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A new virtual team competence defining model

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Virtual team members need to acquire specific competencies to ensure team success. In line with this, by establishing standards for selection the virtual team members can provide their successful performance that achieves organisational goals. The article focuses on a variety of factors that affect the professional competencies in virtual teams. It also suggests models for measuring such competencies. The authors also present an example of how the model may be applied. Namely, in case study this article focuses upon the capacities of a virtual organisation to form the project team the members of which will come from a virtual university, on the basis of knowledge and collaboration. Conclusion and recommendation are made for further research and improvements in this area.

Keywords: virtual organisations; virtual university; virtual teams; competencies; fuzzy logic model

JEL classification: L22, I2, J23, J24, D8

1. Introduction

In the conditions of a tremendous industrial advance in information and communication technologies today and in the full swing of the world economic crisis, the chances of industry and universities to survive are rather thin unless they undergo necessary changes. These changes are reflected in the interconnection of the social environment, universities and industry, which is a precondition for building a knowledge-based economy.

The most competent people to help conduct research and development processes can be found at virtual universities. The role itself of a virtual university, apart from the educative role it plays in a modern society, is seen in the cooperation with virtual organisations. A detailed analysis of the modalities of cooperation between the university and the company, as well as their effect on both the company and the university is presented in the article (Talaba, 2007). Earlier analyses of the modalities of cooperation between the university and the companies were mostly focused upon patenting, licencing and forming incubator firms; however, it was proved that the role of such modalities in the cooperation between the university and the industry is of minor value in comparison with collaboration on publishing, organising conferences and informal interactions in the domain of working together on projects.

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Virtual companies that develop their activities on a global level function through virtual teams as a most common form of virtual collaboration (Grimshaw & Kwok, 1998; Klein, 1994). An ever higher speed at which virtual companies increase their production brings forth an additional demand to access the knowledge resources of virtual universities (Badrinarayanan & Arnett, 2008; Fuller, Hardin, & Davison, 2006; Samarah, Paul, & Tadisina, 2007).

This article focuses upon the capacities of a virtual organisation to form the project team the members of which will come from a virtual university, on the basis of knowledge and collaboration. The scope of modelling will be defined for the purpose of learning how to put together a project team the members of which will satisfy the key elements of the project.

2. Theoretical background

2.1. The notion of virtual organisations

Ever since the concept of virtual organisations emerged in 1960s, a large number of studies have been carried out to explore the organisational business processes and the methods of their execution. Generally speaking, every member of a virtual organisation contributes with their core competencies. One who initiates a virtual organisation's forming determines the most appropriate business processes complementary with the business skills of various firms. The synergy effect resulting from the combination of all the core competencies allows for setting up a company that will satisfy the clients' requirements in a flexible manner, and this can be achieved by forming the best possible business team, based on the following principles:

(a) On the basis of independent company networks (Scholz, 1997)
(b) On the basis of one identity (Aken, Hop, & Post, 1998)
(c) On information technologies (Byrne, 1993; Davidow & Malone, 1992; Mowshowitz A., 1994)
(d) On the absence of hierarchy (Bultje & Van Wijk, 1998; Malone & Rockart, 1993; Sieber & Griese, 1998)
(e) On the basis of the differences between the strategy and the operations levels (Mowshowitz, 1999).

The very definition of virtual organisations, however, is not completely worked out. The variety of terms and certain definitions that take into account different aspects of virtual organisations stemmed from different starting points (Barnett, Presley, & Johnson, 1994; Camarinha-Matos & Afsarmanesh, 2003; Gou, Huang, Liu, & Li, 2003).

The analysis of literature published so far has lead to a conclusion that a virtual organisation is generally defined on the basis of the following keywords:

- Collaboration and complementarity
- Networked or distributed organisation
- Temporary organisation
- Infrastructure supporting interoperability.

