A model for agile management of virtual teams for developing smart environments

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***Abstract*— The purpose of this article is to look at how virtual team management models are evolving in the development of smart environments. The main topic under consideration is the possibility of building a model for efficient virtual team management in the construction of smart environments utilizing the DevOps method in the SAFe framework (Scaled Agile Framework). The article will concentrate on developing and executing a virtual team management model that is specially geared to smart environment development projects. The model should make the best use of the agile methodology framework's parts and have a beneficial impact on the process of understanding, adapting, and implementing the DevOps approach in project team management. The research was conducted at the Department of E-business of the Faculty of Organizational Sciences.**

Keywords*— smart environment, virtual teams, agile, SAFe, DevOps, organizational management.*

I. INTRODUCTION

In the age of industrial digitalization, companies are increasingly investing in tools and solutions that enable processes, machines, employees, products and services to be integrated into a single network for data collection and analysis, i.e. in smart environments [1]. Smart environments are at the heart of Industry 4.0. The main purpose of Industry 4.0 is to achieve improvements in terms of automation, operational efficiency, and effectiveness of e-business [2]. Industry 4.0 as a new paradigm includes Cyber-Physical Systems (CPS), Internet of Intelligent Devices (IoT), Internet of Intelligent Services (IoS), robotics, big data, cloud computing, and augmented reality [3]. It is based on new network technologies (5G, WiFi6, SD-WAN) and requires new procedures (eg data analysis software), which require specific company capabilities (eg continuous innovation, lifelong learning, trust, data sharing), and these conditions development of specific business models as well as new models of organizational management. Adoption of these technologies is essential for the development of smart business processes [4].

An important element of new smart business environments is the human dimension. As a vision of future society and progress, the concept of Society 5.0 was created within the strategic program of the Government of Japan. Society 5.0 is a society that should enable the solution of various social challenges by including the mentioned technologies in business and social life [5].

A smart environment is complex, and as such seeks an adequate systemic organization that would enable its functioning. Virtual teams have emerged as a convenient structure in such an environment. They are characterized by the use of IT, changes in organizational design, and the dispersion of a multicultural workforce [6]. They are most often formed as multidisciplinary teams, whose members have complex but complementary competencies suitable for software development.

The natural evolution and adaptation of virtual teams is not a simple process concerning the existing organizational structure which includes: formalization of the process and strategy of virtual teamwork [7], the role of technology in the virtual team environment [8], organization of virtual team communication [9]; creating suitable business environments for virtual team operations [10] and the interaction of virtual team members [11], [12].

On the other hand, the development of smart environments and the management of such systems after they are in operation cannot be separated, so the DevOps approach is suitable for the development of smart environments. DevOps enables communication, integration, automation, and close collaboration of all people needed to plan, develop, test, implement, publish, and maintain solutions [13]. DevOps has the potential to help accelerate system development, ensure system quality, and optimize system reliability in the field. [14].

The trend of introducing virtual teams in the organization of work has not bypassed academic institutions either. In academia, several applications are used to form a virtual learning environment [15], e.g. Moodle open-source platform [16][17], interactive course materials, labs, and quizzes [18], as well as tutorials and simulations [19]. At the same time, such projects enrich students with real-world experience in intercultural communication, time zones, time management, and virtual socializing [20], assuming they are carefully designed and team members have appropriate instruction. They provide an invaluable experience that later students as future employers can effectively use [21].

This paper will explore opportunities to develop a virtual team management model in smart environment development based on the comprehensive SAFe 5.0 scaling framework, as

well as the DevOps part of the Agile Product Delivery competency in SAFe [22]. The model will rely on the principles and core competencies underlying the SAFe framework. It is assumed that DevOps, as part of the Agile Product Delivery competence in SAFe, meets the needs of a smart environment and is adequate for managing virtual teams. The model should explore potential strategies regarding the formation and use of virtual teams, propose and discuss the development of a virtual team management model in the development of smart environments that encompasses the main directions of the current research literature.

The primary goal of the research is to analyze the possibilities of applying the DevOps approach in the agile framework of SAFe for organizing the work of virtual teams in a smart environment, as well as defining a strategy for developing and adapting an appropriate model of managing virtual teams in a smart environment.

II. LITERATURE REVIEW

Creating and maintaining a virtual team is not easy. Virtual teams are formed concerning the existing organizational structure, they are multidisciplinary, and to be successful, they are composed of professionals with complementary competencies that are considered suitable and imply opportunities for the development of smart environments.

Previous research in this area has shown that there are several problems and that the basis for solving this complex organizational environment lies in creating an integrated model. There is a need to explore new approaches and models for organizing virtual teams in new business conditions, starting from current models and practices related to agile software development (Scrum, SAFe, etc.). In agile development, designers, testers, developers, and integrators merge into inter-functional teams responsible for continuous software delivery [14].

