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Evgeny Zaramenskikh
Alena Fedorova *Editors*

Digital Transformation and New Challenges

Changes in Business and Society in the Digital Era

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Series Editor's Foreword

The digital transformation is one of the most important developments of our times. We see how digitalization can increase the efficiency of business processes, e.g. through robotic process automation, and we also know how digitalization affords new business models, e.g. through the Internet of Things, data-driven services or distributed ledger technology. In the future, more and more data of different types will be taken into account, further increasing the sensitivity and productivity of systems. In the area of NeuroIS, for instance, break-through achievements have been made during the past decade to capture and analyse body data in order to develop emotion-sensing devices for business and our private lives as well. Given a plethora of technological innovations today, finding the sweet spot where the right mix of technology adds significant value for people in a specific use context is key. The area of business process management has developed a rich set of tools, methods and theories to both identify and realize such opportunities.

Take for instance Tesco, the UK retailer entered the South Korean market not by opening stores but by putting up posters showing pictures of groceries together with a QR code for people to scan on their way to work and to receive the goods delivered to their door steps by the time they return home from work. This model made Tesco the second biggest retailer in the country in only a few months, using digital technology and very well fitting the use context. As research has shown, South Korean people tend to work a lot, they do not particularly enjoy grocery shopping, plus they commute on public transport. Also, most of the people there would be technology-savvy and like to try out new digital services. So in this setting, Tesco found a sweet spot where technological affordances meet peoples' needs and both their work and life preferences.

Digital technology, however, cannot only accelerate business; it has also started to play a major role in helping us to address grand challenges of our society, such as environmental and social challenges. The field of GreenIS has made important contributions to support more sustainable practices in many application areas. Sensor networks, for instance, allow for a better alignment of supply and demand, as, e.g., of energy, in smart houses. In a recent project, for instance, we have equipped public bins with sensors and adjusted the routing to collect the bins according to the charging level of the bins, which reduced routing by more than 75%. Also, this information

is now used to optimize bin capacities, and such processes can be applied in many logistic scenarios. Also, information systems are widely used for social interaction, social inclusion and participation. Take the education sphere, for instance, where open distance education formats provide people regardless of regional and socio-economic constraints to learn and personally develop. The EDUglopedia project, for instance, has created a global account of Information Systems programs as well as a rich repository of open learning and teaching materials, which greatly advances opportunities of all regions around the world to participate in global discourse and development (see: www.eduglopedia.org).

However, it is not only about the opportunities, but very much also important challenges that arise when business and society increasingly digitalize. How do work systems change and how can we assure they will change for the better? How can we conceptualize and model work systems in the digital age? What are the implications for the work force and what are consequences for our society? As we collect more and more data of many origins and kinds, how can we assure privacy and ethically correct conduct with this data. Obviously, digitalization means to move more towards man–machine societies, but what will be the mechanisms and values in such societies be? In our research on digital capital creation, for instance, we therefore also investigate the role of the (state) governance in setting the right frame for digital transformation (www.digialcapital.li).

This book covers both the opportunities and the challenges of the digital transformation. It comprises contributions from highly influential authors in the field, who provide an impressive account of the digital transformation body of knowledge. I applaud to the editors, who have been able to put together such a valuable source of contributions for both research and practice. The book is testament of a highly productive community of Information Systems researchers, who have formed as the Russian Chapter of the Association for Information Systems (AIS). I would like to congratulate the entire community, and Prof. Evgeny Zaramenskikh, in specific, for creating such strong movement and making such important contributions.

I can highly recommend this selection of fine contributions to the important topic of digital transformation and new challenges. Enjoy reading and let us all stay in touch on the global journey of digital transformation!

Vaduz, Liechtenstein Prof. Dr. Jan vom Brocke

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Enterprise and Organizational Modelling

Design Thinking in the Development of Project Management Approaches and Modeling of Business Processes of the Organization

Elena Vasilieva

Abstract The article offers the possibility to develop project management and reengineering of business processes due to the inclusion of Design Thinking techniques. The stages of process modeling invariant to the project context are highlighted. The comparison of traditional and proposed approaches is carried out. The uncertainty of the modern world and constantly changing conditions require the project team to be able to study business processes and the person in the business process directly in context. Design Thinking will remove or at least mitigate the uncertainty associated with the definition and understanding of the variability of the content of the project, will reveal the bottlenecks of business processes, will reveal the user's pain. Using an integrated approach involves the development of templates of a specific project artifact using Design Thinking techniques for projects of a specific type at a specific stage of the project life cycle. Descriptions of the proposed methods are given Guerrilla Ethnography, Video Ethnography, Customer Journey Map and Service Blueprint, Matrix of positive and negative experience, HMW, Current-Future-Barriers, The World Café. The design-based thinking approach is more flexible than the traditional linear step-by-step design process, helping to more actively identify and understand knowledge about potential and current problems, as well as their possible solutions. In addition, Design Thinking forms the project consciousness of the group. At the same time, the focus of creativity shifts to identifying the real needs of users and quickly launching a prototype to test the idea of changes embodied in the reengineering project.

Keywords Project management · Reengineering · Business process · Business process modeling · Uncertainty · Design thinking · Risk analysis artifacts · Human-centered approach

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1 Introduction

The changes made in the latest editions of Project Management Body Of Knowledge (PMBOK), Enterprise Risk Manadgement Committee of Sponsoring Organizations of the Treadway Commission Exposure (COSO ERM 2017), Risk management—Guidelines ISO 31000:2018 reflect the General trend-adaptation of project management approaches to the rapid change of the external environment, flexible response to new technology challenges and the need to form a knowledge accumulation circuit. In the last decade there has been an adjustment of process thinking with a change of emphasis on customer-oriented processes and adaptation to changing business conditions. More and more attention is paid to the study of the activities of knowledge workers (knowledge-intensive work) involved in generating value for the consumer [1]. In this regard, of particular interest is the synergy of proven time-tested tools and methods of approaches to continuous improvement and process transformation, as well as the methodology of Design Thinking.

The continuous improvement approach is aimed at improving the operational processes of the organization through the identification of problem areas, sources and ways to reduce costs, and the search for points of growth in the effectiveness of organizational activities. Through continuous improvement, developers seek to analyze, identify, measure, and find opportunities to improve business processes. Process transformation (reorganization, reengineering) involves a fundamental rethinking of processes, and first of all, it involves the transformation of end-to-end processes. It involves bringing processes, metrics, business functions, technologies, elements of the organizational structure in line with the strategic goals of the organization and its tactical objectives for the organization (sometimes mention one of the definitions of the term “cardinal reengineering of the business process” [2], a measurable increase in the value of a product/service to the consumer. At the same time, it is assumed that innovations, new concepts, technologies will be introduced into everyday work, new opportunities for process improvements will be identified, etc. It is believed that in the process of transformation, no idea will remain without consideration, no proposal will be rejected (with the exception of incompatible with the legislation, financial capabilities and policies of the company). Improvement in this approach is not the goal, but the consequence of a radical rethinking of the process.

The study was carried out in the framework of the preparation of the report at the conference “Designing Business Architectures". The purpose of the research is to identify approaches that help business architects to find effective solutions in the field of organizational development. In the First Chapter the scheme of inclusion of techniques of Design Thinking in the scheme of modeling of processes is presented. In the Second Chapter the list of artifacts of risk analysis from the point of view of various contours of management is defined, and also the iterative procedure of their formation for integration of process of risk management in a contour of acceptance of strategic and operational design decisions is developed. A comparison of the traditional and proposed approach on the example of the analysis of project risks in terms of adapting the goals and content of the project, taking into account possible negative

risks. The Third Chapter outlines popular step-by-step techniques (empathy, focus, generation and selection, prototyping, testing) that can be applied in business process reengineering and IT projects. Advantages of popular Design Thinking techniques.

2 Design Thinking in the Development of Approach to Modeling of Business Processes of the Organization

Business process modeling is an indispensable component of many different projects, ranging from projects in which the business process is the target object of study, documentation/change. This group of projects includes regulation of business processes, improvement of business processes, automation of business processes, reorganization/reengineering/transformation of business processes. Another group includes projects in which business processes are not the target object of study, but their study, documentation, change is necessary to achieve the ultimate goal of the project. In such projects, business process modeling is one (or more, if as IS and TO BE modeling is required) of the steps. An example of this group of projects is the project of information system implementation, including ERP-system (Enterprise Resource Planning—system).

As an example, the following set of Design Thinking tools and techniques in the context of business process design (see Table 1). If you select the stage of business process modeling from the context of the project in which it is carried out, you can select the following typical steps:

(1) fixing the purpose of modeling, including the formulation of a list of questions that will have to answer the developed process model, as well as the definition of forms of documents as the results of modeling;

Table 1 Inclusion of design thinking techniques in the process modeling scheme

The process modeling scheme	Design thinking	Reengineering
«As Is»: I. The purpose of modeling	Guerrilla Ethnography, Co-Design, Moccasins, In-depth interviews, 5Why, 5 W, Triads	Fixing the business process context
II. Gathering information about the process	Empathy Map, CJM, Service Blueprint	Visualization of the profile and actions
«To Be»: III. Process modeling	POV: HMW, Current-Future-Barriers, The World Café	The transition to the destination state
IV. Process model testing	The Venn diagram ‘Sustainable solutions’, Feedback Grid: Impact/Effort Matrix	Balanced scorecard

(2) collection of information about the process, including one of the techniques of information collection (or a combination thereof): the study of documents, interviews, questionnaires, observations;
(3) direct process modeling—creation of text, tabular and/or graphical descriptions;
(4) analysis of the developed process models.

In some projects, business process modeling is an independent step, in others, modeling is performed in the context of business process analysis.

An integrated process design scheme usually includes a description of the business context, designing the internal structure of the business process, planning the implementation project of the designed business process. Steps 1, 2 and 4 can be performed using Design Thinking techniques to increase their efficiency and effectiveness. Design Thinking methodology includes a variety of information visualization tools that will identify and record the results of the study of the needs of the participants of the analyzed business processes. Development of proposals for process optimization and reengineering, as a rule, consists of several iterations, where the project team will study the current state of the process, formulate hypotheses and create sketches of improvement options, identify the best and test them in a test mode.

3 Design Thinking in the Development of Project Management Approach

Design Thinking methods and tools can also be useful in project management. The effective application of the proposed approach implies the development of templates for the formation of a specific project artifact by a specific tool of Design Thinking for projects of a specific type at a specific stage of the project life cycle. Each of the stages of project management, starting from the planning stage, involves the possibility of reversal to clarify further actions caused by a change of context, project conditions and other factors. The iteration of processes and the mandatory emphasis on in-depth research of the environment in which a given process, user, product, service exists is at the heart of the methodology of Design Thinking and is supported by a variety of techniques and tools. Each of the steps of the integrated approach assumes that the designers, having tested the hypothesis, can at any time make “a pivot” [3] to other ideas.

In addition to the iteratively inherent in the Design Thinking process itself, project management suggests that the process of forming analysis artifacts is also iterative. This process of creating artifacts in the framework of Design Thinking involves the development of acceptable scenarios for each of the 6 iterations, starting from the first (product content), and ending with the sixth (product content, project content, strategy, risk register, change response plans, adjustment of project contract terms). When compared with PMBOK process groups, the first five iterations should be

performed at the project initiation and planning stages. A mandatory requirement is the gradual sequential inclusion in the work of the next artifact and the implementation at each iteration of the entire list of stages of Design Thinking from empathy to prototyping and testing. This is necessary to fully understand the possible set of scenarios for each artifact, its impact on other artifacts and on the results of the project. If you immediately try to formalize the full chain of artifacts-then certainly there will be a loss of information that requires understanding at the stage of risk analysis, and we will get the same level of knowledge about the project as in the traditional approach.

At each iteration there is a formation, comprehension of variability and quantitative estimation of borders of admissible variability of a set of artifacts of the risk analysis. For each of the artifacts, a knowledge structure template can be developed to improve the efficiency of the Design Thinking stages. In process of accumulation in the considered organization of knowledge on the realized projects, efficiency of actions for risk reduction and efficiency of the made project decisions templates can be specified taking into account the revealed specifics. The project cases themselves can also be used as a guide in the risk analysis of new projects.

The application of Design Thinking is also justified in the design of the business strategy of the organization, the implementation of innovations taking into account possible risks to improve the efficiency and customer focus of business as the main factor of adaptability of modern organizations.

4 Design Thinking Techniques in the Study of the Project Context and Stages of Business Process Modeling

The Design Thinking approach, actively promoted as a practical tool and scientific discipline by Hasso Plattner Institute (SAP) and d. school (Stanford), is aimed at creating a product or service demanded by the consumer [4–8].

Design Thinking is often associated solely with the discipline of design and is considered as the tool of creativity, which involves a huge amount of magical manipulation of cards multi-colored post-it [7]. However, an outstanding scientist, Nobel laureate Herbert Simon, whose developments are in demand today by specialists in various technical fields (engineers, system technicians, programmers), in 1969 he first wrote about the importance of the development of human thinking through empirical rules, experience, the ability to adapt to conditions of high uncertainty of the environment [9]. His analysis of the nature of organized complexity is the basis of research in the field of artificial intelligence, information processing, complex systems. Today, many design researchers believe that Herbert Simon is the founder of the philosophy of Design Thinking.

The Soviet scientist and inventor Heinrich Altshuller also studied the problem of teaching people to build thought processes so that every person who is engaged in creative work can find non-standard solutions to complex unusual problems.

The first publication of the principles of the organization of “creative solution of a new technical problem” [10], which formed the Basis of the Theory of Inventive Problem Solving (TRIZ), contained conclusions about the importance of studying and experimental study of the growth opportunities of research potential, “mental processes of technical creativity". We can continue the list of scientists that studies the features of development of creative abilities of the person calling the Shchedrovitsky [11], Bekhtereva [12], Khryascheva [13], Michalko [14], de Bono [15, 16], etc.

Today, Design Thinking as a separate discipline is studied in colleges, business schools and universities. Methods of Design Thinking approach allow to improve and hone creative abilities through the formation of response processes, teamwork, game mechanics, visualization and inspiration, teach “to be more flexible in the application of their knowledge” [15], develop emotional intelligence and empathy [17], structure information, help to see connections and relationships in complex systems.

Eric Rees calls Design Thinking -one of the basic principles of the approach “Lean Start-up” [14]. Philip Kotler in recent books reveals the value of research unconscious motives of consumers in the context of globalization of proposals, where the empathy of an entrepreneur to their potential buyers—is its key success factor [18], and emphasizes the need to include lateral thinking in the development of a unique trade (value) proposal [16, 19].

Among them are Stanford D. School, Hasso Plattner Institute, Hyper Island, the MBA program of the California College of art, the 16-month MBA program “for hybrid thinkers” of the University of Philadelphia, within the framework of the Carey Business school at Johns Hopkins University and the College of art at the University of Maryland-a joint program in design and leadership (Design Leadership), Babson College, Hyper Island (Sweden), the design Laboratory of the University of Sydney. The center for Design Thinking was opened in Moscow last year and is actively functioning. Training programs of the laboratory of Design Thinking and customer experience are held in the many Russian companies. IBM and Microsoft conduct design research on a commercial basis, as well as train their team, developing a corporate culture in General, so that the staff formed not only an engineering culture, but also soft skills, creativity and flexibility of thinking. The approach is implemented as part of the management process in international companies IBM, AirBnB, Procter & Gamble, GE, Apple, used in corporate tasks in Russian banks and IT companies. The results are implemented on the portals of the Moscow Government (mos.ru), in the services of the Moscow metro, the state Corporation “RosAtom”, the company “TELE2”.