Based on the above listed characteristics of virtual organisations a definition of virtual organisation will be formed. Namely, virtual companies are, in our opinion,

temporary organisations that continually develop, are redefined and renovated for a practical business purpose and in accordance with the business needs adjusted to the market demand. They create networks with other virtual companies, depending on the competences of their virtual teams, thus forming a business chain. It is in this framework that teams of employees work together making use of the ICT.

2.2. Virtual teams

As a result of technological advances, companies are compelled to seek out innovative ways to adopt and incorporate virtual teams. In his work (Olli-Pekka, Rajala, & Jyrämä, 2011) maintains that the knowledge the virtual teams use is the knowledge owned by the team members. Using the knowledge of a virtual team increases the number of individuals accountable in the knowledge sharing process, thus creating a broad organisational network. In other words, virtual organisations can improve their internal knowledge sharing through forming virtual teams whose explicit task is to share knowledge and persuade other employees to follow their example. It is important to note that the formal knowledge of the whole team ensures organisational strength and legitimate both on the team level and on the individual level.

2.2.1. Complexity of assembling project teams

When assembling a team, special attention is paid to its structure. The structure itself should be such that the skills, competencies and character traits of team members are complementary. Teams with the same or similar profiles of experts have not proved to be efficient in practice. Besides, practice imposes that, apart from skill and work experience, the criteria for team member selection should include the member character traits. The traits such as vigour, persistence, perseverance, tactfulness, ability to cope, loyalty to the firm are the preconditions of the team success, in as much as it is the skills and the expertise of the team members (CPM, 2005).

2.3. Virtual university

The notion of virtual university has a broad meaning, one that includes students' physical presence at the university, the availability of computers, a measure of support of non-teaching staff, reduced infrastructure and the requirements that curricula should be divided into modules for the purpose of higher flexibility (Bacsich, 2004). A large number of works are based on improving the electronic platform for education. A smaller number of authors, however, focus upon business processes within a virtual university.

2.4. Competencies

Organisations are increasingly turning to global virtual teams in order to find a new ways of gaining competitive advantage. With the growing deployment of such teams, it is becoming more important for organisations to understand what makes them successful (Msod, 2008).

Competency is the capability of an individual verified by a written document and stating the fact that this individual is capable of doing a certain job. It is important to point out that, in the course of his/her education, the individual develops his/her competence in accordance with the standards set for that job (Radović Marković, 2011).

A large number of competencies can be grouped into two classes:

- Competencies that can be successfully implemented in a large number of different tasks (general competencies)
- Knowledge, skills or strategies adequate to the organisation that is specific and requires that one adapts in a specific manner.

Competencies are the measurable knowledge, skills, abilities, and behaviours (KSABs) critical to successful job performance (Hill, McGonigle, Hunter, Sipes, & Hebda, 2014).

(Allen & Velden, 2005) Created a special methodology on the basis of which the highly educated personnel are expected to develop at least five areas of general competencies (Radovic-Markovic & Markovic, 2014):

(1) Professional expertise: the highly educated are expected to be experts in their professional areas;
(2) Functional flexibility: it is understood that highly educated personnel have to be able to respond to new challenges and promptly capture new knowledge;
(3) Innovation and knowledge management: apart from being able to perform their tasks effectively, the highly educated are expected to create an environment in which innovation management will be knowledge-based;
(4) Human resource mobilisation: the highly educated are expected to mobilise all available human resources and guide them in a desired direction;
(5) International orientation: highly educated persons are expected to be strongly inter-oriented, given the globalisation processes.

2.5. Social network analysis

The organisational analysis approach is used in this article to specify the requirements, the SNetCol method which is essentially based on the implementation of the social network analysis methodology. This analysis is extensively applied in cases of collaboration and networking, given that its starting point are the criteria that define the 'best' collaboration practices. It allows for the assessment of collaboration in the organisation, provides information on informal organisational structure that co-exists with the formal one and has an important role in the information and knowledge sharing. It also helps find out who collaborates efficiently with whom within the organisation in that it identifies weak points and strong points in the collaboration within the institution and classify them in terms of importance of the requirements for an integral system of information management, which in turn results in significant improvement in the information management and sharing processes (Pereira & Soares, 2007).

