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AN OUTLINED APPROACH TO CREATING KNOWLEDGE MANAGEMENT SYSTEMS IN SOFTWARE DEVELOPING ORGANIZATIONS WITH REGARD TO THE QUALITY MANAGEMENT SYSTEM

Introduction

In numerous researchers' opinion, the current stage of the civilization development can be defined as information society. The information society development is principally determined by utilization of information and knowledge as combined with various communication and information techniques. It seems that for the information society, Software Producing Organizations (SDO) are of fundamental importance. We propose to define these organizations as the ones that participate in all stages of the software life cycle or only in selected ones. By way of example: in case of the life cycle defined as the "V-model", such stages will be: user requirements definition, software related requirements definition, architectural design, detailed design, coding, module testing, integration testing, whole system testing, user acceptance testing [Dąbrowski, Subieta, 2005]. The SDO is frequently treated as an almost perfect example of a knowledge-based organization [Fazlagić, 2005] since the results of its activities (software and software related services) are knowledge-based products. Hence the necessity occurs to create a Knowledge Management System (KMS) in such an organization.

The important status of the SDO seems to result from the following factors:

a) the importance of efficient software for proper functioning of the information society; it results in the SDO's continuous drive for production of software that fulfils the customer's requirements (good quality) and does not contain any significant errors (i.e. the ones that preclude exploitation),

b) a strict relation between an effective KMS in the SDO and the quality of the software delivered as required by customers.

Bearing in mind the above, it seems that the following thesis should be proposed: it is necessary to undertake activities aimed at establishing a KMS in the SDO, while taking into consideration the QMS. The thesis is justifiable, the more so as there are few publications on this subject in the Polish literature (the Google search engine has returned 159 documents on inputting the following search term "knowledge management system in a software producing organization", and upon a careful reviewing – verification – only 9 remained).

The outlined approach presented in the paper is an attempt to prepare a research aimed at employing the attainment of quality management system to construction of knowledge management systems in software developing organizations. The research in all likelihood has the uniqueness value which can be proved by the presented below studies in the broadly conceived subject area of knowledge management and knowledge management systems. Some of them have been described in short below. They refer to the information technology branch in the scope of e.g. software development in an organization, application of information technologies in the course of implementation of virtual projects, relations between raising knowledge by the employee, sharing knowledge with the group, raising the effectiveness of the organization's operations.

The examples given are not an exhaustive presentation of all the works undertaken in this area. The description is not complete; its aim is only to demonstrate how diverse studies are undertaken and brought to an end, for instance through making public their results. The author has been interested in the investigations and their results – available in literature – as conducted recently, i.e. in 2009 and later. The below survey of the studies conducted is a proof that the research undertook by the author is in no case a continuation of those studies.

Thus, A.M. Subramianian has identified the factors affecting the use of knowledge management systems [Subramanian, Soh, 2009]. He classified them as technological, individual, organizational, and social ones. The research was done on software companies providing services to minimum 500 customers each. They offer their software to finance, administration, telecommunication, production, and health protection sectors. A special questionnaire was prepared. It contained 31 questions which were answered by 180 respondents.

P. Arora, D. Owens, D. Khazanchi [2010] are concerned with developing a (software) tool that facilitates knowledge management in organisations participating in implementation of virtual projects. The projects are understood as undertakings which are effected by geographically disseminated members of the team. They apply information technologies in their work by means of which they communicate. The tool is aimed at transferring and sharing knowledge in virtual projects in an efficient and cost-effective manner. It is enabled – as the authors suggests – through creating database patterns. Theoretical foundations of the tool are based – according to the authors – on the theory developed previously by other researchers (Kazanchi and Zigurs, the years 2005-2008). The researchers identified the cases in which the said tool may be applied in the course of implementation of virtual projects. The tool is a prototype which needs verification. A questionnaire was published which included 42 questions. The answer to the questions will allow to adjust the virtual projects to the capabilities of the IT tool.