Design Thinking is a creative iterative process consisting of such key stages as empathy, focusing on a specific problem, generating ideas, choosing the best one, prototyping, testing [20]. The ability to work with implicit knowledge, identification of real problems based on deep study of client experience, activation of creativity and intuition in solving non-trivial tasks and generating new business ideas, as well as ensuring effective communication between process participants make this approach in demand when performing informal stages of project management.

Selection of a specific pool of Design Thinking techniques for the realization of the synergy of the approaches of project management and reengineering of business processes is not a trivial task, requiring understanding of a specific project in the context of which you are modeling a business process, as well as a number of restrictions such as the planned duration and cost of the project, the amount of attracted resources, including human, the level of staff, degree of possession of practical skills of application of methods of Design Thinking, presence of consultants, the organizational culture, etc.

4.1 The First Phase of Design Thinking "Empathy"

At the initial stage, the main role is given to observation and understanding of the problem. The profile of the target consumer is made, process or experience of interaction of the consumer with a product or service is studied.

1. Guerrilla Ethnography includes in its pool technique included observation and photo-video of the user's actions, a day with the user, etc. Interviews using the technique of questions "Five why". It is widely known and included by Eric Ries in the methodology of "Lean startup" [3, 19]. The secret of the technique is to repeat the question "Why?" even if the answers seem obvious. Thus, the Respondent is provoked to sincerity that allows revealing "implicit knowledge" on key questions of research, to discover deep, hidden motives and feelings of the user, to see other parties of a problem. The triad method will help to increase the effectiveness of interviews [18, 21]. The method is to compare the process with two similar ones. Thus, the differences between one process and the other two are better identified, a more complete description is given, and the emotions that give the key to the possible correction of the process failures are determined.
   Video Ethnography is a good tool that can be useful both at the stage of problem research and when testing a prototype. Especially if the user is directly involved in the experiment. By choosing this surveillance tool, you have to "follow the shadow" of the user to understand how he performs actions in his usual environment: at home, at work, on the street, in the store, etc. it is Useful to take a photo of the person with whom you talked (if, of course, he gives his consent), for at least three reasons:

(1) if you have only notes left after the interview, interviewing 10 more people, you can hardly remember "whose thoughts they were", however, looking at the person's face, you will remember your conversation with him much faster;
(2) you will be able to use the material to compile a "portrait gallery", a map of empathy, which is extremely effective both for work and for communication with other team members;

(3) the gallery of portraits in the presentation can impressively affect the customer or investor, confirming the enormity of the work done to study the target audience.

In the matrix of positive and negative customer experience, it is convenient to record and analyze the results of interviews. The result-drawing up a user profile, pain points of the process.

2. The visualization of the user profile through The Empathy Map. The Empathy Map is a method by which you can make an assumption about the identity of the client and reveal the needs of the target audience. The Empathy map [5, 6, 8, 20], reflects the characteristic features of a particular character ("Person-model"), which is given a name, determine its age, features, artifacts. The map consists of 4–6 blocks in which hypotheses about the consumer or the results of the interview are recorded: thinks and feels (experiences of the consumer), hears (whose opinion is important to him), sees (channels for obtaining information), says and does (experience of interaction with the product), pains (problems that can be solved with the help of the product functionality) and achievements (benefits that the product can provide). The blocks are recorded hypotheses about the consumer or the results of the interview. Each entry should contain one highlighted consumer characteristic, a quote from an interview, or a question that has yet to be answered in further research.

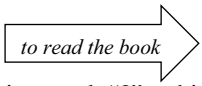
The profile of the customer, by the way, will help to understand how to communicate better with him: the language of numbers or with the help of visual images and memorable associations.

The Empathy map can be performed in Internet services: app.mural.ly, realtimeboard.com (after rebranding—miro.com but in this case, the implementation of the map requires a lot of effort and limits teamwork, so stickers and flipchart will create hypotheses about the target audience faster and based on different opinions.

The results of an empirical study of user actions are recorded in the Customer (user) Journey Map (CJM). Other names that can be found in the literature are User Journey Map (UJM), User Experience Maps, Service Blueprint, or service Map. The steps of building a CJM are usually reduced to finding problem areas in business processes that can be detected with deeper detail, developing scenarios to remove barriers to the execution of business tasks by the user. CJM is usually organized into stages (sometimes called phases) that the user goes through as part of a specific task or time span. Each stage marks the main goal that the user is trying to achieve in their overall journey.

Each stage of the analyzed process can be divided into four categories (PEDPL model): previous experience—Pre-Experience; problems of current experience—During Experience; results after completion—Post-Experience, as well as missed alternatives, lost experience—Lost Experience.

When building a CJM, the emphasis is placed on the study of user experience, impressions, and not the internal regulations of the process under study. In the study of client or user experience, they study the entire chain of actions, try to understand what emotions are experienced by the process participants, identify pain points and

ways to correct them. We recommend adding special symbols to this technique to fix the route: A :  B; actions 

; emotions: smiles  or  . It is also convenient to use the question mark "?" to highlight the difficulties faced by consumers on their way, and ideas for their resolution to indicate the exclamation mark "!".

Service Blueprint (service map)—expanding the chain of customer experience through the structural description of the service. The service map describes not only the actions of the service client, but also the visible and invisible actions of the service provider in relation to the client, reflects the nature of support for the business system, including it infrastructure, identifies bottlenecks in the business process, assesses the studied processes: what is important; where can you go wrong; where are the risks? [20].

The CJM canvas can be rendered in Internet services; archi.com, miro.com, uxpressia.com or displayed in a spreadsheet. A template for creating a Customer Journey Map for a mobile application or web service can be downloaded from the resource mcjmtemplate.factory.mn.

4.2 The Second Phase of Design Thinking "Focus"

The phase of Design Thinking "focusing" involves the use of the POV ("Point-of-View") method, that is, the definition of vision, assessment of the situation, a detailed description of the problem and the allocation of the main direction in the search for a way out of it. At the generation stage, many possible solutions are created during brainstorming, which will be analyzed in terms of the three constraints of Design Thinking (client desirability, technological feasibility and profitability) and from which the best ones will be selected at the selection stage. In this step, the POV-question is formulated using the "How Might We" (HMW) technique in the format: "How can we help to solve the problem and surprise" (see Fig. 1).

At present, it is safe to say that most of the breakthrough ideas developed by creative groups of design thinkers, appeared thanks to the successful combination of two tools: HMW (How Might We) and Current-Future-Barriers. Focusing on the problem with a POV-question and HMW technique can be formulated in the format: "How can we help to solve the problem and surprise".

How can we help _____,
to solve the problem _____
and surprise _____ *(the world)*

Fig. 1 Outline of a POV-question and HMW

The Current-Future-Barriers (CFB) canvas is a tool for analyzing how to remove obstacles and barriers between the current situation creating the problem (the present) and the ideal solution (the desired future state). With CFB, you can provide in-depth analysis and a clear picture of the possibilities of transition to the target state.

4.3 The Third Phase of Design Thinking "IDEATE"

To evaluate and select the best variant (hypotheses) of the design, a "Impact/Effort" Matrix can be constructed. The teams then move on to creating a prototype of the key idea that has received maximum ratings on the efficiency criterion and minimum ratings on the cost criterion.

The "Impact/Effort" Matrix can be used to assess the effectiveness of risk mitigation measures both at the project initiation stage and at the project implementation stage after the product is released to the target market.

To test the viability of innovative proposals, an analysis of ideas can be carried out through a diagram of three overlapping subsets-spheres of innovation "Sustainable solutions". It reflects the basic principles of innovation development: it should be in demand by people, feasible from the point of view of technology and cost-effective.

4.4 The Last Phases of Design Thinking Prototyping and Testing

Phases of Design Thinking "prototyping" and "testing" allow you to work out the idea developed in the process of research on the layout, sketch or script. in these design phases, a pilot test is conducted with the help of engaged business process users for this purpose.

Testing is better carried out on the principle of "The World Café" (rounds of 5–10-15 min). Starting to work on one problem, after 15 min one project team moves on to the problem being studied by the other (changing tables). Team captains ("masters of the table"), accepting new participants of brainstorming at their table, are obliged to quickly explain to them the essence of the problem, previously formulated hypotheses, fix their doubts and new ideas. Further, the tables are changed in three stages every 15, 10, 5 min, respectively. Participants of other teams can highlight the strengths and weaknesses of the hypotheses discussed.

At the end of the design session, it is good to analyze the actions, highlight the mistakes and successes of personal growth. Design Thinking forms the project consciousness of the group. Discussion, rethinking hypotheses, thinking about ideas at the stage of its implementation in the layout allows you to develop a systemic view of the problem under study, the ability to analyze, make decisions and learn, which are the key characteristics of systemic thinking. At the same time, the focus

of creativity is shifted to identifying the real needs of users and quickly launching the development for testing with minimal changes at the prototype level, in order to confirm the demand for the idea of changes embodied in the reengineering project. In the European scientific literature, the "design-thinking" approach is also referred to as "human-centered design" (HCD) or design based on human involvement.

The company's skills in the use of Design Thinking tools can be used in meetings, strategic sessions, brainstorming [22, 23].

5 Conclusion

Thus, the author obtained the following conclusions:

1. Process modeling of business processes can be integrated with Design Thinking techniques. The Design Thinking methodology is well suited for formulating poorly defined problems and forming solutions, involving project participants and stakeholders. The uncertainty of the modern world and the constantly changing conditions of projects require active involvement of project team members and stakeholders in the processes of analysis and development of solutions, which are mostly informal. Therefore, such processes require the use of methods to enhance the use of intuition and experience of specialists, creative, conscious project thinking and customer-oriented strategic approach. In our opinion, Design Thinking will remove or at least mitigate the uncertainty associated with the definition and understanding of the variability of the content of the project. From the point of view of the classical foundations of project management, the certainty with the qualitative characteristics of the product (its consumer properties), as well as the choice of marketing and production strategy within the project will allow to intelligently determine the hierarchical structure of the project and improve the quality of subsequent use of traditional tools of operational project management.
2. Design Thinking can improve the project management process. In addition to solving the main task of user experience research, Design Thinking techniques will ensure effective interaction of project participants throughout the project life cycle. Combining variants of implementation of elements of strategy, it is possible to receive new unexpected decisions and to give a meaningful assessment to already known combinations. Determining the dimension of the set of acceptable options for the strategy is also a regulated factor in the process of conducting the study. The stage of working out the goals and content of the project depends entirely on the intuition and experience of the project Manager and team members, as well as on the degree of their involvement in the process. Therefore, the use of Design Thinking technologies for the formation of customer-oriented products, project content, effective strategies for project

implementation, as well as to increase awareness when making project decisions and the effectiveness of the dialogue between project participants seems to the authors a reasonable idea.

3. Analysis of project risks largely determines the success of strategic decision-making. Unlike the traditional approach to the analysis of project risks the inclusion in the methodology of techniques of Design Thinking makes the analysis more flexible and contextually relevant object of study, contributes to increased identification and recognition of knowledge about potential and current issues and their possible solutions. The proposed expanded list of risk management artifacts and iterative procedure of their formation throughout the project life cycle are the basis for further empirical research, adaptation of the project strategy in terms of reducing the impact of risks, ensuring effective communication of project participants, accumulation of knowledge about projects.
4. Design Thinking is necessary when you need to understand the conflicting requirements and expectations of customers (the Empathy Map, Guerrilla Ethnography, POV-question). Or when your competitors have made a breakthrough, and you have nothing to quickly respond to their challenge (the Triad method, the Matrix of Positive and Negative Customer Experience). Design Thinking forces you to "get out of the office" [20], helps you learn to cooperate with others and be inspired by other people's ideas, to discover new points of view and unexpected opportunities, to be able to direct your creative abilities to solve problems. The developer of software products and services will find in the Design Thinking tools to find sources for new ideas (Random Stimulus method, SCAMPER, World café), testing (User Path Map or Customer Journey Map, included observation, Wizard of Oz or "Wizard of Oz"), prototyping and evaluation of the achievability of project goals.
5. Design Thinking helps to learn to cooperate with others and be inspired by other people's ideas, to discover new points of view and unexpected opportunities, to be able to direct their creativity to solve problems. The leader in the Design Thinking approach will discover the basis for changing the corporate culture of the organization. Discussion of important tasks in an informal setting at a round table with the help of various techniques of Design Thinking will help to maximize the potential and ideas of their employees for business development, involve staff in the problem and increase their responsibility for change. In the company skills of application of tools of Design Thinking can be applied at carrying out meetings, strategic sessions, brainstorming sessions. Advanced system competencies will help you overcome problems and make decisions in a complex, constantly changing environment. They require a combination of imagination, sensitivity and ability, allowing you to see how the parts of the whole are connected and connected. The tools included in the process of Design Thinking develop empathy, logic, imagination, intuition and system thinking, the ability to organize and direct collective co-creativity, engage practical thinking.

Companies need to pay special attention to flexibility and innovation, and, most importantly, to understanding customer needs, in order to maintain their position in digital markets and in the struggle for customers. A business model that is competitive in the market today may be obsolete or unusable tomorrow. This forces companies to look for new prospects for development in the digital environment of the Internet. Digital transformation is the change of a business model implemented in the physical world to a business model that brings the activities of an organization into a virtual environment. At the same time, unlike automation, when part of the business functions is taken over by information technology, digital transformation involves the exclusion of some basic element from the value chain, replacing it with robots' process by process. In this regard, companies should create a space for experimentation, rapid prototyping, testing of new ideas and introducing a culture of rapid innovation, introduce flexible organizational structures and flexible methods to reduce the development of new solutions. That is why the adaptation and application of flexible approaches, such as Agile, Scrum, Kanban, Design Thinking and other creative methodologies, which were previously considered the prerogative of only software developers, are so popular in advanced companies. Such approaches can increase employee satisfaction and engagement, increase accountability for decisions, empower Autonomous teams, and treat all opinions as equally valuable.

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Visual Modelling Support for Effective Economic Cluster Activities Engineering

Natalya Aseeva, Eduard Babkin, and Pavel Malyzhenkov

Abstract The clusters represent a powerful mechanism of economic development of regions and often even of entire nations. From the theoretical point of view the clusters represent an organizational model which advantages can be demonstrated by the use of transactional approach. The paper presents an ontological modeling tool that may serve as a visual editor for the DEMO methodology (which actually present a strong deficiency) and simulator of business processes modelling in clusters. The whole design process is described in the article, from converting the DEMO models into EMF classes to transformation of the model into Petri Net and simulation.

Keywords Clusters · DEMO · Ontology applications · Ontology in business · Ontological modelling tools · Business modeling · Visual editor · Simulation · Petri Net

1 Introduction

Business relationships are recognized as a specific type of the resource that a company can use in the realization of relational strategies [9]. The opportunity to mobilize others as "partners" has increasingly become an emergent issue in the strategic management literature. From a resource-based perspective the importance of business relationships is emphasized by the idea that a firm's critical resources may span the boundaries of the firms itself and be embedded in inter-firm resources and routines. A firm uses resources both within the firm (firm-specific resources) and in other organizations (firm-addressable resources).