3. Methodology

This article, unlike most, is different in terms of methodology. It focuses on individual competencies, whereas the literature dealing with more social networks. The reason for this is the fact that it is generally neglected personal competence, which is of great importance in the selection and formation of virtual teams. Accordingly, in defining formula to calculate the personal competencies, we have taken into account various factors that are important for its measurement.

4. Components of employee knowledge

As mentioned in the article (Hyeongon, Seungjin, & Mooyoung, 2011), there are three basic components in the knowledge management principle and these are: (1) Know what is necessary; (2) Know how to apply that; and (3) Know who is capable of applying, i.e. who is closely acquainted with the problem. We used Fuzzy logic model because it is conceptually easy to understand, flexible and tolerant of imprecise data. The proposed model offers a ranking list of most competent persons. Since the project manager has to display the traits of a leader and the ability to recruit competent collaborators in forming a virtual team, it is necessary that he/she should establish their competencies.

On the basis of the above mentioned knowledge management principles, the competency of the virtual team members is mathematically established in equation (1)

$$\begin{aligned}\text{Knowledge Competence (KC)} = {} & \text{Personal Competence (PC)} \\ & + \text{Collaboration Competency (CC)}\end{aligned} \tag{1}$$

where KC is the aggregate competency of each individual team member that a project requires in terms of keywords; PC is the personal competence defined on the basis of already published works; CC is the aggregate collaboration coefficient of each individual member as result of authorship in publications (Radovic Markovic, Baltezarevic, Baltezarevic, & Markovic, 2014).

4.1. Establishing personal competence model in virtual teams

Competency modelling is the activity of determining the specific competencies that are characteristic of high performance and success in a given project. It can be applied to a variety of human resource activities (LaRocca, 2013). In this article we used the fuzzy system of deduction to assess personal competence coefficient. Personal competence and knowledge of the staff cannot be expressed as exact numerical values, as this implies ambiguity and complexity. The fuzzy logic is a concept that can be used to bridge the gap between human reasoning and computer logic (Ross, 2010; Schmidt, Steele, Dillon, & Chang, 2007).

In this research we used the neural theory network system of deduction to assess personal competence coefficient. Neural networks simulate the operation of the human brain while performing a given task or function. A neural network is a massively parallelised distributed processor with a natural ability to store experiential knowledge and of ensuring its use. Artificial neural networks resemble the human brain in two respects:

(1) Neural network covers the knowledge through the training process
(2) Weights among neural connections (strength of synaptic connections) are used to store knowledge.

The procedure for performing the training process is called a training algorithm. Through this process the algorithmic (systematic) way of changing the synaptic weights in order to achieve desired network performance (Rojas, 1996).

4.1.1. Neural model

The model neuron is composed of three basic elements: 1

(a) The set of synaptic weights $\{w_{ij}\}$. Positive Excitatory synaptic weights corresponding to connections, and the negative inhibitor.
(b) Adder (linear combiner) – formed by weighting the sum of inputs
(c) Activation functions – limits the amplitude of the output neurons. Typically it takes the output of the normalisation interval [0, 1] or [-1, 1]

The equations in Figure 1 are:

$$u_k = \sum_{j=1}^{m} w_{k,j} x_j \tag{2}$$

$$y_k = a(u_k - \theta_k) \tag{3}$$

A greater number of neurons connecting to the neural network by making various types of single and multi-layer network architecture (Figure 2).

The most important features of neural networks are:

- The non-linearity, which is fundamentally distributed.
- Input-output mapping, which can restore your through the process of training
- Contextual information. Each neuron in the neural network was influenced by the global activity of other neurons. Therefore, the contextual information naturally inherent to these structures.

