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UDC 004.891.2

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KNOWLEDGE BASED DESIGN OF CONVERGENT SYSTEMS OF SITUATIONAL MANAGEMENT

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Анотація. *Цілеспрямована діяльність ґрунтується на знаннях, і ці знання включають як загальні, так і ситуаційно специфічні знання цільової предметної області. Використання знань у відповідних сферах діяльності забезпечує ефективність процесу створення системи ситуаційного управління. Проектування сучасної комплексної системи ситуаційного управління орієнтовано на її призначення і керовано подіями. Такі системи повинні бути спеціально налаштовані для вирішення актуальних проблем у різних ситуаціях. Проектування є етапом життєвого циклу розробки системи і реалізує процес визначення архітектури системи відповідно до її призначення та задоволення визначених вимог. Ситуаційна управлінська діяльність пов'язана з консолідацією та обробкою інформації гетерогенного походження для отримання семантичної інформації. Впровадження та гармонізація різних компонентів діяльності організації в єдину архітектуру здійснюється шляхом конвергенції. Конвергенція може бути досягнута на основі ієрархічного модельованого підходу шляхом створення системи моделей, які описують різні аспекти цільової системи ситуаційного управління з використанням відповідної моделі знань. Процеси конвергенції засновані на корисних цінностях і принципах, накопичених різними технологіями під час їхнього розвитку. Процес ситуаційного управління може розглядатися як ланцюжок збільшення цінності інформації, і ситуаційне рішення по суті є інформаційним продуктом. У роботі обговорювався підхід, що базується на знаннях, які стосуються ситуаційного управління та проектування систем ситуаційного управління. Результат процесу ситуаційного управління може розглядатися як інформаційний продукт проектної діяльності. У роботі пропонуються архітектурні моделі побудови конвергентної системи ситуаційного управління з використанням знань предметної області.*

Ключові слова: *системи ситуаційного управління, проектування систем, конвергенція, база знань, онтологія.*

Аннотация. *Целенаправленная деятельность основывается на знаниях, и эти знания включают как общие, так и ситуационно специфические знания целевой предметной области. Использование знаний в соответствующих сферах деятельности обеспечивает эффективность процесса создания системы ситуационного управления. Проектирование современной комплексной системы ситуационного управления ориентировано на ее назначение и управляется событиями. Такие системы должны быть специально настроены для решения актуальных проблем в различных ситуациях. Проектирование является этапом жизненного цикла разработки системы и реализует процесс определения архитектуры системы в соответствии с ее назначением и удовлетворением определенных требований. Ситуационная управленческая деятельность связана с консолидацией и обработкой информации гетерогенного происхождения для получения семантической информации. Внедрение и гармонизация различных компонент деятельности организации в единую архитектуру осуществляется путем конвергенции. Конвергенция может быть достигнута на основе иерархического моделирующего подхода путем создания системы моделей, описывающих различные аспекты целевой системы ситуационного управления с использованием соответствующей модели знаний. Процессы конвергенции основаны на полезных ценностях и принципах, накопленных различными технологиями во время их развития. Процесс ситуационного управления может рассматриваться как цепочка увеличения ценности информации, и ситуационное решение по сути является информационным продуктом. В работе обсуждается подход, основанный на знаниях, касающихся ситуационного управления и проектирования систем ситуационного управления. Результат процесса ситуационного управления может рассматриваться как информационный продукт проектной деятельности. В работе предлагаются архитектурные модели построения конвергентной системы ситуационного управления с использованием знаний предметной области.*

Ключевые слова: *системы ситуационного управления, проектирование систем, конвергенция, база знаний, онтология.*

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ISSN 1028-9763. Математичні машини і системи, 2019, № 3