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Economics carried on several approaches to the study of organizational forms, mainly including transaction cost economics, strategic management and institutional perspective. In transaction cost economics literature various roles have been identified for management accounting in inter-firm settings that relates to specific accounting techniques and different uses of accounting information. From the economic point of view, according to the approach of transaction cost theory [30], the two fundamental ways of organizing economic activities are market and hierarchy.

The form of production coordination according to the market model is achieved when the processes are broken down into individual steps carried out by independent firms that interact with each other through exchange transactions. Price formation, through the dynamics of supply and demand, ensure coordination between the parties. However, markets often do not work perfectly. Asymmetric information, uncertainty, high asset specificity and exchanged risk of opportunistic behavior are factors that determine an increase in transaction costs and force businesses to make use of hierarchy in the market place as a mode of organization of economic activity.

The transaction analysis may lead to the adoption of quite different flexible organizational solutions which can rapidly redesign their organizational aspect as a response to changes in the external environment. One of them is represented by clusters [19]. In addition, organizational restructuring implies a large social aspect, therefore the exploited communication paradigms, patterns and policies should be presented for decision makers explicitly during that process.

Cluster (also defined as an industrial district) may be defined as a territory with a high concentration of small and medium-sized enterprises with high production specialization, generally characterized by strong interdependence of their production cycles and strongly integrated with the local socio-economic environment. Another source defines them as geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions that compete but also collaborate. The competitiveness of industrial districts derives from the particularity of production organization in form of flexible specialization for which the production cycle is divided into different phases, and each firm specializes in completing a particular stage of production, which ensures lower costs, flexibility and innovation.

So, the main element for the choice of the suitable business organizational form, in particular, clusters, is the quality of interaction, which minimal act is transaction. From this point of view DEMO [13] that stands for Design and Engineering Methodology for Organizations represents a valid support. DEMO was developed to model and analyze business processes of organizations and provide understanding of communication, information, action and organization. This methodology includes PSI-theory, that explains functioning and structure of the organization and organizational modelling methodology answering the question how to design the organizational model for your organization: what to ask and how to model. The main contribution of this methodology is the provision of the essential model of the organization using several diagramming techniques that stem from the informational, documental and organizational realization [14].

So, the analysis of models built on the methodology of DEMO allows the company to obtain detailed understanding of the processes of governance and cooperation and serves as a basis for business reengineering and information infrastructure development, consistent with the business requirements [3–6, 15].

However, for this methodology a sufficient support tool for wider professional audience usage does not seem to exist. There is only one commercial editor Xemod [31], a set of templates for Visio and editor browser prototype, but all of them are not without some disadvantages. The greatest number of gaps has been identified for a widely used set of templates for Microsoft Visio. Moreover, the DEMO methodology is still not extended to support simulation experiments, so there are no known tools or executable environment where business-analysts could conduct model validation and investigate dynamic behavior of systems for better understanding of organization design.

In view of the above mentioned, the necessity arises to develop an open platform for modelling that will provide tools for creating and editing all types of DEMO-diagrams, set up an opportunity for simulation modeling of created business processes. The platform will expand the opportunities for modeling for independent developers and integrating modeling tools with other types of information systems. Thus, with the help of the EMF technology [7], the authors developed the foundation for this open platform that supports not only the basic creation and editing of DEMO diagrams, but also provides ground for simulation in ProM 6 by converting PSD to a readable Petri Net in the pnml format. So, the main aim of this study is to provide an effective solution for creating an object-oriented diagram editor for DEMO modeling.

The present article includes four sections: review of the literature, describing of DEMO Modeler, process of simulation and conclusion.

2 Literature Review

Modern enterprises are mainly characterized by complexity and constantly changing nature and the companies are more and more focusing on their core competencies, outsourcing business tasks to their business partners. That is why the researchers try to develop a business domain model that satisfies the following requirement: it should make a clear distinction between the essential business actions and other processes, it should have the right level of detail and finally it should be complete [1]. Such business domain mode is called enterprise ontology.

Despite being largely applied, the main focus of all modern modelling languages is on graphical constructs rather than on formal semantics; for example, BPMN presents conceptual ambiguities regarding the interpretation of its metamodel. Furthermore, as people have different mental models they are likely to have different understanding of what a business model represents. This problem can be solved by using the ontological approach. According to Gruber, an ontology is “a formal, explicit specification of

a shared conceptualization" [17] and all these languages cannot provide description of organization at the ontological level.

Some researchers tried to build an ontological business model framework that could provide users (managers, consultants process-, or IS/IT-designers) with easy either to understand, analyze and compare descriptions of the business model of their enterprises [11, 20–24] or to develop approach to modelling business processes at the semantic level, integrating knowledge about the organizational context, workflow activities and Semantic Web Services [8]. However, the idea of using ontologies in the area of business process management is not new. For example, Wand and Weber have used ontologies to describe and evaluate certain aspects of modeling languages [27, 28].

DEMO, standing for Design and Engineering Methodology for Organizations is constituted by the Enterprise Ontology that is defined by Jan Dietz (the author of this methodology). Enterprise Ontology is also based on the theory of Communicative Action and the Language-Action Perspective. According to Jan Dietz, DEMO is a methodology for designing, modelling and engineering organizations. The main function of this methodology is the provision of the essential model of the organization using several diagramming techniques of its business processes (as defined by the DEMO theory), thereby disengaging from the informational, documental and organizational realization.

Various approaches have been used to provide an efficient simulation technique for the DEMO models. Discrete-event simulation approach can be successfully based on the transaction-flow view [18]. Using this method, we could present our system with discrete units dealing with limited resources, while moving through the system. DEMO's Process Model Diagram contains all allowed steps in a business process as well as their relations, which is the most suitable diagram for creating a Petri Net simulation model [26].

As a key concept at software development stage we will try to use the MDA approach [2]. The main point behind the MDA is the fact that the resulting software product will be deployed to different platforms that can be used together or separately. That is why higher-level models are developed independently of specific platform realization, in order to provide higher level of abstraction for non-programmers and concentrate on "what we develop" rather than "how we develop". In the framework of our research we attempt to divide a software product into two levels where at the bottom it includes development tools and descriptions of entities and classes, and at the top it includes general architecture of future software—a model of the DEMO methodology and the ecore_diagram based metamodel with all of entities that DEMO diagrams are constructed from.

The problem requires a lot of further investigation. In particular, it is necessary to make an attempt to diminish the disadvantages of the practical application of the methodology lying in its unsuitability for visualization of business processes dynamically using existing tools and adding new aspects to consider. The possible solution to this problem is proposed in the present study by integrating previously created graphical editor DEMO Modeler to simulation modeling environment ProM 6.

Finally, it seems appropriate to add that there is one more alternative approach for describing the enterprise architecture, ArchiMate [29]. ArchiMate might outperform DEMO in functional components, but on the other hand, it lacks guidelines for process modelling, conceptual clarity and precision, that is why some researchers integrate ArchiMate with DEMO. This fact seems to add to the importance of our research, which is aimed at filling the gaps in the functionality of the DEMO methodology.

3 Development of the Object-Oriented Graphic Editor for the DEMO Methodology

3.1 Modelling Framework

The DEMO methodology consists of four interrelated basic models that can be presented in the form of certain diagrams: Construction Model—Actor Transaction Diagram (ATD) and Organization Construction Diagram (OCD), Process Model—Process Structure Diagram (PSD), Action Model—Action Rule Specifications and State Model—Object Fact Diagram (OFD) [13]. Construction Model determines the composition and structure of the organization. Construction Model is composed of two parts: Interaction Model (IAM) and Interstriction Model (ISM). IAM defines the types of transactions in which actor operates as an initiator or an executor. IMS defines the relationship between actors in the organization and information banks that actors use. Process Model describes a pattern (patterns of action) for each transaction, specified in the Construction Model. Action Model defines the rules of actions for each actor. State Model specifies entities and production facts of organization. All these models are closely related to each other and each of them complements others. Therefore, this is one of the reasons why the authors have implemented all these diagrams (ATD, OCD, PSD, OFD) in our editor.

When developing a DEMO-modeler, the Model-Driven Architecture (MDA) approach for software design was taken as the basis. Its main idea is to construct an abstract metamodel of management, exchange of metadata (models) and to establish the method for its transformation into a technology-supported programming (Java, XML, etc.). As a technology for developing the MDA approach we have chosen the Eclipse EMF (Eclipse Modeling Framework) technology [7] that is the core of Eclipse Modeling Project. Eclipse EMF is a tool for creating models and code generation for building tools and other applications based on a structured data model from the model specification prescribed in XMI. Using the EMF technology facilitates expanding the project and integrating it with other projects.

Eclipse Modeling Project (EMP) [16] enables creating a new language for the finished graphic editor without writing an additional code “by hand” using EMF as a tool for development and storage models.

3.2 Description of the Implementation of the DEMO-Modeler

Following the logic mentioned before, we built the ecore-model for diagrams ATD, PSD, OFD and OCD. Example of the ATDecore model is presented in Fig. 1. This allows us obtaining an initial version of the editor, which contains all the basic elements of diagrams, gives an opportunity for building diagrams, but has a number of shortcomings: in particular, it is incorrect display of a number of elements in each diagram. That is why we had to resort to correcting code for these items manually.

Having generated the code with the use of the EMF technology, relying on the obtained Ecore-metamodel, we decided to start from the implementation of the first opportunity for integration and re-usability of different elements in the work. Based on the analysis of the relationships between the models were identified three types of common elements: Actors, Transactions and Boundaries; for each of these this option could be provided. Under the current version, we have implemented an integration scheme ATD → PSD, ATD → OCD, ATD → OFD. The full integration is further expected (related diagrams will be updated in base of any stored diagrams).

All the obtained schemes can be represented as follows (Fig. 2). The scheme contains objects of the ATD diagram and "appropriate" to them objects of other diagrams within the previously selected groups. In other words, this table shows clearly, what objects in other diagrams are created through the establishment of a related ATD diagram.

The suggested editor could not be used without expanding its source java-code and adding of new functionality. However, Java-code, that was generated using the EMF technology, on a structured data model, turned out easy and convenient for expansion. The resulting version of the editor presented in Fig. 3.

In terms of Enterprise Engineering, building a well-designed model is impossible without verification, validation and testing of the model. Thus, providing an opportunity for automated translation of created model into anything directly executable that

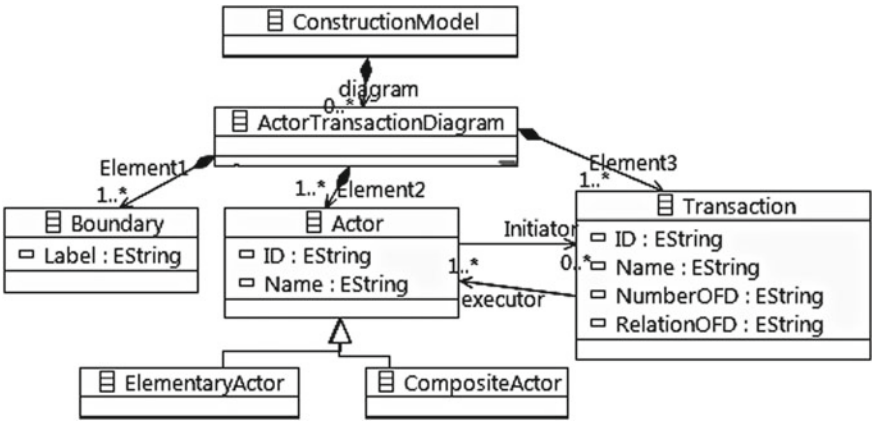

Fig. 1 The model for ATD

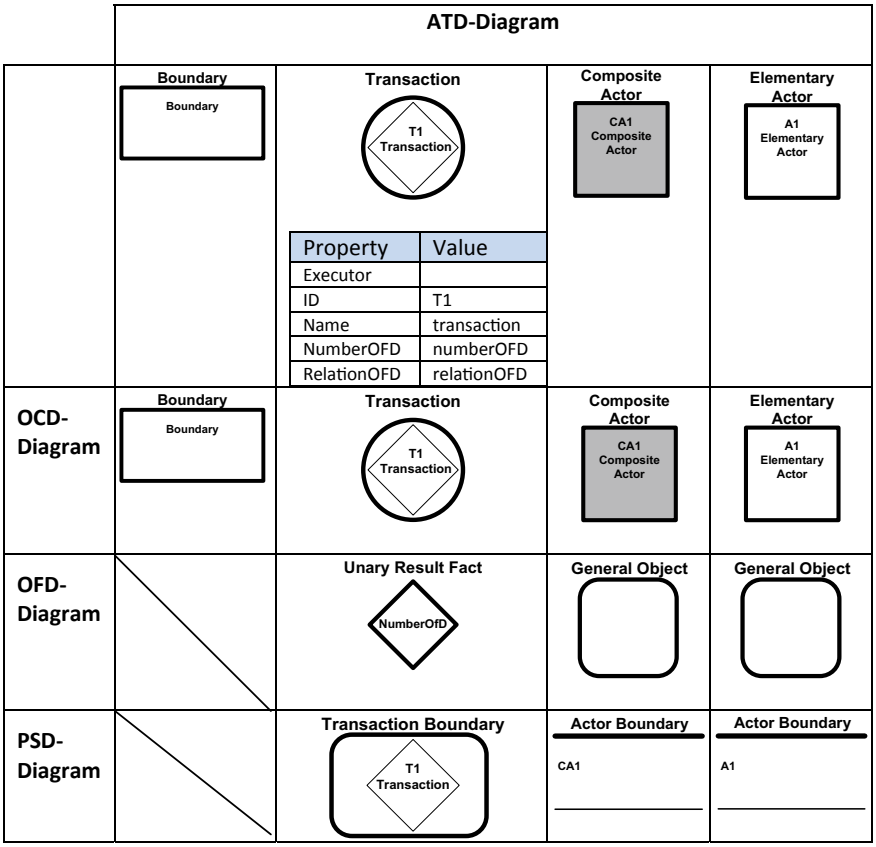

Fig. 2 Integration scheme ATD → PSD, OCD, OFD

can be used for these three processes becomes significant. Moreover, a high-level conceptual model like one of DEMO's cannot be verified and validated automatically, and requires human factor.

In order to solve the problem without making any changes to the methodology itself, it was decided to use the method of translating models into Petri nets proposed in [26], automate this translation and ensure the preservation of the obtained nets in a format that is received by one of the most widely supported tools—ProM 6.

The reasons why the authors have chosen a Petri Net based workflow system for modeling were formulated in [25], where the following three strengths are emphasized: (1) formal semantics despite the graphical nature; (2) state-based instead of event-based; and (3) abundance of analysis techniques. All these reasons can be reduced to one: proved suitability for simulation of Petri Nets. Moreover, in [12] it is stated that the most valuable advantage of Petri Nets lies in the fact that they can be directly executable, so the models can be easily used to examine the behavioral aspects of the modeled system during simulation.