Krishnaveni and Raja [2009] have commenced their research with a knowledge management life cycle. The elements of the cycle are processes. There are seven such processes (e.g. knowledge organization, knowledge archiving, etc.). Descriptive elements (descriptors), in the number of 51, were indicated for each of the life cycle elements. The authors carried out studies – with the application of statistical models – indicating the effect of the knowledge management life cycle model on the benefits achieved in respect of knowledge by companies of the information technology sector. Respondents, in the number of 59, allowed to collect a proper sample for research.

Batra [2010] has developed research forms on the basis of various sources (articles, periodicals, the Internet, etc.). The respondents were 50 employees of the IT company NCR – with a considerable professional experience, representing the executive level. Hypotheses were made and their statistical verification was carried out. The hypotheses concerned without limitation:

– the determination of the mutual impact between knowledge management processes (the knowledge management life cycle according to Leibowitz was adopted) and the individual increase of knowledge of the organisation employee with a simultaneous support of the organisation effectiveness,

– the impact of the constructed knowledge management processes for people working in a connection network on product (service) innovations delivered to customers.

L.Z. Cantú with a team has constructed and then validated a model of generation and transfer of knowledge in an organization [Cantú, Criado, Criado, 2009]. The model investigates the relations between three dimensions, namely: knowledge generation, knowledge transfer, and secret knowledge extension (occurrence areas). The specified dimensions are provided with more details through stating proper components (constructs). Thus, knowledge generations have such components as: organizational culture, management style, personnel motivation, learning opportunity. The research was participated by thirty companies of the information technology sector from the Barcelona region. The average length of time of the companies in the market is 3, 4 years. The respondents were 105 employees of those companies. The research was conducted by means of questionnaires and the results were presented with the use of statistical models.

E. Revilla [2009] has selected for the research 80 products under development. The impact of individual categories of the information technology description (differentiation, assimilation, exploitation, exploration) on the knowledge base of the products developed was examined. It follows from the research that information technology solutions supplement more the developed product knowledge base in respect of their exploitation than in respect of development of knowledge on the products.

N. Mundra with collaborators has undertaken a research concerning the participation of knowledge management in realisation of a more effective organisation management strategy [Mundra et al., 2011]. A questionnaire with 12 questions was addressed to 15 companies of the information technology sector, including so well known as: Siemens, HP, Accenture. The questionnaire with inquiries was drawn up on the basis of original sources (direct observation, talks with proper persons, etc.), as well as secondary ones (Intranet, the company's official documents, discussions, etc.).

The article presents an outline approach to creating a KMS in the SDO, however with regard to the QMS. It is a result of the author's many years' experience as a designer, programmer, implementation organizer and project

manager in SDO's. Another field of his experience is works related to designing, documenting and implementing Quality Management Systems (QMS) for Polish and foreign companies fulfilling the requirements of the SDO definition as quoted above.

The requirements that the above outline approach should meet may be reduced to the following elements:

a) it refers to the idea of quality management systems (QMS) as reflected in ISO international standards since these standard are most frequently the base for designing, documenting, implementing and maintaining Quality Management Systems. The QMS is defined as a management system (a system for setting policies and objectives as well as achieving the objectives) intended for running an organization (a group of people and infrastructure with responsibilities, authorities and relations assigned) and supervising it with regard to quality [PN-EN ISO 9001:2000…];

b) it links the QMS, through ISO standards, with standard specifications in the form of all types of guides related to the SDO;

c) it makes it possible to locate knowledge in the SDO;

d) it makes it possible to specify elements of the KMS with the purpose of analysing them;

e) it makes it possible to analyse elements of the KMS which should contribute to the improvement of the KMS, and this in turn affects the QMS (a delivery of efficient software that meets customers' requirements).

It follows from the requirements which should be complied with by the outline approach to the KMS formation that the approach is closely related to the QMS. The above thesis can also be met in publications on the subject in the form of the suggestion that the QMS may be susceptible to the KMS, i.e. it can be a carrier for such a system [Cieśliński et al., 2005; Chrabański, 2005b; Kołakowski, Tobaszewska, 2006]. The proposed approach to the KMS formation for the SDO is composed of seven stages (see Figure 1). The stages are specified below (along with their characteristics).