Research conducted so far has identified the following challenges affecting the work of virtual teams [23]:

- Awareness of colleagues and their participation in the team,
- Motivational sense of the presence of others,
- Difficult to establish trust,
- Level of technical competence of team members,
- Level of technical infrastructure,
- Nature of the job,
- Explicit management,
- Common basis,
- Competitive / cooperative culture and
- Alignment of incentives and goals.

Research to date has noted four implications that affect the aforementioned execution of collaborative tasks in virtual teams [23]:

- Assistance in creating a common idea and standards in work,
- Facilitating communication,
- Ensuring a mechanism for transparency of work and
- Designing technology that is easy to use.

The virtual team is expected to achieve the same performance and give the same results as the traditional team [24]. The difference between a traditional and a virtual team is that in a virtual context an individual performance can be more obvious and easier to measure. Although several factors positively affect the performance of virtual project teams, the performance factors that are likely to be implemented in virtual project teams are as follows: motivation and team affiliation (individual performance), communication, trust, team collaboration, reliability of project information, and social presence (team performance), good team leadership and project goals (team performance) [25]–[30]. The analysis of the literature also finds other factors: culture, organizational work environment, team size or membership, team values, team reputation, and personal behavior, as some of the criteria that affect the performance of virtual teams [25]–[27], [31].

Understanding all of the above is crucial for analyzing, developing, and using all the resources necessary to support virtual teams, and finding an adequate solution to build and implement virtual team management models [23].

III. METHODOLOGY

A. *Modeling architectures for virtual team management system in the development of smart environments*

The idea is to develop the infrastructure of a virtual team management model in the development of smart environments. The proposed model includes the following components (Figure 1):

1) Virtual team collaboration system: Database, User data management, Data exchange services, Security, and data protection.

2) Smart environment development systems: Cloud database, IoT device platform (hardware and software components), Technologies for the development of IoT devices.

3) Management systems: SAFe for managing the development of smart environments, DevOps, Models for monitoring and evaluating the work of virtual teams.

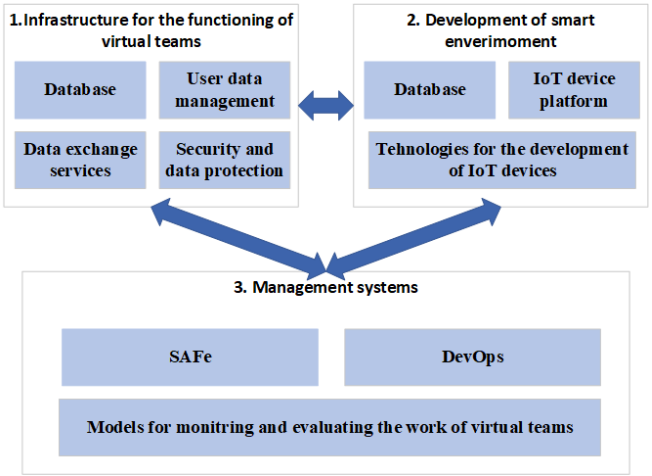

Fig. 1. Infrastructure structure of virtual team management models in the development of smart environments

The architecture of the system for the collaboration of virtual teams consists of a database, a data exchange service with the provision of an adequate level of security. Services are located in the cloud (eg MS Teams, Skype, Viber, WhatsApp, Mattermost, BigBlueButton, email services)

although they can also be located within the organization's infrastructure (local email server).

The smart environment development system consists of a database, an IoT device platform (hardware and software components) as well as IoT device development technologies.

The hardware components of the IoT platform are:

- Sensors that read the physical characteristics of the environment,
- Actuators who perform physical tasks,
- Microcomputers and
- Microcontrollers.

The software components of the IoT platform include application development tools, operating systems used on intelligent devices, and software developed for the platform's functionality. To develop platform, it is necessary to use integrated development environments (IDE). For programming microcomputers, standard programming languages are used, such as Python, Java, and others, and thus standard development environments, for example, Eclipse [32].

The third component of the model consists of control systems. Those are:

- SAFe agile framework for managing the development of IoT projects,
- DevOps framework as an integral part of SAFe, and part of the agile product delivery competence and
- Models for monitoring and evaluating the work of virtual teams.

To integrate the system for collaboration of virtual teams with the system for development of smart environments, services for monitoring and managing the development of smart environments (eg. OpenProject, Moodle, and GitHub), cloud computing infrastructure with adequate security and data protection are used.

B. Organization modeling for the implementation of the SAFe framework and the implementation of the DevOps approach

The organization of the management model of virtual teams in the development environment is designed to use the principles and values of the SAFe agile framework and the process of creating IoT as an example of the development environment is based on the DevOps approach.