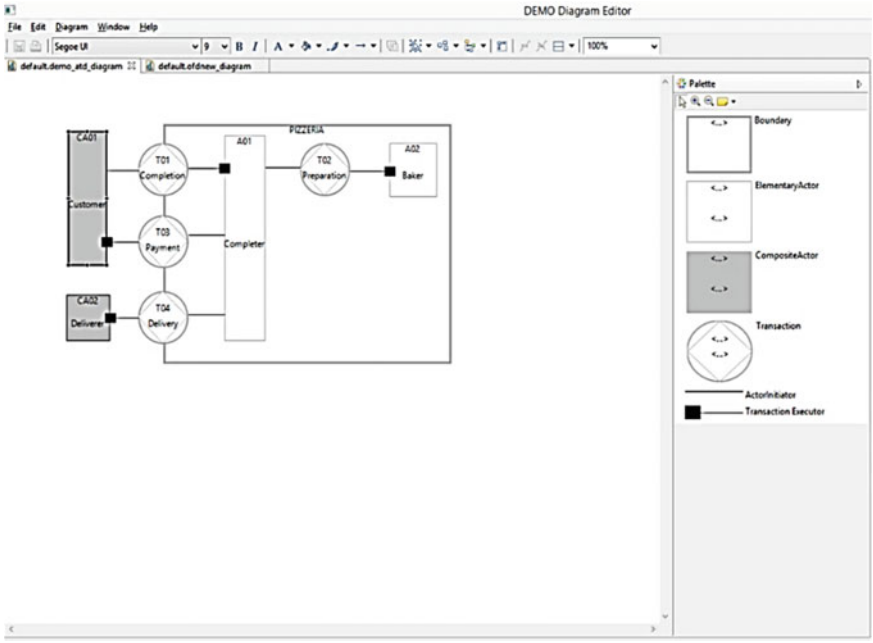

Fig. 3 The final version of the editor ATD diagram

The reasons for choosing ProM 6 lie in the broad functionality offered by this tool, which includes not only performing a simple simulation, but also configuring visibility of transitions, creating configurable Petri nets, Nets with data, discovery of the process data-flow (log file is required) and more than two dozens of other different functions. In addition, this tool is the only free one among the tools with a similar functionality (i.e. Celonis Discovery, Discovery Analyst, RapidProm), it is being actively developed and independent developers constantly supplement it [10].

Under the current version of the DEMO Modeler only the basic cases for transactions were developed, as not all of the proposed translation templates will be needed in further translation into a Petri Net. Particularly, we do not provide an opportunity to create optional transactions or to designate multiple execution of a transaction, therefore corresponding templates are not actual for us.

We will consider the following behavior patterns proposed in [26]: basic transaction pattern, standard transaction pattern, self-initiated transaction, request & no wait, request & wait for completion of request, request & wait for promise.

According to the presented translation schemes for each transaction, several steps are to be made in order to create a Petri net. Initially, the relationships between transactions are analyzed by the tool in order to determine automatically the appropriate translation template.

The analysis of connection takes place on the basis of the created XML files containing information about the objects drawn: IDs, labels references and so on. To

use the translation, it would be required a non-mandatory for a typical usage tag "parent". The tag "parent" is intended to specify transaction each Starting Process Step, Ending Process Step and Execute Transaction object refers to and represents just an ID of "parent" transaction. Using this tag, the tool identifies exactly what pattern should be used analyzing relations between transactions, simply observing to what element of transaction what kind of link refers. After performing the analysis, each transaction is translated to the corresponding Petri Net part according to templates mentioned above. The resulting transaction represents a node of XML document, containing id, label, activity, appearance characteristics: color, position, dimensions. The construction of each pair of consecutive transitions is accompanied by the addition of a place that has the approximate form. Also, each link is also transformed to a node and after generating all transitions, places and arcs, we add an end transition.

Thus, we get ready to be loaded into ProM 6 or any other tool that supports the pnml format Petri Net, derived from Process Structure Diagram of DEMO. Actors are ignored in the current version, but their automatic conversion will be also developed.

In order to supplement DEMO with diverse performance measures attached to entities, optional attributes for each of them have been specified. Moreover, each actor role is supplemented with a resource name. In substance, actor roles (actor boundaries) in DEMO are high-level entities useful for conceptual modelling, but they are inapplicable in simulation modelling. For simulation, it is supposed to access the availability of resources which influences waiting times and other variables, and several actors can represent one real entity in fact with its own capacity and quantity. That is why, within DEMO Modeler each actor can be attached to a group of resources or can represent a group by itself, also it can contain a number of real actors and capacity (number of transitions that can be executed in one moment of time). That way, availability of resources can be easily estimated by allocating real resources to each transition in corresponding Petri Net.

Lastly, decision rules for choice point were added as optional attributes for transactions. Actually, these decision rules are also sometimes indicated in Action Rules Specifications, and the modeler can simply transfer them from one model to another. If not, they can be additionally detected or omitted.

To sum up, the resulting Petri Net, either supplemented or not supplemented by the elements indicated above, can be used for ProM simulation experiments anyway, for building other based on Petri Net models, provided by the tool (i.e. configurable Petri Nets, Petri Nets with data), or may be translated into other notations (like BPMN), supplemented and analyzed with other proposed techniques (i.e. conformance checking or operational support).

3.3 Example

In this section, we provide an example of automated translation of PSD diagram to a Petri Net of a well-known Pizzeria case in more detail. Firstly the PSD diagram created in DEMO Modeler (Fig. 4) is presented.

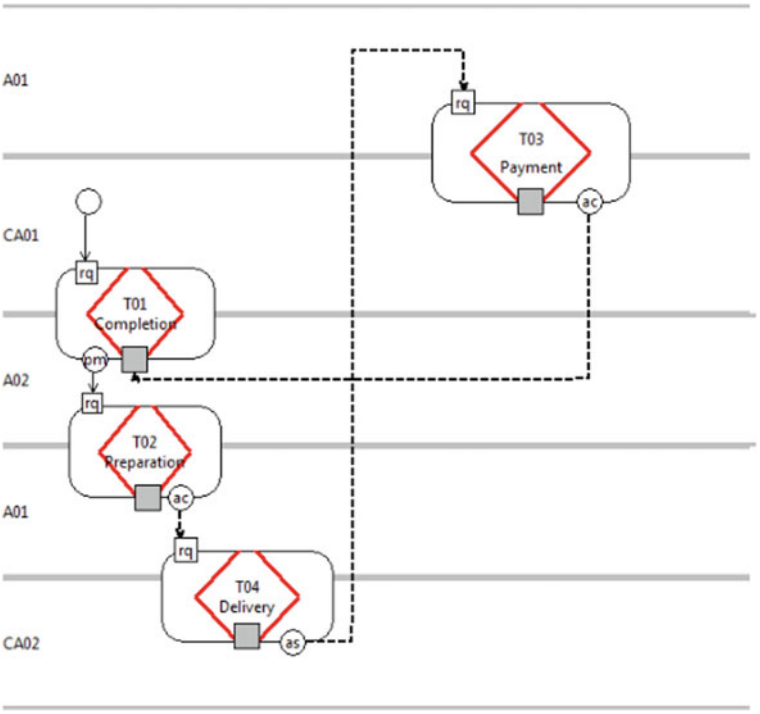

Fig. 4 PSD diagram created in DEMO modeler

Firstly, we have to isolate transactions and analyze the connections between them. We also store their order for the subsequent generation of places and arcs. After analyzing connections and generating transaction nodes, we create a source place (it must be Initial Marking for ProM 6) and places for each two connected transactions. When places, transitions and stored connections have been obtained, we add an arc to each trinity "transition—place—transition". We also store actors and then use the information about them to transform our net and visualize it taking into account actor roles (currently represented only as determining the location of transitions factor). Below is the result of importing our pnml-net to ProM 6 (Fig. 5).

This is the view of our Petri net. Therefore, we can use all the features provided by this free tool to analyze, complete or edit our Petri net, opened to simulation, bottleneck analysis, conformance checking, and dozens of other useful features.

For instance, after uploading a pnml file generated by DEMOModeler to ProM the user can perform a simple simulation of a (stochastic) Petri Net. This kind of analysis provides user with an artificial log readable by the DEMOModeler. All the options entered to conduct an experiment are stored in a specific ProM file and can be easily extracted from it to be shown in the DEMOModeler. Results gained in such an experiment are also stored in a file, thus they can be uploaded and opened in the DEMOModeler. In other words, the DEMOModeler is able to parse, open and store

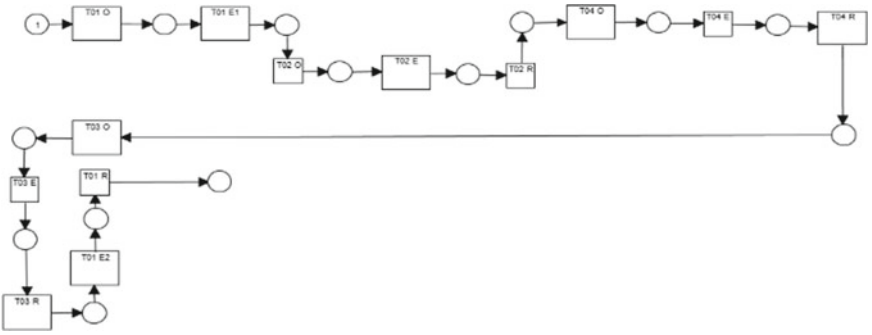

Fig. 5 The result of importing pnml-net to ProM 6

compressed mxml files generated by ProM and other tools, and present them in the form of a regular table. After uploading the mxml file to DEMOModeler, it can be attached to the model for further usage, so every time a modeler proceeds to opening or editing the model processed by ProM, he can view previously gained results. This part of the interaction is subject to further improvement during the product development.

The automated translation of PSD diagram into the specific Petri Net Markup Language, supported by ProM (pnml), provides the user with a wide range of other opportunities. First of all, ProM 6 supports conversion of Petri Net to a BPMN model, so our DEMO model becomes a BPMN one in two steps without any complexity or additional constructions and without supplementary time spent on (re)modelling. Secondly, many other tools, such as ePNK, PNML Framework, Petri Web, Coloane, etc., claim support of the PNML Standard, thus automatically generated in the DEMOModeler files can be easily used in an escalating number of tools. Therefore, we see that the usage of this format opens many other opportunities for DEMOModeler users.

4 Conclusion

Different studies confirm that the strategies of successful clusters are cooperation with other companies up to the establishment of business networks across the territory, the joint effort aimed at applying product and process innovations, common marketing and internationalization strategies, the limited location, synergies with universities and research centers, and collaboration with social partners. From this point of view DEMO methodology, having transaction a as a basic element for business modelling, represents a valid tool for designing and analyzing clusters.

We have designed and developed a domain-specific modeling editor for visual creating and editing DEMO models and providing the process of organization modelling for wider professional audience usage with essential characteristics

currently ignored by other tools supporting DEMO methodology. While designing and developing a DEMO Modeler all the problems mentioned above were successfully solved (i.e. inconvenience in dividing the full transaction instrument in template for PSD, the lack of dotted line for PSD, the presence of redundant elements, no opportunity of simultaneous working on several diagrams, lack of plug-in for OCD, outdated methodology diagrams, etc.) Moreover, an attempt has been made to diminish one of disadvantages of discussed methodology—absence of opportunity for conducting simulation experiments. The applied changes assist to conduct simulation experiments, while do not have a significant impact on the ontological representation and do not distort it.

There are several points that should be mentioned as advantages of the developed software: opportunity to create and edit all DEMO diagrams, integration of models in order to avoid duplication of entities, support for the latest version of the methodology (3.6c), user friendly interface, opportunity of simultaneous working on several diagrams, presence of severe restrictions on the combination of elements, opportunity of simulation (availability of automated translation PSD diagrams in Petri Net for further analysis using tools supporting pnml format).

Among other advantages: extensibility of the editor due to the use of the EMF technology, opportunity of integration with other Eclipse projects, unified information model for all components.

The results of the current investigation allow us to observe the business processes of the cluster dynamically and, to identify their bottlenecks.

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Process of Technological Innovation Management in a Manufacturing Company: Assessment and Improvement

Olga Dolganova

Abstract In the modern world, to ensure their competitiveness, organizations are forced to continuously improve their activities, especially through the implementation of innovative technological products and services. This paper presents an approach to assessing the innovation management process of a manufacturing company. It also formulates the areas for improving this process on the example of medium production enterprises in Russia. The TIPA process evaluation method is used as the basis of this approach. In analyzing and formulating recommendations for improving the process, the reference models, methods and frameworks are used: COBIT 2019, PCF APQC, Capability-Based Planning and TOGAF Standard, Agile—Stage-Gate method. Based on the experience of conducting this assessment at 3 Russian manufacturing enterprises, recommendations are formulated on the application of this approach. The main directions of improving the process of technological innovation management are also identified.

Keywords Innovation management · Process assessment · TIPA · COBIT · PCF APQC · Enterprise architecture · Agile–stage-gate

1 Introduction

The practice of implementing the innovation management processes and creating new products in manufacturing companies shows that those who have described and tuned this process are two to three times more likely to succeed [1]. Leading companies have a formalized process of managing a new product from idea to launch (new-product development projects from idea to launch). Various researchers notice that traditional development methods no longer work effectively, because they do not allow proactive responses to changing conditions and requirements. Leading-edge companies are switching to the Agile-Stage-Gate hybrid model, as it retains a stage system to support structure and control, while allowing for a flexible development

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approach, providing the required high rate and productivity of implementation of innovative solutions [2].

The aim of this work is to determine the optimal approach to assess and improve the process of managing the technological innovations of a manufacturing enterprise. Therefore, two key questions are formulated:

1. What approach should be used to evaluate the innovation management process?
2. Which reference model is best suited for constructing the target state of the process of a given process?
3. Which improvement path is the most preferable for the innovation management process of an average manufacturing company?

In the main part of this article, in Sect. 1, we analyze scientific research and practical experience in the field of evaluating innovation management processes and developing a new product. It discusses modern standards in the field of process management and IT management, reference models and frameworks that contain recommendations for the study, evaluation and improvement of business processes and IT processes. Section 2 describes the proposed approach to process evaluation. Section 3, using the example of three medium Russian manufacturing and trading companies, shows how the above approach was applied and what results were obtained.

Approaches to the assessment and improvement of management processes.

Technological innovations represent the key tools for achieving strategic goals, capturing the best market positions or entering new markets for goods and services. For companies that adhere to the "Value Innovation" concept, innovation is necessary to create new markets and re-evaluate the existing ones [3]. The organization of innovative activities in the company has for a long time been an object of close attention. M. Hammer has developed a number of recommendations on the effective implementation of innovations, on procedures of auditing the processes [4–6].

Multiple approaches and methods for assessing and improving the business processes have been formulated to date. Different methods of improvement were proposed by Harmon [7], Madison [8]. However nowadays, when the conditions in the external and internal environment of the company change very fast, these approaches are not so efficient. Therefore a need has arisen for more flexible methods of evaluation and improvement.

Various approaches are used for these purposes in production companies. They are proposed in intersectoral and specialized frameworks and standards, for instance the ISO / IEC 33002 [9], the CMMI [10] family of models, COBIT PAM, COBIT 2019 [11], TIPA [12], Enterprise SPICE [13] and Automative SPICE [14]. Each of these standards has its own characteristics of application, and was originally developed for specific industries, but today they all have an intersectoral character.

For example, TIPA complies with the requirements of ISO/IEC 33002 in process assessment (standard scale and evaluation method, standard maturity scale, standard aggregation method) [15], and also with ITIL in terms of planning IT service management and improving IT processes [12]. When the processes related to technological innovation are concerned, such a two-fold compliance becomes an important

advantage in choosing the assessment method. The disadvantage of TIPA is the lack of coupling with the principles of Enterprise Architecture [16]. This makes it difficult to plan changes in accordance with the strategic goals of company and the key architectural factors. This deficiency can be compensated by using the concept of Capability-Based Planning and the ArchiMate Standard for coupling the Enterprise Architecture. This will allow to simulate the dependencies between the capabilities, which is very important when forming the roadmap of transformations [17].

