses the results collected in the course of the latter [20]. Therefore, this method can be considered as the one for the verification of effectiveness of the management system in the laboratory made during the audit or self-assessment, especially since all the other input data to the review may be input data to the two methods described previously [27]. It is important that the data for the review management was credible. Traditionally, the preparation and review is the responsibility of the representative for quality (in the PN-EN ISO/IEC 17025:2005 standard, referred to as the manager for quality) in consultation with the management of the laboratory. He establishes the topics under review – all those that require the preparation by the management system, and other relevant for the laboratory. On the basis of arrangements made in the course of review, one shall draw up plans for goals and tasks for the next period [13]. Within the reviews, the management shall evaluate not only the degree of achievement of the specific objectives of quality, but also the regularity of their definition [16].

The next method that can evaluate the effectiveness of the management system is *surveying*. It allows the assessment of effectiveness of the management system in the laboratory, from the point of view of all stakeholders, including customers. According to the PN-EN ISO/IEC 17025:2005 standard, the laboratory shall obtain feedback from customers (both positive and negative) in order to [21]:

- improve its management system,
- perform testing activities,

- provide customer service.

Then, if the laboratory chooses the method of surveying in obtaining feedback from customers and stakeholders, it needs to narrow it to evaluate the effectiveness of actions or processes covered by the system, because none of the parties involved almost never sees directly the management system, and can only apply for its effectiveness on the basis on the performance of activities and processes implemented to this party. The customer of the laboratory may be unhappy because of improperly prepared test reports or delays in the delivery of results, while subcontractors of the laboratory may express dissatisfaction with insufficiently detailed information on the conditions of test performance, etc. The only restriction and disadvantage of this method is to obtain subjective opinions of various stakeholders. In order to obtain a more accurate assessment of effectiveness of the activities performed in the management system, and, consequently, the effectiveness of the processes and the system itself, it is possible to employ also other test methods, which are used for example in marketing research [8]. In the course of such studies, it is recommended to use the greatest possible amount of information sources [27].

The effectiveness *in financial terms* is another method that can be used in the laboratory, through the conversion of data from the processes into information on finances [20]. The financial appraisal is offered in the PN-EN ISO 9004:2010 standard, and in the PN-EN ISO/IEC 17025:2005 standard these issues are not dealt with. Implementation of the financial appraisal is important and can be justified as a result of the process of finding a comparable measure for different processes in the management system, however, it is difficult to agree with the statement that the mere fact of the implementation of such a procedure will allow not only the increase of effectiveness of the entire system, but the entire organization, which is suggested by the ISO 9004 standard [8]. The proposed method of expressing the effectiveness is quite controversial. For example, Robert Kaplan explicitly states that the application of methods to assess the performance of organizations, based solely on financial measures, is the limit. He stresses the need to use measures that relate to the time, the quality or the performance [9]. Also M. Hammer, discussing ways to measure the processes, in addition to financial measures, mentions also measures related to the time, the accuracy, the use of property, emphasizing, that they do not limit the list of possible applications. The use of only the financial measures would in effect result in the determination of efficiency of the quality management system in the enterprise [5, 27].

Each test and evaluation of the effectiveness of the management system in the laboratory must be preceded by a collection of the relevant data on its actual state. Not all of these data may be obtained through surveys or through interviews with customers or other stakeholders. A valuable source of information, and, consequently the information on effectiveness of the management system, is the system documentation and records. This opinion is confirmed by standards, where it is said that the use of documentation helps to evaluate the effectiveness and continuing suitability of the system, and the goal to establish and maintain records is to provide evidence of compliance with the requirements and proof for the effectiveness of the system operation [27]. According to the standards, both documentation and records are not only a source of data on the effectiveness of processes and activities. Their use is to support the effective operation of processes in the laboratory, including the assurance of effective planning, conduct and monitoring of its processes [19].

5 Summary

Development of the enterprise is inseparably connected with the necessity of constant changes, resulting primarily from the need to keep up with the competition, adaptation to the expectations of the market and the introduction of new technologies and methods. There is therefore a need to effectively manage these changes, while maintaining the stability of the organization's business processes [25]. The development of a laboratory depends on the proper choice of management. In recent years, a way to prove the competence of laboratories involved in testing, measurement and calibration is functioning in the management system, in accordance with the PN-EN ISO/IEC 17025:2005 standard and on this basis to obtain accreditation, being awarded by the Polish Centre for Accreditation. One of the requirements of the standard is a continual improvement of the effectiveness of the management system. Therefore, the top management and employees of the laboratory must take steps in order to ensure the effectiveness and prove it. Evidence of laboratory competence and effectiveness of the management system are primarily the results of audits, management reviews, proficiency testing, as well as the recognition and trust from customers. However, in order to improve the effectiveness of their management systems, laboratories shall go beyond the requirements of the PN-EN ISO/IEC 17025:2005 standard and make use of a wide range of

supporting standards of the quality management, as well as use various methods to improve and properly assess the effectiveness of their management system. Laboratories often focus on typically technical areas, which is understandable, but it is equally important to focus on the elements, coming typically from the management.

If the laboratory will continue to grow, and the management system will be effective, this would equate to the proper execution of tasks, obtaining reliable results and meeting customer requirements, but also to a quick response to changes in the laboratory, and thus may affect the competitiveness of the laboratory in the market of accredited laboratories.

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