Stage 1: Classification of QMS processes

A starting point for the proposed approach is a classification of QMS processes. They have been divided as follows:

a) main processes − they apply to product (here: software) realization and reflect the product life cycle as starting from software (product) related requirements specification through requirements reviewing, product realization planning, purchases, production and service delivery and follow up activities,

b) auxiliary processes − they support proper functioning of management processes, main processes and auxiliary processes,

c) management processes – they can be reduced to decisions constituting the QMS as taken by the top management; they can include documentation related requirements and management responsibility which in turns includes management commitment, customer-oriented approach, quality policy, planning, responsibility, authorities, communication, management review,

d) improvement processes – they include continuous improvement and preventive corrective activities.

Details regarding the process description can be found in some articles [Chrabański, 2005a].

Stage 2: Development of assumptions of a semantic model for presentation of requirements of ISO 9001:2000 and recommendations of ISO/IEC 90003:2004 (hereinafter called "model")

The ISO 9001:2000 standard is too general to render the QMS specificity for the SDO. The standard presents the requirements that should be met by an organization (here: SDO) so that the QMS might comply with standard requirements. The above standard has been expanded through provision of detailed recommendations. The recommendations are included in ISO/IEC 90003:2004 (Software engineering – Guidelines for the application of ISO 9001:2000 to computer software). The Polish Standardisation Committee has not had the standard translated yet [ISO/IEC 90003:2004…]. The semantic model should facilitate application of both the above standards through defining the meaning of contents of specific elements of the standards. They have been divided into the following groups:

a) postulates, i.e. demands or requirements,

b) questions, i.e. issues that should be additionally paid attention to and possibly resolved.

Both the postulates and the questions can be attributed with different meanings of the attached contents (extensions) as provided by the ISO 9001:2000 standard and the ISO/IEC 90003:2004 recommendations. Those extensions may refer to:

a) the proposed method of realization,

b) specification of the scope,

c) additional notes as regards the realization method,

d) examples,

e) references to other sections of ISO 9001:2000,

f) references to other standards.

For individual sections of the ISO 9001:2000 standard and the related recommendations, the above extensions may occur in different numbers (e.g. several methods of specifying the scope, several examples, etc.) and with different intensity (e.g. only examples are given, or a number of realization methods, or some additional notes, or a reference to a standard other than ISO 9001:2000 are also provided). All the relations in the semantic model as described above are shown in Figure 2.

Stage 3: Presentation of individual QMS by means of a semantic model

Using the model potentialities, individual QMS processes can be presented. More information on the subject can be found in some books [Chrabański et al., 2007].

Stage 4: Working out of maps of individual processes while taking into account the model assumptions

The legend to the Figure consists of markings of the icons applied. The process map presents in a one place a selected process in an abbreviated form, thus enabling the process analysis.

Stage 5: Working out of potential decisions as a method for knowledge localization

The process map prepared for reviewing the design and development process, as complying with the requirements of ISO 9001:2000 and recommenddations specified in ISO/IEC 90003:2004, will be used for linking the QMS with the KMS. Assuming that the key knowledge management processes include: knowledge localization, knowledge procurement, knowledge development, knowledge sharing, knowledge dissemination, knowledge utilization, knowledge maintenance [Probst et al., 2002], the hypothesis can be proposed that it is possible to elaborate the localization of knowledge in an SDO that applies the QMS – an example of a key knowledge management process – provided that potential decisions to be taken by the implementing team are previously defined [Kisielnicki, 2003].

The Table below presents potential decisions for selected model elements (section 7.3.4 – Design and development review). The decisions localize knowledge in an SDO which applies the QMS.