The procedure of evaluating the process can be conventionally divided into two kind of work [13]. One work consists in comparing the current process with reference models, recommendations from industry and government regulatory organizations, and best practices. The second work is identification of areas for improvement of process under investigation using maturity assessment models or opportunity assessment models.

The following models and classifications can be considered as reference basis: ISO / IEC 15504-2; intersectoral or specialized process classifiers, such as PCF APQC; industry reference models, such as: COBIT for IT processes, SCOR for supply chains.

In the course of analyzing the organization of the process under investigation, it is necessary to study the principles and methods of management, and evaluate how they correspond to the goals and objectives of the company and how they will assure the required level of productivity and effectiveness.

In the field of technological innovation management and creation of IT products and services, the key requirements for the processes of development and implementation are the speed and the compliance of result with consumer expectations. To ensure the agreement with these requirements, companies are forced to use flexible multi-iterative methods of managing the products and services. Such concepts and methods include Len Startup [18], Agile [19, 20]. In manufacturing companies, the management of technological product development is also increasingly shifting to flexible techniques. For instance, the use of Agile–Stage-Gate hybrid method allows increasing the rate of development of innovative solutions and providing the required number of iterations to achieve the customer satisfaction with a found solution [2].

2 Development of an Approach to Assessing the Process of Innovation Management

An approach to assess the process of innovation management was developed for medium-sized manufacturing companies whose main activity is not related to providing the IT services. In order to remain competitive, they are developing new sources of value. Among them are automation of customer interaction, marketing and consumer processes [21], as well as improvement of production management processes using IT.

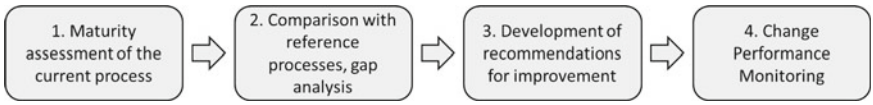

Fig. 1 Key stages of the adapted TIPA method (Class 2)

In this paper, we are talking about medium-sized manufacturing enterprises, to which we conventionally classify companies with revenues of 1–2 billion roubles a year and a staff of 250–1000 people. Most of these enterprises have already the partially or fully described business processes. However, they are not prepared to incur significant expenses for the use of CMMI or other large-scale and paid tools of analysis and evaluation. Therefore, a more accessible methodology, like TIPA, may be the most suitable option.

Of the 3 TIPA classes, the class 2 was chosen, since it is designed to assess the maturity of individual processes and is focused on evaluating and improving processes to achieve the company's internal goals [22, 23], which represents the scope of this paper.

As part of the adaptation of this method to assess the innovation management process of an average company, some simplification was introduced in the procedure. Thus, the proposed approach presents 4 key stages, which are shown in Fig. 1.

Stage 1. Maturity assessment of the current process. In order to determine to what extent is the process formalized and implemented, the proposed model of assessing the possibilities COBIT 2019 can be used. It is based on one of the most common approaches to assessing the capabilities and capabilities of CMMI. At the same time, COBIT 2019 is an open framework that includes, in addition to the reference process model for IT, the recommendations on assessing the maturity and possibilities [24]. These recommendations are developed not only for processes but also for other components of practices. This allows a more detailed assessment of the studied area of activity.

Step 2. Comparison with reference processes, gap analysis. Consumer Products Process Classification Framework APQC (v.7.2.1.) proposes to systematize processes and activities by kinds of activity in the organization [25]. So, as part of the Define and manage technology innovation process, it provides 7 activities:

«Establish selection criteria for research initiatives,
«Analyze emerging technology concepts,
«Identify technology concepts and capabilities»,
«Execute IT research projects»,
«Evaluate IT research project outcomes»,
«Identify and promote viable concepts»,
«Develop and plan IT investment projects».

COBIT 2019 recommends implementing 6 practices as part of innovation management [11]:

«Create an environment conducive to innovation»,

«Maintain an understanding of the enterprise environment»,
«Monitor and scan the technology environment»,
«Assess the potential of emerging technologies and innovative ideas»,
«Recommend appropriate further initiatives»,
«Monitor the implementation and use of innovation».

In PCF APQC, innovation management activity is implemented in the framework of environmental assessment, as well as in the process of identifying and evaluating strategic options for achieving the organization's goals. This is partly in line with the recommendations of COBIT 2019. However, this kind of activity is splitted into different categories of processes: strategic management and IT management. COBIT identifies a separate group of practices which are proposed for implementation to solve the problem of innovation management (APO04). However, this framework is designed specifically for the governance and management of IT in the company. For the type of organization under consideration, the management of technological innovation is of broader importance, as it is demonstrated in PCF APQC. Therefore, we propose to use a reference model that is built on the basis of two frameworks described above. Figure 2 presents the sequence of processes of the developed reference model.

Table 1 describes the activities in the framework of these processes.

Stage 3. Development of recommendations for improvement. As one of the key recommendations for improving the process under study, we propose to switch to the Agile hybrid management method—Stage-Gate. In a traditional Stage-Gate structure, the Agile method can be embedded in different ways [2]. For medium manufacturing companies we recommend to implement the innovation management process according to the Stage-Gate model [1, 2, 26, 27], and to use Agile at the stage of product development and testing. A complete transition to Agile, or its application at the first stage of implementation of the studied process is impractical. This is due to the fact that the instability that accompanies the Agile approach, the lack of necessary competencies inside the company and skills to work in this mode will not allow to bring the project to the development stage, or they will significantly

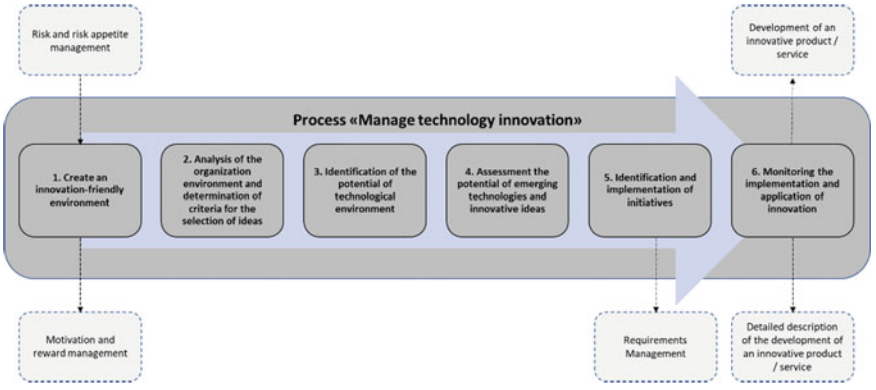

Fig. 2 Model of process «Manage technology innovation»

Table 1 Activities of process «Manage technology innovation»

No.	Subprocess	Activity
1	Create an innovation-friendly environment	Create an innovation plan Provide infrastructure for innovation Encourage innovation ideas from staff, customers, suppliers and business partners and move ideas forward
2	Analysis of the organization environment and determination of criteria for the selection of ideas	Analysis of the driving forces and challenges of the industry and a specific organization Analysis of the advantages and disadvantages, bottlenecks and advantages of the current activities of the organization Defining selection criteria for innovative ideas and suggestions
3	Identification of the potential of technological environment	Identification of key elements that ensure the competitive advantage of the company (potential value) Determining the organization's needs for innovations and the opportunities to implement them Organization of the collection of ideas and suggestions of employees of the organization and external stakeholders
4	Assessment the potential of emerging technologies and innovative ideas	Select ideas that are consistent with the goals and objectives of the organization for detailed consideration Evaluate identified technologies Identification of problems that need to be solved before the start of the implementation of the innovation project Determining the necessary resources for the implementation of the initiative Organize a preliminary review of the viability and effectiveness of the proposed ideas
5	Identification and implementation of initiatives	Documenting the results of testing ideas and suggestions Analysis and generalization of the causes of deviations Preparation for launching the implementation of accepted initiatives
6	Monitoring the implementation and application of innovation	Verification of the compliance of innovations with the organization's goals Assessment of development opportunities Analysis of the applicability and effectiveness of the implemented innovation

increase the implementation time of this process. With the current implementation model the better results can not be achieved either. A hybrid method allows reducing the implementation time of an initiative from an idea to a finished product by 20–30% [2].

Stages provide a capability of monitoring and managing the processes of identification, selection and implementation of innovative projects. Gates represent the decision-making points to determine ideas for implementation, timing, resources, analyze the progress of implementation. However, the formulated results, assessments, and metrics have rather general character, are not detailed, that provides the possibility to maneuver and brings flexibility in implementation and adjustment.

Step 4. Change Performance Monitoring. For permanent improvement in technological innovation, it is important to ensure that the procedure of process assessment is cyclical in accordance with the TIPA method. It is necessary to monitor with a certain frequency the effectiveness of changes, to assess the achievement of specified indicators, and based of the data obtained, take a decision on further actions at a new cycle of process improvement.

3 Application of the Developed Approach in Russian Manufacturing Enterprises

This approach has been tested in three manufacturing companies: the production of office furniture; production and sale of equipment for cash processing and storage of valuables; and production, implementation and maintenance of transport systems. All studied companies are approximately equal in scale and turnover. In addition, each of them is a niche leader. However, they all experience difficulties in developing their innovative component. The results of the assessment are broadly similar. There are discrepancies only in the details of the implementation of subprocesses and operations. Therefore, we will consider the features of the proposed approach by the example of a manufacturing and trading company that produces and sells the office furniture.

The company's management formulated the task to improve the innovation management process to create conditions for the continuous development of the portfolio of products and services, through the introduction of new IT solutions. The proposed approach to assessing and developing directions for improving the change management process has been successfully applied in this situation.

A study of the current innovation management process showed that the process achieves its original goal by performing a predefined set of actions. This corresponds to the 2nd level of possibilities [24]. The maturity also corresponds to the 2nd level, given the presence of process control operations, interest in improvement, process performance monitoring, but the latter procedure is not standardized. Thus, the next step is to improve the process through organizational changes.

As a result of the assessment in accordance with class 2 according to the TIPA method, the following artifacts were developed: a list of detailed conclusions for the process under study and its subprocesses; model of the current and target processes; recommendations for improving the process and the main results that should be achieved as a result of the implementation of the proposed changes.

Create an innovation-friendly environment. Activities to create an environment in the organization that will contribute to the development and implementation of innovations should be guided by the risk appetite of the company's management. Therefore, it is important that the results of the risk assessment of the company and possible ways of its development [11] be considered.

In addition, creating an innovative and supportive environment in a company is difficult without appropriate motivational support. Various tools should be used to reward and encourage innovative activity of employees, putting forward the ideas and proposals for improving business processes, developing new products and services.

To support this activity, the production holding company under consideration introduced an information system that allows it to collect and manage the ideas and initiatives of the company employees. In addition, this solution provides a classification of ideas according to the goals and areas of the organization, managing the status of proposals and tracking their implementation. It also provides the ability to manage incentives and rewards for innovative activity.

Analysis of the organization environment and determination of criteria for the selection of ideas. Innovation activities shall comply with the company's strategy and its limitations with a clear understanding of environmental trends: competitors, customers, regulatory agencies and the social atmosphere. At this stage «Establish selection criteria for research initiatives» [25] should be defined. The formulated recommendations can also be implemented through an IT solution that supports the collection and management of innovative proposals in the company.

Identification of the potential of technological environment. As part of the analysis of the possibilities and potential of the proposed innovative technologies, it is important to use the knowledge and opinions of stakeholders in the field of current IT infrastructure and possible directions for its improvement. It is necessary to determine: the business potential of the proposed IT solution, development and implementation time, risks and the possibility of ensuring compliance with regulatory requirements, possible ways to incorporate into the enterprise architecture (problems and necessary changes).

The proposed Agile-Stage-Gate hybrid model requires a new take on the process. The formed plan and schedule for the implementation of the initiative will have a rather high-level description that will allow maneuvering with time, while making it possible to estimate the costs of the project. This estimate is very rough, which entails some uncertainty. But if the task is to quickly introduce innovation, then it is necessary to take the appropriate risks.

Assessment the potential of emerging technologies and innovative ideas. It is important to determine the prospects of these IT solutions, the possibility of development, scaling, building functionality, etc. In addition, it is important to consider the effectiveness of the application in a particular organization. Performing this process

will allow generating data for the development of a high-level description of the proposed solution and its inclusion in the organization's architecture, as well as for determining the necessary requirements for the implementation of this innovative proposal.

When developing innovative solutions using the Agile-Stage-Gate approach, the focus is on the result and productivity of the developed technological solution. Therefore, to evaluate the improvements made, appropriate metrics should be formulated. These metrics can further be used for assessment of the effects of innovation.

Identification and implementation of initiatives. This stage is highly desirable to ensure continuous ongoing innovative development of the organization. Evaluation of the results of initiatives gives an idea of the best practices within the organization, the effectiveness of the application of certain IT solutions. This allows you to develop sound recommendations for adjusting the directions of innovative development, evaluation criteria and the selection of ideas for implementation. It will also improve the quality of decision-making at the beginning of the process of technological innovation management.

Monitoring the implementation and application of innovation. User experience, the rapid development of technology and IT services forces organizations to constantly improve IT services and products. This leads to the fact that it is already becoming impractical to use the traditional life cycle, such as a "waterfall", for developing innovations, and it's time to switch to the more flexible methods. They allow to manage and improve the product continuously. Therefore, it is recommended that the classic requirement of deep preliminary design be replaced by the development of a Minimum Viable Architecture (MVA). It defines the minimum set of architectural solutions and infrastructure capabilities that determine the beginning of the first (or next) flexible iteration [28].

To provide a link between the recommendations obtained by evaluating the process using the TIPA method and the principles of organization architecture (principles of Enterprise Architecture), a model was developed that demonstrates the relationship between the strategy and the plan of changes in the enterprise architecture based on improvement opportunities (Fig. 3).

A similar model, implemented in ArchiMate notation, allows to schematically present proposals for improving the process, the necessary resources and goals that this improvement will achieve. Thus, by means of Capability-Based Planning [17] and the TOGAF Standard method [29], it is possible to ensure the desired coordination of projects to change the company's activities and IT within the framework of architectural design.

4 Conclusion

The innovative activity of manufacturing companies today is the key to their competitiveness. Therefore, it is important to create the conditions for effective innovation management. For this purpose it is necessary to ensure the identification of the best

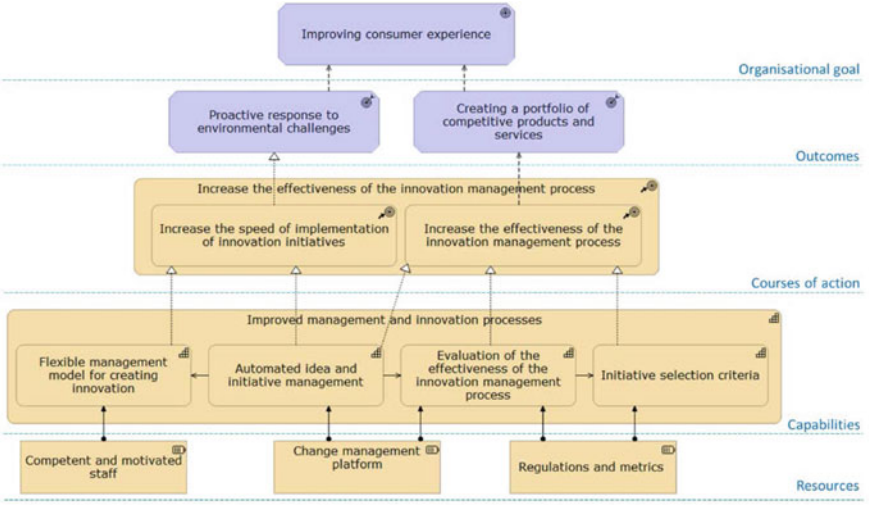

Fig. 3 Goals and opportunities for improving the process of innovation management

innovative ideas which, following the implementation, will achieve the strategic goals of the company; and rapid development and implementation of new technological products and services. To evaluate the current process and identify areas for improvement, it is recommended to use a combination of assessment and analysis methods for the current innovation management process adapted to the specifics of medium production enterprises. To identify key assessment steps, the TIPA method is proposed for use. To analyze the compliance of the process with best practices, a reference process model based on PCF APQC and COBIT 2019 has been developed. It is recommended to use the Capability-Based Planning method to coordinate the recommendations formulated for improving the process with the existing Enterprise Architecture.