Abstract. *Aimful activity is based on knowledge, and this knowledge includes both general and situational-specific knowledge of the target domain. The use of knowledge in relevant areas of activity ensures the effectiveness of the process of creating a system of situational management. The design of a modern integrated system of situational management is focused on its purpose and is controlled by events, and such systems must be specifically configured to solve actual problems in various situations. Design is a stage in the life cycle of developing a system and implements the process of determining the system architecture in accordance with its purpose and meeting certain requirements. Situational management activities related to the consolidation and processing of information of heterogeneous origin for obtaining semantic information. The implementation and harmonization of various components of the organization's activities into a single architecture is carried out by convergence. Convergence can be achieved on the basis of a hierarchical modeling approach by creating a system of models describing various aspects of the target system of situational management using an appropriate knowledge model. Processes of convergence are based on useful values and principles accumulated by various technologies during their development. The process of situational management can be considered as a chain of increasing the value of information, and the situational decision is essentially an information product. The paper discussed an approach based on knowledge of situational management and the design of situational management systems. The result of the situational management process can be considered as an information product of the project activity. The paper proposes architectural models for constructing convergent systems of situational management using the knowledge of the subject area.*
Keywords: *systems of situation management, systems design, convergence, knowledgebase, ontology.*

DOI: 10.34121/1028-9763-2019-3-67-74

1. Introduction

Modern technologies of situation awareness, situation management and decision-making are convergent and may consists of components of different origin. Moreover, the composition of these components into target system is informal problem and may require additional design process. At the day, there is a gap between of automated management of converged IT infrastructure and convergence of technologies for solving enterprise business problem for specific problem domain.

2. Models and technologies for situation management

Since the early 80's, when the problem of situation awareness and situation management (SM) was formulated, a number of management models were proposed that differ in the transformation and use of information at the stages of the situation management [1–3]. The methods of processing information inherent to each stage are more useful.

Situation management process might be presented as project activity [4, 5]. The main stages of situation management are [5]: situation awareness and assessment, activity planning, decision making, iterative (decision implementation and monitoring, decision correction), results warehousing and assessment. Processes of situational management should be provided by appropriate type of organization. Any organization is described by architecture that consolidates all its components supporting performing the mission of organization. Modern organizations are information and software intensive, thus they are belong to cyber human systems. Organization provided situational management services should be situationally adaptable by adequate configuring information processing means and tools. Therefore, it is necessary describe formally the task of situation management for the use of CAD approach to enterprise architecture design for systems of situation management called computer aided systems design (CASD).

System design is a stage of system development life cycle and realizes the process of defining the architecture for a system to satisfy specified requirements. Consequently, system design is aimed to define and describe different aspects of system architecture. The architecture of the system of situational management (SSM) can be based on different enterprise architecture (EA) models, for example, Zachman's Enterprise Framework (ZEF) [6], TOGAF [7], DoDAF [8] etc.

The baseline of situation management as project activity is definition of its goals and requirements. One of the main requirement of effective architecture design is the maturity of all its elements and conformity between them. The situation notion could be defined as a conscious knowledge of the individual (-s) about the dynamics of the environment, represented by certain types of information messages that is the basis for constructing a substantiated interpretation of the sequence of changes in states (dynamics) of the world (subject area) from a certain point of view [5]. In situational management information presents as assessment of a state of a target domain through the formal logical treatment of knowledge and beliefs in the context of information theory, results of questionnaires, or propagation of general messaging. Semantic information theory defines semantic information as well formed, meaningful, useful and (it is desirably) truthful information.

Situational management activity concerned with consolidation and processing of information of heterogeneous origin to receive semantic information. Hence, it is important to develop adequate means (principles, methods and tools) for information consolidation. Most common approach to information consolidation is based on information fusion methods.

According to Data Fusion Information Group (DFIG) Model [9] there are defined six levels of information fusion:

Level 0 – Data Assessment;

Level 1 – Object Assessment;

Level 3 – Impact Assessment;

Level 4 – Process Refinement;

Level 5 – User Refinement;

Level 6 – Mission Management.