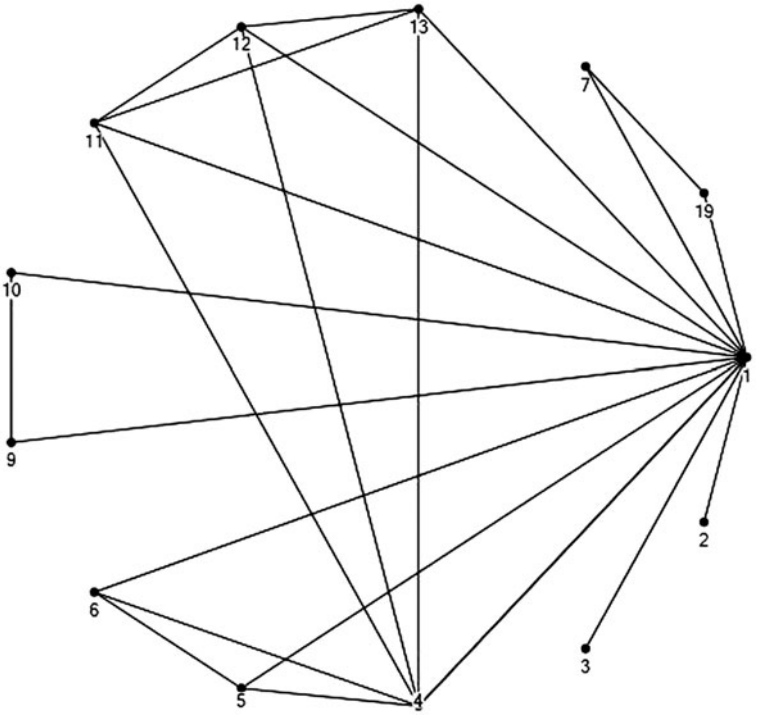
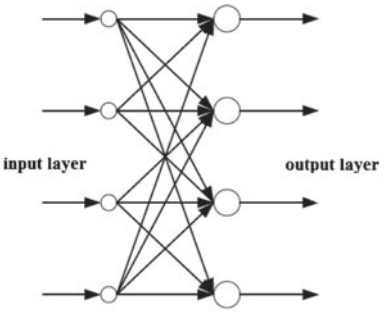
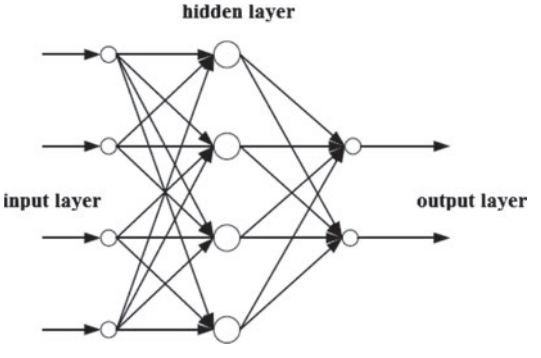


Figure 1. The network diagram of employees (Radovic Markovic et al., 2014).



(a) Feed forward single layer neural network



(b) Feed forward multi-layer neural network

Figure 2. Network architecture.
Source: Created by the authors.

Based on the analogy of neural networks in the field of knowledge transfer between the author references, achieved the formation of a network of associates with appropriate mutual influence. Defining the value of completely knowledgeable means increasing personal knowledge through a network of associates equation 4, which is analogous to equation 2.

$$\mathrm{CK}_i = \sum_{m=1}^{N} \mathrm{CK}_{i,m} \tag{4}$$

$$\mathrm{CK}_{i,m} = \mathrm{PK}_{i,m} + \mathrm{SNK}_{i,m} = \mathrm{PK}_{i,m} + \sum_{j=1}^{N} w_{i,j} * \mathrm{CK}_{j,m} \tag{5}$$

where:

$\mathrm{CK_{i,m}}$ – Completely knowledgeable person *i* for *m* keyword combination for 1 to N

$\mathrm{PK_{i,m}}$ – Personal competence coefficient of *i* member for keyword *m*

$\mathrm{SNK_{i,m}}$ – Social networks knowledge of *i* member for keyword *m*

$w_{i,j}$ – weight factor which is derived by entering the number of coauthorships between two persons

j – Is co-author on publications.