This approach provides the opportunity for continuous improvement of the process, which is extremely important for the stable and confident development of an average production company.

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Analysis of the University's Supporting Business Processes Using Process Mining Methods

Mikhail Dorrer and Alexandra Dorrer

Abstract In this work, the problem of analyzing the effectiveness of the university's supporting business process on the example of the process of preparing and issuing orders and instructions formalizing the organizational status of students at the university was solved. This business process is quite critical for the university because of its high complexity and significant legal risks that arise if the process is performed with errors. To analyze business processes, we used the Process Mining methodology and ProM software. As the initial data, we used the event log of the automated university management system for 5 years, containing 195,928 events for 9366 students. As a result of the analysis, failures and errors in the business process under study were identified, which concerned both failures in its implementation (repetitions, errors) and the organization of the provision of educational services (a high proportion of students whose learning path differs from the most rational one). Suggestions for improving the work were formulated. The results of the work testify to the high efficiency of the application of Process Mining methods to the improvement of university's supporting business processes.

Keywords Business-process · Process mining · Process improvement · Education

1 Introduction

Process mining—a technology based on the actual use of business processes [1, 2]. Process models based on the actual behavior of systems are usually very different from models developed by humans. It often happens that when testing, significant discrepancies are revealed between a manually constructed model and the behavior of a real system.

The main idea of the analysis of processes is to identify, track, improve and eliminate errors of real processes in the enterprise, extracting data from event logs. They represent the actual implementation of business processes through user interaction

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with information systems. Based on the analysis, decisions can be made on adjusting the company's business processes or to the settings of the information system.

This technology is used in many industries, and there are works devoted to the analysis of the processes of educational institutions. So, in [3, 4] the processes of providing educational services are investigated. These and similar articles form an area of research such as EPM—Educational Process Mining.

Thus, the aim of the work is to analyze the business processes of an educational institution of higher education on the example of Vyatka State University [5] using Process mining using ProM software [6].

However, for an educational institution, it is important not only the main business process—the provision of educational services. The performance of the university, like any organization, is largely determined by the effectiveness of supporting processes. In this paper, it is proposed to use Process mining methods for the analytical processing of the business process of preparing and issuing orders and instructions that formalize the organizational status of students at the university. The practical significance of this work lies in the fact that this method can be used to identify failures and errors in this process, to track the causes of problems and errors in the business process, and to formulate proposals for troubleshooting.

2 Method

The main idea of the analysis of processes is to identify, track, improve and eliminate errors of real processes in the enterprise, extracting data from event logs, which are the starting point for this technology and contain information about events that occur during the execution of a business process [1].

Discovery of a process or reverse recovery of a business process consists in reconstructing a model without using any a priori information, based solely on events protocol records.

The conformance checking consists in checking the reality displayed in the protocols with the model of the business process itself and vice versa. Note that in this procedure, different types of models can be taken into account, i.e. conformity checking can be used for procedural models, organizational models, descriptive models, business rules/policies, laws, etc.

Conformity checking algorithms help identify gaps between simulated and observed behavior. They calculate compliance rates and provide diagnostic information to explain observed differences. Using algorithms of this type, it is possible to analyze in detail the use cases that do not correspond to the constructed model.

At the stage of refinement of the model (enhancement), the analyst improves or supplements the initial model of the process, using the data from the protocol of events.

An analysis of the university's processes was supposed to answer the following questions:

What will the university's business process model look like based on collected event data?

Does the constructed model correspond to the logical model of the educational institution?

What are the most frequent routes?

Do model routes match the event log?

All calculations in the work were performed using the ProM program [6].

3 Results

3.1 Initial Data

In this work, to analyze business processes using the Process mining method, an event log was used, which was collected by the Vyatka State University staff about students from July 2003 to December 2016.

The event log for this process contains 195,928 events. They are combined in 9366 chains of processes (of which only 9241 are complete), each of which corresponds to a sequence of actions in working with one student for the entire period of his studies at the university.

3.2 Event Log Primary Processing

Figure 1 shows an example of an analysis of the event log with the allocation of cases—chains of events, each of which is associated with an individual student.

Fig. 1 Displaying cases as event streams

Each case is presented in the form of streams of triangular events. The color of events describes their frequency. Green is a very common event, red is rare.

3.3 Building and Analyzing a Network of Events

To build a model of event dependence in this work, a heuristic algorithm was used, implemented in the plugin "Mine for a Heuristics using Heuristics miner" [6, 7]. This algorithm is a modification of the alpha algorithm. The stages of the algorithms coincide almost completely. But a significant difference is in the simplified approach to the compilation of ordered event relations.

Figure 2 shows the plugin parameters used in processing the university event log.

After configuring the plugin parameters, a heuristic network of processes was built from this event log.

Without even considering the model in detail, you can see that it has an excessive number of start events. In practice, there are not so many of them, the set is limited to various options for entering the university and transferring from other educational institutions. This situation is explained by the fact that at the beginning of the formation of the event log some students were already enrolled and the first event that was introduced about them was the starting one.

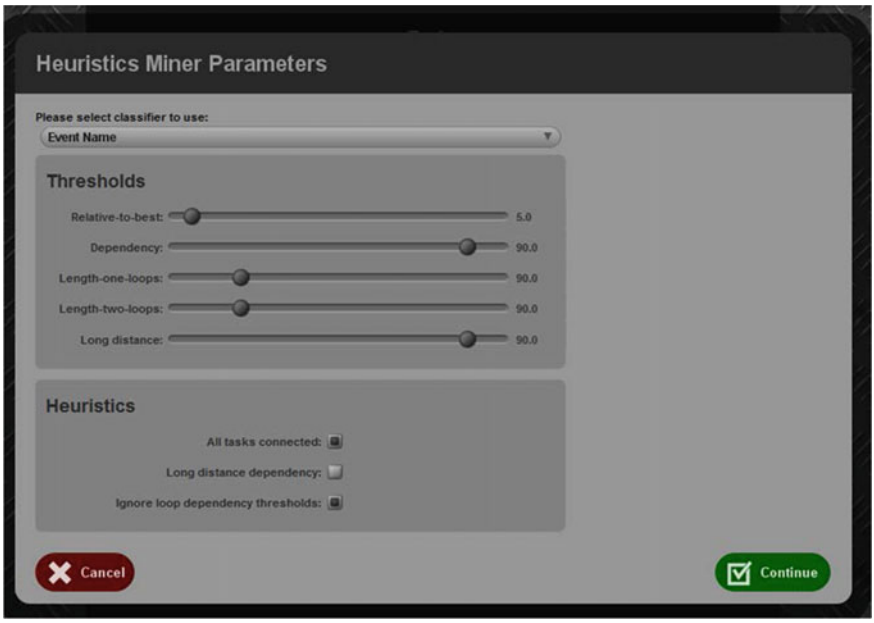

Fig. 2 Parameters of the mine for a heuristics using heuristics miner plugin

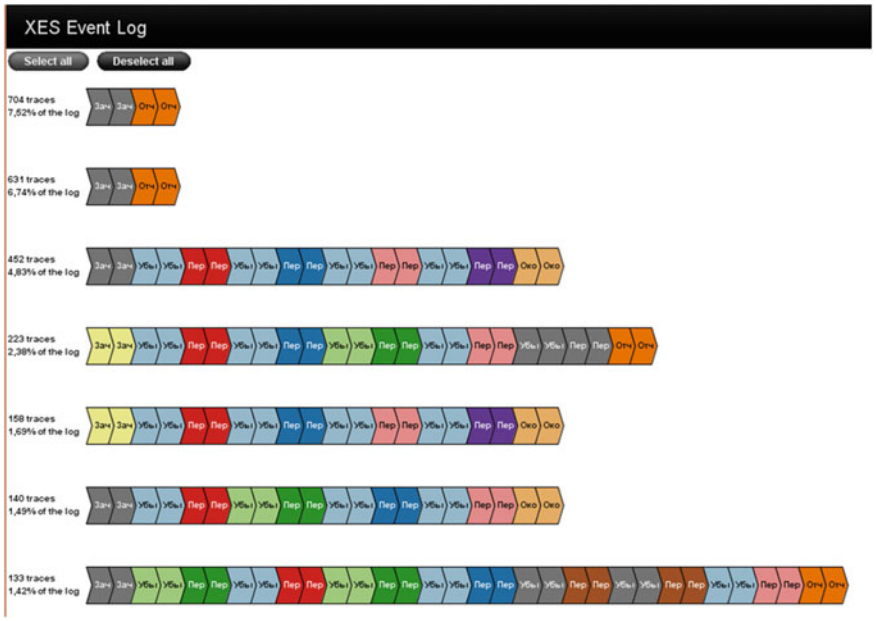

Fig. 3 Event sequence options

An analysis of the heuristic network of the process revealed several problematic situations in working with students. So, according to the university regulations, after the end of any year of study, the event "Departure from the year" should occur, and only then "transfer to the next year". In this model, the event "Transfer to the 2nd year" has only two input events: "Transfer to the 2nd year" and "Enrollment in the 1st year on a paid basis under the reduced program" (Fig. 3), which does not correspond to the reference model of the business process.

The identified problem made it possible to formulate recommendations for university employees on improving the procedure for working with students' documents.

3.4 Analysis of Frequently Occurring Sequences of Events

To visualize the sequence of events, the Explorer events log plugin was used. This plugin allows you to retrieve event logs for a sequence system. The results of this plugin are the constructed routes of the sequence of transitions by the event log, which is transmitted to this plugin as input. Transitions of the constructed system correspond to events in the log. The total number of sequences is 9350 (Fig. 4).

Figure 5 shows the sequence of events "Enrollment in 1 year in GB or targeted training > Departure from a year > Transfer to 2 year > Departure from a year >

Fig. 4 The chain of sequences

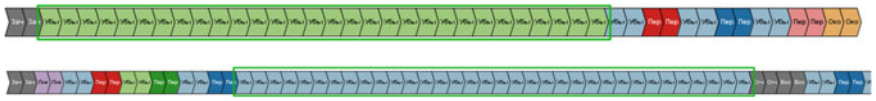

Fig. 5 Identifying personnel errors in the event log

Transfer to 3 year > Departure from a year > Transfer to 4 year > Departure from a year > Transfer to 5 year > Graduation and issuance of a diploma of the established form." This chain of sequences is the "ideal" life cycle of the student's learning process, that is, the student never had debts, was not transferred, etc. Figure 5 shows that only 158 students graduated from the university by completing this chain of events.

The improvement of the educational process should be carried out in order to maximize the number of students passing along this trajectory, since it is this requirement that will ensure the release of the maximum number of specialists with the necessary minimum labor intensity of the process. This will ensure the maximum efficiency of the educational process according to the criterion of "maximum output at minimum cost."

The analysis of frequently repeated events allowed to identify errors in the actions of employees, reflected in the event log (Fig. 6). So, in one sequence in a row 15

Fig. 6 Fuzzy sequence sets

events "Departure to another group" were recorded in a row. In another sequence, the event "Departure" was repeated 17 times.

Most likely this error appeared either as a result of the carelessness of the employee who entered the data, or as a result of a failure in the information system. This problem was also reflected in the recommendation for the university.

3.5 Route Compliance Analysis

"Conformance checking" is used to compare the reference model of processes with the event log of the same process. To check the correspondence of routes, the plugin "Fuzzy miner" was used [8, 9]. The plugin is used to check the developed process models for compliance with the expected data (sequences of events). Based on expert judgment and event log data, the plugin builds the expected sequences.

This plugin allows you to build sets of frequent fuzzy elements; to build a model, the plugin uses a dependency graph representation. Figure 7 shows the sets of fuzzy sequences for the university event log. Each sequence refers to the student's life cycle.

Conformity checking methods take the process model and the event log as input and return a set of differences between the behavior recorded in the process model and the behavior recorded in the event log. Each event is highlighted in a specific color:

- Green—Transition inside the cluster (occurs when some event routes are combined into a cluster);
- Gray—allowable transition;

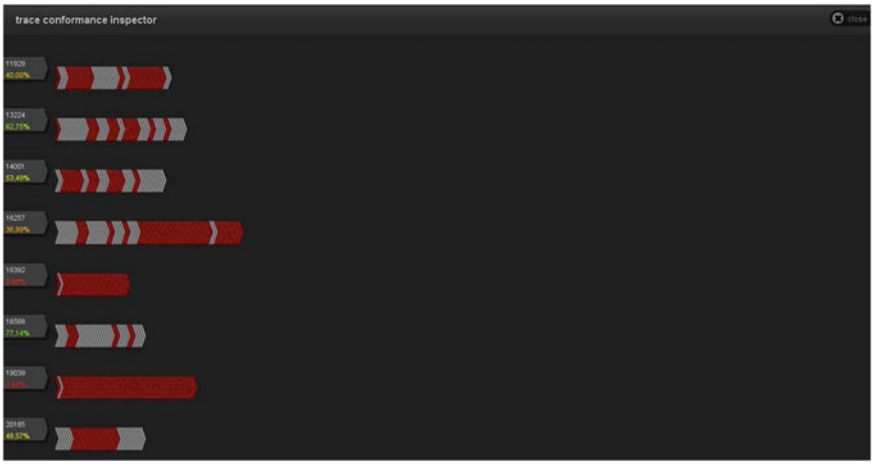

Fig. 7 Fuzzy sequence sets

- Red—invalid transition.

In this event log, when analyzing the model, a lot of routes were identified, in which there were only 1–2 admissible transitions. To a greater extent, the model contains routes with 60–85% of permissible transitions.

In this work, conformance checking was carried out in order to identify facts of work in the process that do not comply with the university regulations or its optimal condition. This work is carried out in order to improve the work of employees. A route with 100% compliance is an ideal route for the analyzed model. Analysis of the event log showed that only 158 routes were selected as routes that correspond to the ideal business process model of an educational institution of higher education. The following sequence was considered as an ideal model:

> Enrollment in the 1st year at the expense of the state budget or targeted training> Departure from the year> Transfer to the 2nd year> Departure from the year> Transfer to the 3rd year> Departure from the year> Transfer to the 4th year> Departure from the year> Transfer to the 5th year> Graduation and issuance of a diploma of the established form.

This route has 100% allowable transitions.

4 Discussion

The first thing worth noting is that not all sequences adhere to the rule: after the end of any year, the event "Departure from the year" should occur, and only then "transfer to the next year".