To refinement of different levels, it is necessary to use adequate hierarchy of notions concerned with basic notion of "information". I-SDKW model of information [10] covers different cycles of thinking such as learning, intelligence, and decision cycles. Thus, information is transformed through receiving, collecting, aggregating, filtering, representing, awareness, interpreting, judging, using, enrichment, composing, and growing to higher-level stages.

During situation management process, it is necessary to compose different computerizing technologies: visualization, communication, data analysis and processing, knowledge using and generation, etc. Main sense of SM process in SSM is increasing of value of information about problem situation. This value increasing is provided through information value chain according to I-SDKW model [10]. Value chain enrichment is provided by enterprise organization, which realizes activity processes to achieve enterprise goals and objectives.

SSM is an organization that provides services to support collective collaborative processes of decision-making aimed at solving the problems associated with situation awareness/management in the relevant subject area. So building an effective organization is one of the conditions for effective work of the SSM. The organization is based on the appropriate model of EA, the choice of which depends on the set of factors determined by the conditions and environment of the organization functioning.

The main factors that influence the choice of the EA model of the SSM are the following components of activity: the mission of the organization; overall vision and strategy for implementing this mission; policy makers to ensure the implementation of the mission; goals to be achieved in the implementation of activities; problems (tasks) that are solved in the course of the mission; the nomenclature of services, providing the solution of the tasks, models (programs) of activity; problem-oriented knowledge bases; repository of protocols of the carried out activity; repositories of descriptions of precedents. A generalized model of components of the organization activity vision is presented in Fig. 1. Incorporation and harmonizing of these components in single organization is carried out by the way of convergence.

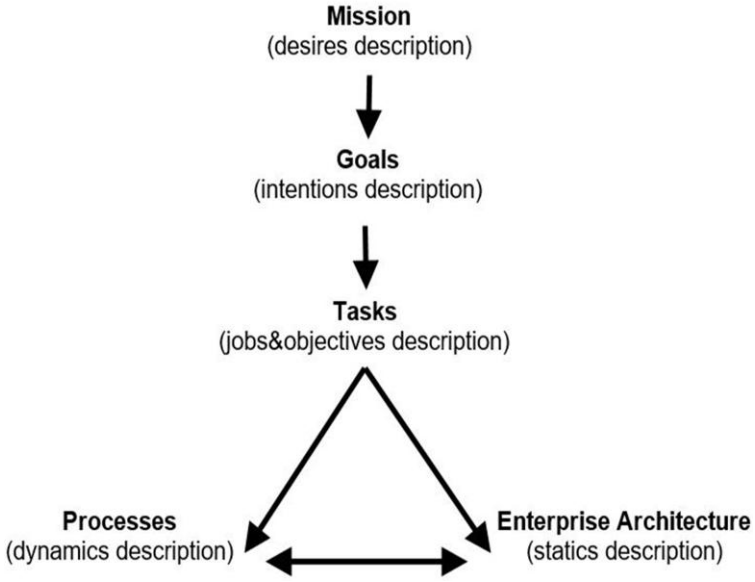

Figure 1 – Components of the organization activity vision

3. Design and decision models for systems of situational management

Different scenarios might realize development of the SSM: architecture driven, event/ situation driven, goal driven, capability driven, and value driven. Any design process in general consists of key subprocesses: needs recognition, problem definition, requirements engineering, synthesis, analysis and optimization, evaluation and presentation. Design process subprocesses for SSM might be based on popular model of situation awareness [11]. In spite of that situation awareness is the core stage of situation management process decision making, decision implementation, and situation management results assessment also are essential stages. Design process for SSM includes situation analysis, requirements engineering, EA synthesis, EA analysis, EA optimization, EA architecture evaluation, EA architecture representation.