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Potential decisions localizing knowledge in an SDO
for design and development as a QMS process

| No.	Model element	Potential decisions localizing knowledge in SDO
1.	**Postulate 1** (9001:2000, section 7.3.4 – Design and development review): At suitable stages, systematic reviews of design and development shall be performed in accordance with planned arrangements (see 7.3.1 – Design and development planning): a) to evaluate the ability of the results of design and development to meet requirements, b) to identify any problems and propose necessary actions	Specification of stages at which systematic reviews must be conducted
2.	**Postulate 2** (9001:2000, section 7.3.4 – Design and development review): Participants in such reviews shall include representatives of functions concerned with the design and development stage(s) being reviewed. Records of the results of the reviews and any necessary actions shall be maintained (see 4.2.4- Control of records)	Specification of records of the results of the reviews and any necessary actions; specification of the services related to the design and development stages that are subject to reviews
3.	**Question 1** (ISO/IEC 90003, section 7.3.4 – Design and development review): The degree of formality and rigour of the activities associated with the review processes should be appropriate for the complexity of the product, the quality requirements and the degree of risk associated with the specified use of the software product	Specification of the degree of formality of the activities associated with the review processes
4.	**Question 2** (ISO/IEC 90003, section 7.3.4 – Design and development review): The organization should establish procedures for dealing with process and product deficiencies or nonconformities identified during these activities (see 8.3). It is recommended that these activities be documented	Specification of procedures for dealing with process and product deficiencies or non-conformities identified during these activities
5.	**Question 3** (ISO/IEC 90003, section 7.3.4 – Design and development review): During design and development reviews, criteria such as feasibility, security, safety, programming rules and testability should be taken into account	Specification of criteria taken into account during design and development reviews

Stage 6: Defining of knowledge elements of the KMS

The localization of knowledge will most probably allow to define knowledge elements. At this stage of the proposed outline, the author of the article employs the hierarchy of knowledge description levels as worked out after K. Wiig. The above knowledge hierarchy includes: domain, region, segment, element, atom. They will not be described due to the limited scope of this article.