In this event log for the 2nd year, you can transfer only from the event "Enrollment in the 1st year with an agreement on the commercial learning for the reduced program", which does not correspond to the logical model of the university's business process. This error most likely appeared due to a failure in the system. In the formation of sequences, other transitions to the status of "Transfer to the 2nd year" were carried out. And when building a model, this data was not considered software. This means that there was a failure in the information system, and the data in the event log was damaged, which contributed to the incorrect reading of all data when building a business process model.

A similar situation with the event "Transfer to 3 year. This event starts after the end of the "Transfer to another group" event; all other options for getting into this event are absent in the model.

The second thing is that it was revealed that the event "Liquidation of academic debts" is quite common. From this it follows that more students have debts while studying at the university. This is a signal that you should pay attention to this and identify the reasons for the frequent appearance of student arrears. If necessary, a deeper analysis of the processes can be carried out to identify which professions most often have arrears in order to further work with departments to identify the reasons for the appearance of such a large number of students for a long time.

It is also worth noting that most likely in the university's information system, system malfunctions periodically occur, since events are looped in some routes, which is not a natural action. Failures disrupt data recorded in the event log.

It should be noted separately that only 158 students out of 9,500 for the period of data collection (five years) entered and graduated from the university without any arrears, transfer to another group, deductions, academic leave, etc. This route is ideal for the logical business process of the university, but quite rare, as practice has shown.

This work clearly demonstrated that the Process mining method is quite effectively used for analytical processing of university business processes. Prospects for further work may include the following:

1. Analysis of the total complexity of the process.
2. Analysis of the probability of repetition of routes.
3. Identification of which faculties and specialties is most often deductible in connection with academic arrears (identifying the causes and possible ways to reduce the number of arrears).
4. Which faculties and specialties are more in demand, which are more often received.

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Conceptual Approach to Express Tacit Knowledge by Human–Machine Interactions

Gennady Kanygin and Olga Kononova

Abstract The paper analyzes the problem of expressing tacit knowledge by participants in social processes interacting through ICT. This unsolved problem prevents organizing the human–machine interaction, which with due completeness and efficiency would take into account the vast social experience of people. The research question is how we can extract individual tacit knowledge and so formalize it? Answered this question, we could process information with ICT more meaningfully especially when humans need to team working. To solve the problem of expressing tacit knowledge by participants in social processes, we propose that any human within ICT would express his tacit knowledge by means of natural language. In this way, we preserve its essential role in social communication. However, the tacit knowledge should assume not the traditional form of a text stream, but structural view obtained by using special visual linking mechanism (VLM) associating natural language utterances. The paper examines the foundations of the introduction and structure of the VLM. How a person can apply the mechanism is explained through an example of the expression of tacit knowledge, functioning as part of human common ideas.

Keywords Tacit knowledge · Information and communication technologies · Human–machine interaction · Visual representation of information · Industry 4 · Modeling of social processes · Smart city · Knowledge management

1 Introduction

Nowadays, traditional cities become "smart" [1–4]. However, as Cavada and als. argue there are many definitions of what is a "smart city" [5]. The scholars name three themes of these definitions—ICT, the need for sustainable development of

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the city and the problems of development of business [ibid.]. However, as noted in [ibid.], there is also no conceptual agreement among scholars who adhere to ICT's theme. For example, Cavada and als. analyze the works [6, 7] in which researchers demonstrate different views. In order to understand what the general features of smart ICT can consist of, it is necessary to pay attention to the features of the areas of city life, for the maintenance of which the ICT themselves are used.

The traditional model of a smart city is focused on housing, transport, energy [8–12]. Such areas as culture or tourism rarely becomes goals for cities' development by virtue of smart technologies. The encouraging exception is the concept of Moscow development with the direction of "Human and Social Capital", where the development of cultural aspects is declared as fundamental along with traditional areas [13]. Incomplete coverage of urban development processes is due to the complexity of the sociocultural information space of urban agglomerations. In these processes, nature, human activity (for example, politics or culture) and digital technologies are diverse and closely intertwined, which creates fundamental difficulties in managing them [14].

The variety of economic, cultural, demographic, political, and other processes, maintained by corresponding "smart" technology (ST), forces researchers to include actively the processes' participants in the framework of ST. Thus, the idea of obtaining social information directly from those who apply this information in practice comes into being [15]. The city under the control of ST "lives" by the interaction of the local government and citizens [16, 17]. Thus, one of the most important components of a "smart city" is "smart citizens" who are able to describe life situations with the necessary completeness and relevance. Only they can make possible the existence of better versions of smart cities by quickly and intimately describing social processes [18–21].

Nowadays there is a generalization of the basic ideas of a "smart" approach called Industry 4.0 [22–24]. On the one hand, Industry 4.0 is a conglomerate of "smart objects" interacting as part of "smart grids". In other words, Industry 4.0 is an ever-expanding set of mutually overlapping technologies such as: Internet of Things, Internet Services, Multi-Agent Systems, Augmented Reality Systems and others with sufficient availability of computing resources, communication tools and information storage [25]. A demonstration of the social diversity of a smart city based on Industry 4.0 can be done by designing the architecture for the interaction of "smart objects" in the context of an urban environment in which objects exist and interplay with other components of this environment [26–30].

Industry 4.0, on the other hand, is the interaction of people through ICT [25]. Dragicevic, als. [31] proposed a conceptual model of Industry 4.0 representing in the form a multi-level diagram the information society functioning under the control of ST (see [31], Fig. 5). The model demonstrates knowledge dynamics in the industry 4.0 as the result of the interaction between human and computer agents. The model is based on the process of expression by an individual (human agent or actor) of his implicit knowledge.

However, as the authors themselves note, the process of expressing tacit knowing is presented in a reduced form. It has not been considered Human-to-Human (H2H)

communication, but only the Human-to-Machine (H2M) interaction. In addition, there are three important reservations. Firstly, there is the simplification of the situation of man–machine interaction occurring in existing computer systems [ibid., 11]. Secondly, the authors understand this process according to the philosophical ba-concept [32]. So the context of understanding implicit knowledge lies outside the problems of ST. Thirdly, with reference to [33] it is emphasized that a person's expression of his implicit knowledge leads not to a familiar three-dimensional, but to "a topological space the network of interactions recursively create as a whole" [31: 11].

Based on a review of the literature, Dragicevic, als [31] summarize: "We have failed to identify an integrated framework that would involve knowledge-based activities of both machine and human actors» [ibid.]. So, unfortunately, neither the conceptual model constructed by the authors, nor the works on which the model is based, can answer to practical need of the participant in social processes to communicate his knowledge to ST.

Our article proposes an approach that allows the human himself to articulate his tacit knowledge through the ordinary use of natural language in the form of graphs of a special kind. Such graphs, on the one hand, have a meaningful justification in human activity. On the other hand, operating with graphs, when people expressing their implicit knowledge, creates new opportunities for human–machine conceptual integration within ICT.

The objectives of the article are, firstly, an explanation of the original visual mechanism of linking natural language expressions, which is based on the ideas of an ontological approach to knowledge management. Secondly, the proof of the practical operability of such a mechanism in the case when a human needs to express his everyday knowledge in explicit form. Our task is to demonstrate how the tacit human knowledge can be practically expressed visually by a person himself for subsequent computer processing.

2 Tacit Human Knowledge as Informational Basis of Modern ICT

According to [31], the basis of all the information functioning in the contour of modern ST is tacit (implicit, latent) knowledge of a person. The idea of implicit knowledge was first proposed by M. Polanyi [34]. However, even today, researchers are making persistent attempts to bring the idea of implicit knowledge to a working instrumental technique [35, 36]. Participants in contemporary discussions note three interrelated key features of implicit knowledge of a person. First, such knowledge is inseparable from its carrier [37]. The second, individualized implicit knowledge is essentially determined by the context [38, 39]. Third, it is difficult to formalize [39].

In the domestic scientific literature on the problems of knowledge management, there are philosophical and engineering orientations touching the theme of

implicit knowledge. In philosophical works, an analysis being made of the category of "implicit knowledge" as one of the components of the functioning of information in social systems. Such an analysis do not mean developing proposals for the technological development of modern ICT.

In works on knowledge engineering, there is no mention of the "esoteric" category of implicit knowledge. However, the problems of transferring human experience to the information system are characterized as the most difficult when extracting expert knowledge. The result of the analysis of emerging problems, de facto caused by an implicit form of people thinking, are proposals for technological improvement, for example, proposals to develop tools for visualizing human knowledge. In sociology, the most famous supporter of the "implicit" view of the formation of sociological knowledge is P. Lazarsfeld. He coined the term "imagery", which refers to a vague idea of the researcher about something that precedes his scientific definitions (cited from [40]: 26–29).

3 The Pragmatic Use of Natural Language in Describing the Social Process

Just as Dragicevic, als. [31], we do not know how implicit knowledge functions and cannot offer its model. Therefore, in order to solve the problems of expressing imagery by the individual himself, we rely on the pragmatics of the use of natural language, which is known to all from our common practice of social interaction. The pragmatic use of natural language is the everyday custom of any person to describe something using verbal utterances, to construct and understand the meanings of other people's actions through speech. This use of speech is based on the personal experience, knowledge and skills of each actor, is the first and main common feature of an unlimited number of social processes to be managed with the help of ICT.

Taking the pragmatic use of natural language as the basis of people's communication, we do not block any actor from accessing any existing special resources that can complement his knowledge and experience. Among them, there are text corps, survey data, Wikipedia, publications, archival materials, etc. However, we argue that humans will implement the final integration of all the intellectual resources applied by them through using speech.

Every native speaker, in particular, researcher, knows how this application occurs. When summing up the results of any project, its author writes a report having form of a text, which represent a collection of natural language expressions. Another example is a plan of social development of the city. Built up in the form of documents, instructions, prescriptions, the plan is a set of natural language statements designed to coordinate the actions of members of society. Although it is possible that the report or plan include graphs, charts, tables, and other types of information, but the semantic

integration is effectuated using speech and its well-known produce, i.e. text. We want that the ST's actors would perform this semantic verbal integration in the form of graphs expressing visually the semantic links hidden in tacit knowledge.

4 Tacit Knowledge and Its Wording

The usual role of computer agents in any ICT is to automate the processes of extracting and processing information through which actors interact. In the case of implicit knowledge, the operation of extracting information is an action of information creation. This action serves to manifest by the person himself his latent representations that exist in "his separate head" and are thus hidden from others [36]. As a rule, such an explicit form is the text (alphanumeric stream).

Because social practice is wider than any idea of it, this transition from the internal images of a human to their wording in text form is the prerogative of man. Therefore, the expression of latent knowledge by a person as a part of ST cannot be controlled by technological support based on predefined criteria.

However, what exactly cannot be controlled in the conceptual actions of a person when he expresses tacit knowledge? We think that uncontrollable is the correspondence between tacit knowledge and its textual formulation, which the knowledge carrier establishes by means of speech. At the same time, the presence of the textual wording itself, i.e. explicit expression of latent human's images, leaves the possibility of analytical actions that can be carried out not only by the human, but also by a computer program.

5 The Mechanism for Linking Wordings of Implicit Knowledge

To carry out such actions, it is necessary to induce the actor to present his implicit knowledge not in the form of a text stream, but through a special mechanism for linking individual text formulations. Ordinary human would understand the functioning of such a mechanism due to the visual representation of its structure and intuitively clear actions with it.

Verbal formulations arising as usually at the discretion of a person should remain the initial stage in expressing his latent knowledge in the form of a text. However, the knowledge carrier should establish the relations between them not through new verbal statements, but in the form of graphs able to demonstrate visually semantic relationships hidden in human's head.

For example, a person who has an internal idea of his apartment and wants to transfer his knowledge to ST for further operation says "I have an apartment." Thus, he creates using speech a single verbal statement that makes sense for any carrier

of knowledge. Further, he wants to clarify that there are a room, a kitchen and other premises in his apartment. He can articulate these clarifying aspects of his implicit knowledge of the apartment in the form of corresponding natural-language statements, for example, to begin with very simple ones—"room" and "kitchen".

Now, in an effort to consolidate its implicit knowledge, articulated as shown in the previous paragraph, the knowledge carrier can combine separate phrases about the apartment and its premises in the form of a new natural-language statement. Let it be "I have a room and a kitchen in my apartment." Thus, with the help of a new utterance, he will unite his implicit knowledge behind the initial utterances about the apartment and its premises into a single whole.

The idea of a visual linking mechanism (VLM) is to offer to a human, when articulating his latent knowledge by means of natural language, to conjoin verbal wordings not in the form of a new verbal wording, but with the help of a visual "pictogram". Such a pictogram can, unlike a text stream, express explicitly the relationships between the meaningful statements originally made by the person himself. For example, as shown below:

$$\text{Apartment} \rightarrow \text{Includes} \rightarrow \text{Room, Kitchen} \tag{1}$$

The indicated pictogram, in our opinion, accurately conveys the human meanings contained in the above verbal formulations. At the same time, the pictogram shows connections in the form of edges of the graph. Semantics, i.e. the expression of correspondence between an explicit textual formulation and the implicit knowledge of a person underlying it, is presented in nodes. A pictogram is a semantic chain created by a person on the basis of his implicit knowledge in the form of distinct individual aspects of such knowledge. Such a chain, as the example shows, is created "locally", based on some situation a person imagines "in his head". In this case, such situation correlates to the apartment under description. "Includes", "Room" and "Kitchen" occur to be the aspects of knowledge about apartment.

However, if the associating of single wordings is carried out in the indicated structural form, then a person will very quickly encounter the problem of operating with a huge mass of verbal statements, often intersecting in meaning. His work will degenerate into "manual" creation of graphs: acting with such graphs is not easier than articulating latent representations in the form of unifying verbal statements.

Therefore, the proposed VLM expands the idea of the pictogram presented above, based on the principle of parallelization. The sense chain (1) is parallelized into two transitions (2) and (3):

$$\text{Apartment} \rightarrow \text{Includes} \tag{2}$$

$$\text{Includes} \rightarrow \text{Room, Kitchen} \tag{3}$$

In addition, VLM demands the knowledge carrier to make separate designations always in the form of pairs of statements. The first statement is a traditional wording

describing something. The second one fixes the context in relation to which the knowledge carrier considers his first statement. Such a requirement makes the knowledge holder explicitly declare the dependence of implicit knowledge on the context of its expression [38]. Also, the requirement to specify the context disciplines a human when he express his tacit knowledge.

In our case, in accordance with this requirement, the set of natural language utterances can take the form:

(APARTMENT//ACTOR, INCLUDES//APARTMENT,
ROOM//APARTMENT, KITCHEN// APARTMENT).

Given the pairing of wordings, explicit semantic transitions (2) and (3) take the form (4) and (5).[1]

APARTMENT//ACTOR INCLUDES//APARTMENT (4)

INCLUDES//APARTMENT ROOM//APARTMENT
KITCHEN//APARTMENT (5)

The meanings of each statement, from among the paired ones, we have explained earlier. Except for the new word ACTOR, which seems redundant when speaking of the apartment. However, it is obvious that any presentation of implicit knowledge implies a person—the carrier of such knowledge. It was this indisputable fact that we strove to express, indicating as the context of the knowledge associated with the apartment, its carrier, indicated by the word ACTOR.

The interpretation of emerging verbal constructions does not require special knowledge and bases on the natural language experience of a person. The proposed constructions represent the simplest semantic transitions from one aspect of knowledge, expressed by a person, to another such aspect. It is such semantic transitions that a computer user creates by organizing his computerized materials by virtue of the folder graph.