Therefore, the main problem of convergent SSM is harmonization of different concerning IT inside a single enterprise. Convergence may be achieved based on hierarchical model-driven approach by creation of system of models, which describe different aspects of target SSM with the use of appropriate knowledge model. The main goal of system of models creation is to prevent the gaps in value chains of design and, consequently, in value chains of situation management process.

According to EA model, it is necessary to describe all its components and EA in the whole by adequate models with maximum possible level of formalism – from verbal to program. Process of models creation for components and SSM EA in the whole is value addition process through design stages. List of stages of SSM EA design and usable types of models is outlined in Table 1.

Table 1 – Stages of SSM EA design and useable types of models

EA design stage	Type of Model					
	Verbal	Functional	Structural	Process	Data	Analytical
Situation analysis	+ [a]	-	-	+	+	+
Requirement engineering	+	-	-	-	+	-
Synthesis	-	+	+	+	+	+
Analysis	-	+	+	+	+	+
Optimization	-	+	+	+	+	+
Evaluation	+	+	+	+	+	+
Representation	+	+	+	+	+	-

[a] '+' usable,' –' not usable

Situation management activity corresponds to generalized model of components of the organization activity vision (Fig. 1). List of activities of SM process and theirs context is outlined in Table 2.

Table 2 – Context of situation management activity

SM activity	Activity context		
	Descriptive	Informative	Directive
Situation awareness: • Perceprion • Comprehension • Projection	 +[b] + +	 + + +	 - - -
Decision making	+	+	-
Decision implementation	-	+	+
Decision assessment	+	+	-

[b], '+' applicable, '–' not applicable

Design solution and accepted decision might be considered as project activity information product. The value of each product is defined by value chain formed during project process. Convergence and consolidation of design solution components are maintained by appropriate knowledge base. Agreement and implementation coordination of accepted decision maintained by knowledge base also.

The experience of effectively solving problems of different nature for obtaining a new quality of products or services in the project activity process is concentrated in the PMBOK [12] knowledge collection and related to PMBOK standards and practices. Life cycle management of the project is important element of this approach. The questions of life cycle management of projects are considered in the standard ISO/IEC/IEEE 16326-2009 – Systems and Software Engineering – Life Cycle Processes – Project Management. In addition, the standard ISO 21500: 2012 – Guidance on project management is the first a standard of a series of standards for project management, and establishes principles and procedures that present best practices in project management, taking into account PMBOK requirements and quality management standards. The life cycle of SM is presented on Fig. 2.

Figure 2 – Situation management life cycle

The model of project activity gives concrete recommendations on the organization of situational management processes at the main stages of planning, implementation, monitoring and management. Despite many common features in project activity and situational management, the main differences between them are in the initial and final phases. Thus, the initiation of the project is related to the motivation, which is based on obtaining a certain new quality as a result of the project. The beginning of the situational management processes is connected, first of all, with the realization of a situation that needs a definite response. The final stage of the project activity involves obtaining a new product or service. The completion of the situational management process is to achieve the target state of the managed system.

4. Convergence of technologies of situation management

Convergence processes are based on useful values and principles reached by different other technologies during theirs development. Situation management process can be considered as information value chain and the decision in essence is the information product. Use of appropriate information and communication technology (ICT) means and tools produce addition the information value on different stages and steps of situation management. In general, process of SM

can be described as process of transformation and value adding of information by the way of the use and converging of appropriate ICT.

According to process model, input information during of SM is transformed into output information with appropriate context (see Table 2) under governing of control information with the use of available resources. Generalized model of SM process is outlined on Fig. 3. Input information $X(t)$ about situation comes from target domain as the set of signals and/or signal patterns (signs, symbols, tokens etc.). Input information $X(t)$ is transformed into situation management information $Y(t)$ in the form of the sets of descriptive, informative or directive data under governing of control information $C(t)$ concerned with norms, regulation and rules. Therefore $Y(t)$ is the result of complex functional transformation F of input information $X(t)$:

$$Y(t) = F[X(t)]. \quad (1)$$

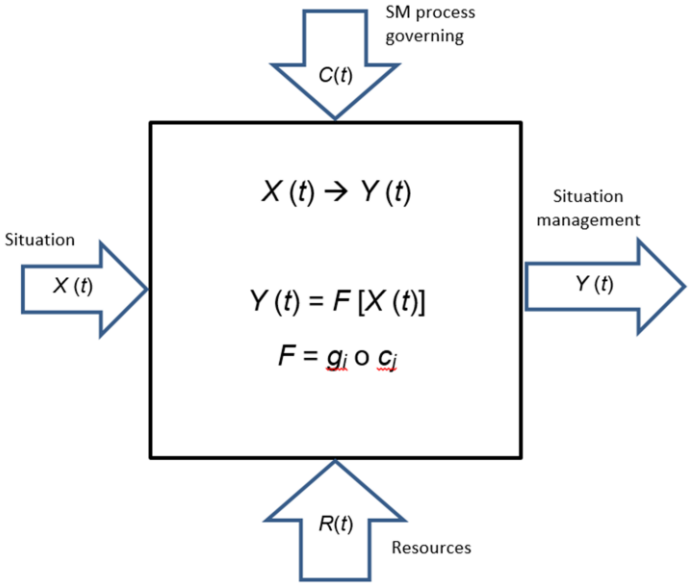

Figure 3 – Generalized model of SM process

Complex transformation function F is a composite function of the set of functional compositions $g_i \; o \; c_j$ of $g_i \in G$ functions of information transformation and $c_j \in C$ functions of transformation governance under resources availability/restrictions $r_k \in R$. Function F may be taken as union of compositions or otherwise.

Information about sets of G, C and R functions are the knowledge subdomains of knowledge target domain. Another subdomain of target knowledge domain is knowledge about scenarios and procedures of processes of situation management (Fig. 2). Converging of different ICT means and tools is defined and take place by realization of appropriate scenario step during SM.

Taking into account proposed analogy between situation management and project activity it is possible to rename project processes to present the SM context in SM processes. Accordance between processes titles are presented in Table 3.

Table 3 – Project and SM processes accordance

Project Processes	SM Processes
Project planning	Situation forecasting
Project assessment and control	Situation awareness
Decision management	Decision making
Risk management	Situation risk management
Configuration management	SSM configuration
Configuration management	SSM configuration
Information management	Situation information management
Measurement	Situation attributes measurement

ICT for SM processes holding can be classified by categories of:

– information reception;
– information consolidation;
– information visualization;
– information analyze;
– information storing and warehousing;
– information interpreting;
– information spreading.

Means and tools of these ICT categories should be converged and, if necessary, diverged during realization of SM stages. Registration and selection for the use of these means and tools is performed with the use of domain knowledgebase.

5. Conclusions and further research

Knowledge based approach to situation management activity and SSM design was discussed in the paper. The result of situation management process may be considered as information product of project activity. The metaphor of information product allows adopting project approach for design and solution making during situation management. Knowledge model as direction engine for product project is proposed. In target knowledge domain are singled out information transformation functions concerned with situation management process governing and resources granting or denying. Separately developed knowledge subdomain of useful for target domain ICTs.

Value addition criteria for assessment of situation management products and design solutions are proposed. Each information transformation during situational management process give some additional value for resulting information composed in output situational management information. These added information values are concerned with the essence of appropriate stage of situation management. For the step of situation awareness and assessment added information value may be concerned with structuring, filtering, clarification of data about situation in target domain. In addition, it may be metadata information about organization and storing data in system of situation management. At the stage of warehousing and assessment of situation management results, it may be information about effectiveness and productivity of situational management procedures for specific use cases.

Further research will concerned with development of specific knowledge models for convergent system design. It necessary to define attributes and interfaces for converging different ICT means and tools used for situation management.

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Стаття надійшла до редакції 27.06.2019