The scheme of the proposed organization is shown in Figure 2:

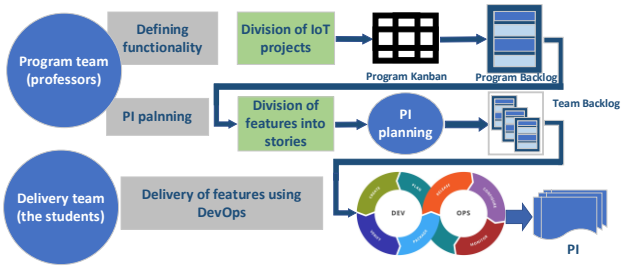

Fig. 2. Application of SAFe framework and implementation of DevOps approach [33]

C. Modeling of software architecture for evaluation and monitoring of the work of virtual teams

For the proposed model the idea is to compile the infrastructure of the system for monitoring and evaluation of projects with the help of tools based on open-source software, ie. open-source tools. Every tool within the system has a role to play. The following will be used to set up such infrastructure:

- Moodle
- Mattermost
- BigBlueButton
- OpenProject
- GitHub

Such a set model creates a comprehensive database that is suitable for the analysis of the work of virtual teams. It is planned that the evaluation will be performed using the analysis of social networks, SNA.

D. Implementation and theoretical implications

The research was conducted at the Department of E-business of the Faculty of Organizational Sciences.

The study was designed so that the use of the e-learning model based on work in virtual teams, organizes and controls a large number of IoT projects (Figure 3).

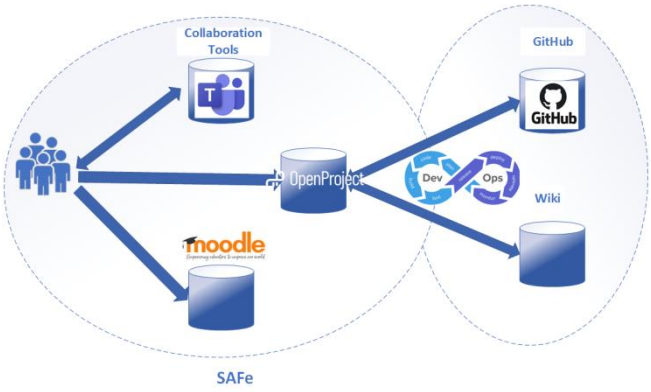

Fig. 3. Model of organizing and controlling a large number of IoT projects based on working in virtual teams

The SAFe framework and the DevOps approach were used, and it was first adapted to the needs of the educational environment. The biggest challenge was organizing the work of students in virtual teams. The research was conducted with undergraduate students in two subjects: the Internet of Intelligent Devices and Risk Management in e-business. Inside both courses, understudies had lectures and exercises on agile methodologies: SAFe and Scrum, as well as on the OpenProject project monitoring tool. Students who attended Risk Management in e-business were given the task of managing IoT projects and had the role of SAFe Scrum master. IoT teams were composed of students who shared the roles of programmer, designer, and tester. Each group had 3 to 5 individuals. The teachers observed and controlled the complete work of the understudies [34].

Product Owners (teachers) made a list of IoT ventures and a list of clearly characterized capacities that each virtual team had to execute (Product Backlog). Teams were shaped, and each was assigned a project. Understudies organized themselves beneath agile standards. The assignment of the SAFe Scrum Master was to supply the development team

with all support and help to guarantee that the team works by the prerequisites of the assigned venture [35]. Team members used the DevOps approach within the development of the IoT project. Code adaptations are put away on GitHub and documentation on the Wiki. All team members, SAFe Scrum Master, as well as Product Owners, utilized these tools through the OpenProject stage. The work and communication on the project between the team members are for the most part organized with the assistance of Microsoft Teams or Viber/WhatsApp. Educating materials and enlightening for project development required for implementation is distributed on Moodle. All parts of the project are documented with the help of OpenProject.

The results of the analysis of the implementation of the virtual team management model in the development of smart environments, which contains the above components, should provide answers to the following questions:

- Is it possible to develop and implement a model for the development and evaluation of infrastructure for communication and collaboration of virtual teams using tools based on open-source software?
- Is it possible to improve the performance of virtual teams?
- Is it possible to measure the performance indicators of virtual teams?

IV. CONCLUSION

The basic idea of the planned experiment is to define a set of continuously measurable characteristics in which each factor will be varied systematically. The aim is to understand the interrelationship of the above variable predictions and outcomes and their impact on teamwork to devise a comprehensive virtual team management model in the development of smart environments that will contribute to the quality of the final solution and project effectiveness.

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