Personal competence is defined on the basis of individual employees' published works having in mind the congruity of keywords in publications and the keywords on

the projects in the last five years. Practice has shown that the reference search by the title is not efficient since there is a probability that the title does not contain the keywords searched for. The search through the whole text of the publication does not yield the desired results either. Hence we decided upon the search by the keywords from the references that researchers entered into the database of the virtual university.

The significance will be valued by the project financier, following the principle of adding the weight factor for each type of publication he finds relevant. In case of scientific research projects, of greater significance are such publications as an article published in a journal of top international importance and a paper in an international journal or a monograph of international importance, while virtual companies may find patents or project reports more important. The values of weight ratios V_k may range from 1 to 10 for important publications and the value 0 for those not important for the project sponsor.

Calculating personal knowledge for each person whose references satisfy certain keywords is defined in equation (6):

$$\mathrm{PK}_{i,m} = \sum_{k=1}^{N} \mathrm{PK}_{i,m,k} * V_k \tag{6}$$

where $\mathrm{PK}_{i,m}$ is the personal knowledge coefficient of i member for keyword m, k is the type of publication for this keyword for $k = 1...N$, V_k is the weight ratio for an individual relevant type of publication.

4.2. Collaboration competency

When the references of employees at the virtual university, of authors and co-authors of papers are entered, a network of collaborators is created. The nodes in this network represent individual collaborators and their interrelation is presented by the papers they collaborated on. Such a network is one to which a social network analysis can be applied, and this analysis includes several major indicators of the quality of the network and its individual nodes (in this case, collaborators). The main communication social network analaysis measures among the members of a virtual team are the density of the global network as well as the density of each group, whereas coordination measures are the degree centrality, closeness centrality and betweenness centrality. The interpretation of these measures is as follows: degree centrality – how many people this person can reach directly; closeness centrality – how fast this person can reach everyone in the network and betweenness centrality – how likely this person is to be the most direct route between two people in the network. Communication measures indicate the intensity of overall team communication, so they are not appropriate as criteria for selecting a project manager; the coordination measures, however, are useful for selecting a project manager. High coordination measure means high liability to have access to any information or knowledge available in a network of team members, so if we select a competent project manager in favour of high values of degree centrality and closeness centrality, it is possible to improve the project performance (Pereira & Soares, 2007).

$$\mathrm{KC}_i = \mathrm{PC}_i + (\mathit{degree\ centrality}_i + \mathit{betweenness\ centrality}_i + \mathit{closeness\ centrality}_i) \tag{7}$$

The person that gets the maximum weighted average of knowledge competence score, degree centrality and closeness centrality should be appointed project manager, equation 4:

$$\text{Max}\left\{\text{PC}_i + (\textit{degree centrality}_i + \textit{betweenness centrality}_i + \textit{closeness centrality}_i)\right\} \quad (8)$$

The knowledge competence of a whole virtual team would be equal to the sum of all the members that satisfy the previously listed criteria: equation 5:

$$\text{KC} = \sum_{i=1}^{P} \text{KC}_i \quad (9)$$

i = team member for $i = 1...P$

On the basis of the previous analysis of the team members and the team leader selection a prototype was designed using the programming language VC#, SQL Server 2008 OLAP, XFuzzy 3.0, as well as NodeXL. The XFuzzy 3.0 modelling tool for fuzzy model is used to model a fuzzy system of deduction for the assessment of personal competence coefficient and includes a possibility to generate a code to be used as an external function in the SQL Server 2008. The entire computing of personal competence is performed within a server and the final result is presented in OLAP. The VC# was used to enter keywords and weight ratios of individual publications, while NodeXL was used to compute the component of collaboration competency. To test the model, references of 23 authors and 143 publications of various types were entered.

5. An example of how the method may be applied

This example contains the definitions of keywords that come out of the definition of the project subject for which the virtual team members are obligated to be competent (Table 1).

The search of publications starts upon creating a number of keyword combinations, and the result has to satisfy the AND criterion Integrated search results are presented in Table 2.