Stage 7: Analysis of knowledge elements of the KMS

Having an access to individual elements of the knowledge hierarchy, one can proceed to knowledge analysis. Conclusions from the analysis conducted should be used for improving all the above mentioned elements in the semantic model.
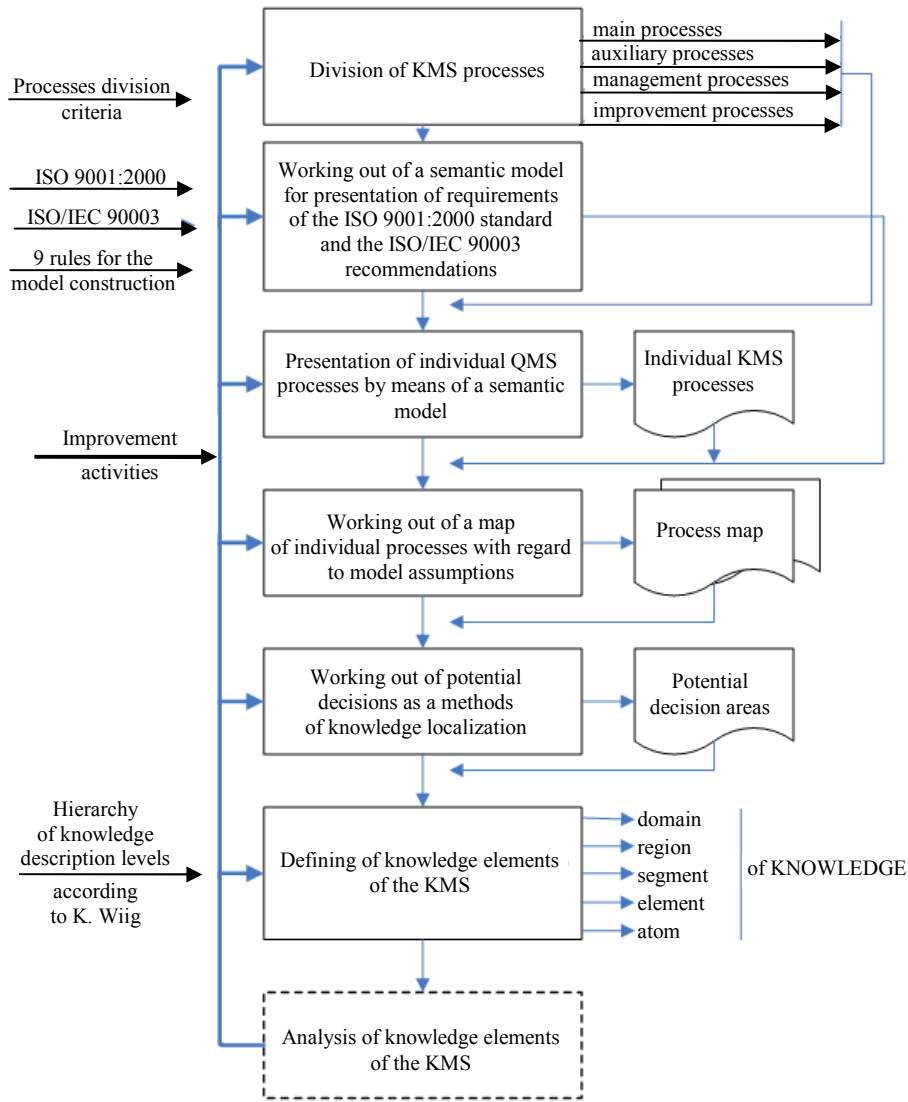
Figure 1. Elements taken onto account when specyfying the method of constructing a KMS for SDO's that apply QMS'
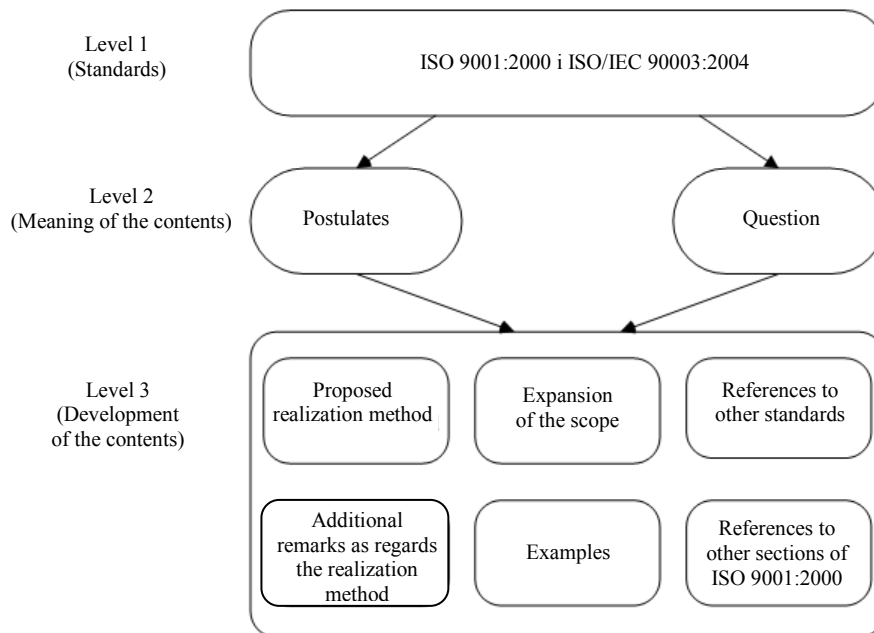
Figure 2. Relations between semantic model levels

Conclusions

The author of the article perceives a close relationship between an effective KMS (Knowledge Management System) in the SDO (Software Delivering Organization) and the quality of the software delivered by the organization as required by customers. Efforts must be undertaken aimed at creating a KMS in the SDO, while taking into account the QMS (Quality Management System). A 7-stage approach has been proposed which allows in effect to localize knowledge (one of key processes of the KMS) in the SDO and to analyse it. The above approach complies with the requirements and recommendations concerning the QMS as defined in international ISO standards.

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