The year of publication and the number of authors are entered into the fuzzyfy and the fuzzy model output values are obtained. In case all types of publications display equal weight factors for the project under consideration (in our example, the factor determined by the project sponsors themselves is the value 10), it must be noted that by varying this weight factor, different values of personal competence and prospective team members are obtained (Table 3).

Table 3 shows that the employee with the maximum competence is Employee 1 with a total score of $\text{KC}_1 = 86.46393$. When all the employees from Table 3 are admitted into a virtual team, the competency of the virtual team is obtained KC=148.79381.

Table 1. Project keywords.

Project keywords	New economy, economic lessons integration

Source: Radovic-Markovic & Markovic, 2014.

Table 2. Search results by keywords.

Type of publication	Year of publication	Publication	Keywords	Authors
International book	2011	1	Management, Management dynamics, Managerial functions, Corporate policy, New economy, Management	Employee 1 Employee 2
The paper in the Proceedings of an international character	2011	2	Economic integration, European Union – Polish economic integration	Employee 1 Employee 3
Editing thematic collections	2011	7	European Union, Serbia, New member states, Economic lessons	Employee 1 Employee 4 Employee 5 Employee 6
International book	2007	15	Entrepreneurs, New economy, E-business, E-entrepreneurs, Globalisation	Employee 1
National importance monograph	2007	19	New economy, Leadership, Managers and leader in new economy	Employee 1 Employee 9 Employee 10
International journal article	2007	28	New Economy, Small business organisations	Employee 1
Editing the international monographs	2009	29	New economy	Employee 1 Employee 4 Employee 11 Employee 12 Employee 13
Monographic study	2009	34	New economy, Women's Entrepreneurship, Entrepreneurship in Serbia	Employee 1 Employee 7 Employee 19

Source: Radovic-Markovic & Markovic, 2014.

Table 3. Knowledge competence.

Personal knowledge		Collaboration competency		
Employee	PK_i	Degree centrality $_i$	Betweenness centrality $_i$	Closeness centrality $_i$
Employee 1	22.38093	12	52	0.083
Employee 2	4.28571	1	0	0.043
Employee 3	4.28571	1	0	0.043
Employee 4	2.85714	6	3	0.056
Employee 5	1.90476	3	0	0.048
Employee 6	1.90476	3	0	0.048
Employee 7	1.90476	2	0	0.045
Employee 9	1.42857	2	0	0.045
Employee 10	1.42857	2	0	0.045
Employee 11	.95238	4	0	0.050
Employee 12	.95238	4	0	0.050
Employee 13	.95238	4	0	0.050
Employee 19	1.90476	2	0	0.045

Source: Radovic-Markovic & Markovic, 2014.

6. Conclusion

The proposed model offers a ranking list of most competent persons. Since the project manager has to display the traits of a leader and the ability to recruit competent collaborators in forming a virtual team, it is necessary that he/she should meausure their competencies.

Our case study showed that a candidate knowledge assessment (within a broader evaluation of their independent work concerning personal competence) as well as that of time relevance of publications in a quantitative domain was performed using the fuzzy model. These quantitative ratings helped us assess candidates for projects in a more unbiased manner. The novelty is also that the project financiers themselves can value the types of publications according to the criterion they favour. The rating of collaboration competency within the social network helps obtain a more objective assessment in selecting prospective team members with a high degree of knowledge and cooperability. The employee with maximum knowledge required for the project, one that can ensure a high degree of collaboration through a social network is appointed project manager. On the basis of these results a competent virtual team can be assembled, capable of effectively solving the tasks set before them. Best practices include ensuring a linkage between the competency initiative and the organisational strategy, focusing on integrating competencies with all HR processes.

At last, we expect that our methodology will be implemented in practice. It can be implemented by prospective project financiers, research institutes, ministries and others. In addition to formulating the original model, the authors propose that a database of experts should be formed on the basis of the keywords from their publications. However, it should be also a good basis for further improvements in this area.

Disclosure statement

No potential conflict of interest was reported by the authors.

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