We have explained the "human" part of the man–machine VLM that allows a person expressing his implicit knowledge. The result of this expression is a set of compact visual structures, two copies of which are pictograms (4) and (5). Each such structure we call *branching*. A set of branchings is a collection of verbal statements, made by the bearer of implicit knowledge, to describe something through the pragmatic use of natural language. An example of such a set follows below.

What is the meaning of human actions using the proposed VLM? For a person, the creation of many separate statements is a common practice of describing something

[1] "//" is a short notation, meaning that the statement to the right of the notation is the context for the statement to the left. Denoting verbal statements in uppercase, we want to emphasize that being linked by VLM they become operable by special algorithms processing data got by VLM (see below, an example).

using speech. Such a description is created with "human" goals: to express your thoughts, to understand each other, to explain to someone what you think about his actions, to express your feelings, etc.

The result of this practice is expressed in the form of many simple semantic connections between individual statements. Such a structural representation of implicit knowledge of a person allows algorithmically constructing a single graph that expresses a connected part of the whole set of statements made by a knowledge carrier. Thus, expressing the elementary aspects of their knowledge in the form of branchings, i.e. visually in the form of separate pictograms structurally similar to pictograms (4) and (5), a person potentially gets the opportunity to operate graphs of unlimited volume. The example below shows how person's work of constructing and interpreting such graphs looks.

Anticipating the example, we explain the key features of VLM. Firstly, when describing something based on VLM, a person does not rely on any preliminary knowledge, existing outside his experience. For example, dictionaries or Internet resources. He expresses his implicit knowledge in relation to the specific conditions in which such an expression occurs. Additionally, the pragmatic use of natural language does not imply human competence in the fields of linguistics, computer linguistics, or modern ICT.

Secondly, the human establishes the relations between individual statements based on his understanding, but taking into account the general scientific rule of preserving the context. According to this rule, the knowledge carrier would introduce each new wording only in relation with the already existing one. Just as well, as any variable in programming can exist only relative to a block. This rule, like other techniques for using the VLM in describing something through speech, a person is able to learn in the process of using tools that express the proposed approach.

6 Example of Expressing Tacit Knowledge

Any knowledge that functions as part of the ST has a tacit form, which the knowledge carrier must express himself explicitly by using natural language. We will call such an explicit form of knowledge information or data. After an actor has created information, it becomes possible to process it by computer agents. In terms of Industry 4.0, the appearance of information solves the problem of the base phase of knowledge functioning in ICT. In the example, we try to demonstrate how to convert tacit knowledge, hidden in an ordinary idea of apartment, in data, i.e. base of any computer processing. Thus, we imitate the essential feature of the actor operating as a part of ICT, i.e. the primordial human function to describe something through speech.

Figure 1 shows two types of information obtained because of an explicit expression of a person's everyday knowledge of an apartment. In the first case, the data is presented in the form of a text stream, which continues our informal answer to the question, what is an apartment? In this textual way an ordinary person expresses his knowledge of something. In the second case, the same implicit knowledge of the

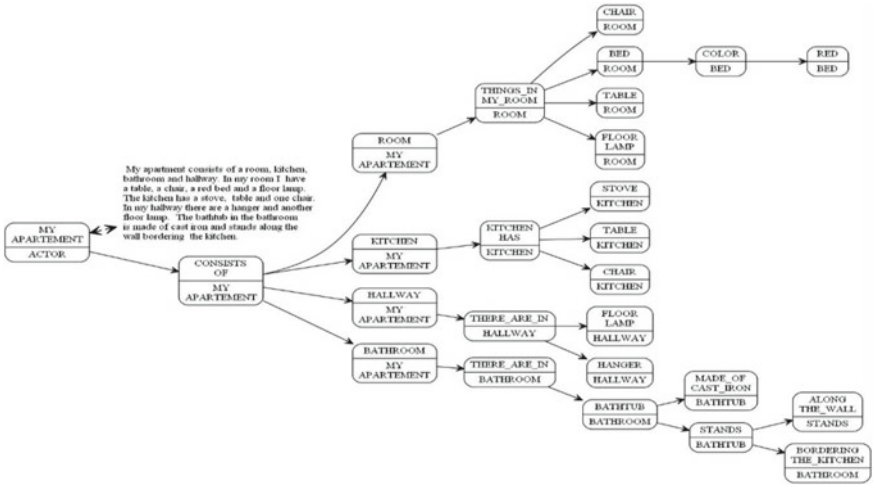

Fig. 1 The visualization of tacit connotations hidden in the common knowledge through the pragmatic use of natural language[2]

apartement is expressed through speech in the form of a graph, which, unlike the text, clearly demonstrates the intuitive connections between the individual aspects of a person's idea of the apartement.

Even in the absence of experience with VLM, a person who speaks a natural language can see the practical identity of the meanings expressed by the text and the graph. Thus, Fig. 1 clearly demonstrates the very non-obvious possibility for ordinary actors of ICT to express their implicit knowledge by virtue of speech directly in the form of a graph, rather than by means of a usual text stream. In turn, the advantage of the visual presentation of information compared to an alphanumeric sequence does not need additional justification.

In order to get a graph instead of text (see Fig. 1), a person, according to the explanations made above, must create a set of separate utterances with which he explains the individual aspects of his image of the apartment. In our case, the set created by the article's authors looks like this:

[2] The drawing is built using our test program Diagogue, that embodies VLM, and program Graphviz [41].

```
    {
    (0) MY APARTEMENT // ACTOR
CONSISTS OF // MY APARTEMENT
    (1) CONSISTS OF // MY APARTEMENT
ROOM // MY APARTEMENT
KITCHEN // MY APARTEMENT
HALLWAY // MY APARTEMENT
BATHROOM // MY APARTEMENT
    (2) ROOM // MY APARTEMENT
THINGS_IN MY_ROOM // ROOM
    (3) THINGS_IN MY_ROOM // ROOM
CHAIR // ROOM
BED // ROOM
TABLE // ROOM
FLOOR LAMP // ROOM
    (4) CHAIR // ROOM
    (5) BED // ROOM
COLOR // BED
    (6) COLOR // BED
RED // BED
    (7) RED // BED
    (8) TABLE // ROOM
    (9) FLOOR LAMP // ROOM
    (10) KITCHEN // MY APARTEMENT
KITCHEN HAS // KITCHEN
    (11) KITCHEN HAS // KITCHEN
STOVE // KITCHEN
TABLE // KITCHEN
CHAIR // KITCHEN
    (12) STOVE // KITCHEN
    (13) TABLE // KITCHEN
    (14) CHAIR // KITCHEN
    (15) HALLWAY // MY APARTEMENT
THERE_ARE_IN // HALLWAY
    (16) THERE_ARE_IN // HALLWAY
FLOOR LAMP // HALLWAY
HANGER // HALLWAY
    (17) FLOOR LAMP // HALLWAY
    (18) HANGER // HALLWAY
    (19) BATHROOM // MY APARTEMENT
THERE_ARE_IN // BATHROOM
    (20) THERE_ARE_IN // BATHROOM
BATHTUB // BATHROOM
```

(21) BATHTUB // BATHROOM
MADE_OF CAST_IRON // BATHTUB
STANDS // BATHTUB
(22) MADE_OF CAST_IRON // BATHTUB
(23) STANDS // BATHTUB
ALONG THE_WALL // STANDS
BORDERING THE_KITCHEN // BATHROOM
(24) ALONG THE_WALL // STANDS
(25) BORDERING THE_KITCHEN // BATHROOM
}

The set of 26 disparate utterances allows an algorithm building up a single graph Fig. 1 without human participation. The algorithm uses, firstly, local connections between individual paired statements; secondly, the mentioned rule of contextual conditionality, which a person is forced to observe due to the structure of the branching by which he locally combines statements. As Fig. 1 shows, the result is a graph of a special kind that expresses the overall relationships between all the statements that the article's authors has introduced to express their tacit knowledge of apartment.

At first glance, a set of branches seem like an artificial construction, the practical use of which by ordinary people connecting through ICT only makes it difficult to obtain information using a natural language. However, in order to understand the merits of the proposed approach, it is necessary to make out clearly that the set of branchings are an integral part of the sequence of actions that make it possible to parallelize the process of building knowledge of any volume by using a person's usual speech. It seems to us that the instrumental feasibility of this process, which we sought to show in the article, is not obvious.

Our experience in solving a number of applied conceptualization problems [38] speaks of further instrumental advantages of using VLM. Advantages add attractiveness to our proposals despite the need for additional efforts. Firstly, the proposed VLM is also a mechanism for flexible scaling of graphs of any size. If the user has a need to clarify any statement that already is in the graph, then he does not need to operate on the graph as a whole, sorting through the numerous possible occurrences of this statement. It is enough for him to add a limited number of additional branchings, required in the sense of refinement. For example, the BED // ROOM → COLORS // BED → RED // ROOM as a graph's branch was created by scaling the BED // ROOM node, which was a sheet in one of the previous versions of the graph. Scaling to the form of Fig. 1 (with the added nodes COLOR // BED, RED // ROOM) was carried out by introducing two new branchings (see the set of branchings: elements 6 and 7). Afterwards, the graph of Fig. 1 has been obtained automatically according to revised set of branchings.

Secondly, the possibility of flexible scaling in combination with the use of ordinary speech to describe something allows a person to get away from the strict rules of "natural scientific" definitions. The expression of implicit knowledge is a process not so much of "final" definition through the linking of some statements to others,

but rather the possibility of unlimited refinement of any statement by their author in response to a corresponding clarifying question. Similar to how the practice of verbal definitions in life situations is arranged. Why spend effort on laying the entire route to Kiev, if, according to the Russian proverb, the "language will bring" to this city by itself?

Thirdly, the double expression of implicit knowledge—in the form of text and in the form of a graph—creates for a person the possibility of semantic self-control of the information he produces. For example, the following procedure is possible, which we used when creating the example. At first, we presented some portion of our implicit knowledge about the apartment in the form of text (Fig. 1). Then we reproduced this text in the form of a graph (Fig. 1) bearing in mind a simple but informal rule: the semantic links of the text should be expressed in the graph. Following this rule, we consistently increased the set of branchings so that the statements presented in the graph could be easily recognized in the source text, and the connections between them on the graph would clearly represent the meanings hidden in the stream of words. At any replenishment of the set of branchings with a new element, we automatically built a graph, according to which we checked visually to what extent we managed to convey the meanings that anyone can recognize in our text describing the apartment. Thus, the construction of the graph in Fig. 1 by means of the VLM is a dynamic process in which the visualization algorithm creates the ability to control visually the completeness of a person's presentation of his implicit knowledge. As the procedure described suggests, the more knowledge a person will operate, the more mental efforts he will save because of visual control of his actions' result.

7 Conclusion

The paper describes the original visual mechanism of linking verbal expressions, which allows a person to display visually the semantic connotations of his latent knowledge in the form of graphs of a special kind. Due to the limited volume of the article, we have demonstrated only the main distinguishing features of the VLM. It is fundamentally important that using VLM, an ordinary human acquires the opportunity to translate by means of speech his informal knowledge into the structural form of a graph, opening up possibilities for next processing of human knowledge to computer agents of ICT. Given the fundamental importance of getting from man sensible information, we assume the numerous possible applications of the VLM or its modifications in ICT, as well as subsequent practical use in social and public administration.

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Design Patterns for Cyber-Physical Systems of Buildings

Aleksey Kychkin, Aleksandr Deryabin, Olga Vikentyeva, and Lidiia Shestakova

Abstract This paper considers scientific and applied aspects of algorithmic and software design for cyber-physical systems (CPS) of buildings. A CPS of a building is a basic element of IT architecture within SmartCity approach. It represents a set of devices, which control life support systems integrated into a premise, means of communication, and the computing resources necessary for user services. In a building's CPS, all equipment and subsystems are combined into a single ecosystem to improve comfort and security, as well as reduce operating costs and resource savings. The paper investigates requirements for building's CPS software. The groups of design patterns are presented, which in practice significantly reduce the time for programming and configuring the building's CPS elements and increase interoperability of developed information applications. CPS algorithms are considered in context of Internet of Things.

Keywords Cyber-physical systems · Internet of things · Smart building · Software architecture · Design patterns

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1 Introduction

Presently, technologies related to smart cities are actively developing. Thus a priority direction of researches in the field of computer sciences is a complex of methods of designing of architectures of the control systems providing integration of information-computer resources with objects of buildings and the constructions equipped with gauges and actuators. Such systems belong to cyber-physical systems (CPS), their components interact with each other using Internet of Things Technologies (IoT), realizing wireless data transmission (Wireless), processing of large volumes of data (BigData), predictive analytics and intellectual adaptation to changes.

The results of the analysis of the activity of the main technological leaders such as Schneider Electric, Honeywell, Samsung, Siemens, Philips, Huawei, Xiaomi, ABB, Toshiba, Emerson, IBM, Microsoft, Google show that the use of IoT technologies in creating Smart Cities around the world, especially in the USA, Germany, Japan, China, Brazil, Russia, India, South Africa BRICS countries in the next 5–10 years will stimulate the development of CPS. Obviously, their effective functioning can be supported by continuous improvement of algorithmic and software.

CPS of the building assumes creation of the uniform information-technological complex from various subsystems providing transfer of the measuring information and control commands [1–4]. Application of CPS in the building significantly increases the efficiency and quality of solutions for management of engineering subsystems, leads to a reduction in operating costs and energy consumption, provides comfortable conditions for work and residence [5–7]. The work of such system consists in the implementation of customizable (for specific users) control of IoT device groups in the building under numerous scenarios, which require the implementation of control commands in real time: of power supply, heating, water supply, lighting, etc. [8]. Despite the considerable variety of available IoT technologies aimed at unification of information interaction between building equipment, the software of different groups of CPS devices has low reliability. Many control systems of intellectual buildings are not compatible with each other, which determines the relevance of creating new open models and software architectures.

2 Overview of Technologies and Standards for the Establishment of Buildings Cyber-Physical Systems

The concept of cyberphysical systems was introduced by Helen Jill, Director of Embedded and Hybrid Systems at the U.S. National Science Foundation in 2006 to denote complexes consisting of natural objects, artificial subsystems and controllers. This research area was further developed by Baheti R. and Gill H., who understood

CPS as transforming technologies for managing interconnected systems between physical assets and computational capabilities [9].

In turn, Wolf W. in [10] defined CPS as a single set of components that are closely linked to each other through information channels. Components here are understood as various natural objects, artificial subsystems and control controllers through which the communication is carried out. In a general case CPS is a new class of engineering systems, which provide close interaction between information and physical components [11].

In Russia in 2017 the Technical Committee (TC 194) "Cyber-physical systems" was established, the activity of which consists in development and implementation of international and national standards, adaptation of international standards to the national level, creation of the system of normative and technical regulation [12]. Currently, TC 194 has developed/is in the process of development until 2025 more than 30 standards related to the following areas: Internet of things, big data, artificial intelligence, intelligent production, Cyber-physical systems.

In 2019 a prospective standardization plan was approved [13], under which the following standards in cyber-physical systems will be developed in 2020–2021:

- GOST R "Information technologies. Cyber-physical systems. Terms and definitions".
- GOST R "Information technologies. Cyber-physical systems. General provisions".
- GOST R "Information technologies. Cyber-physical systems. Road map of standards".
- GOST R "Information technologies. Cyber-physical systems. Methods of automatic assurance of reliability of measuring information".

CPS building is a development of "Smart House" technology, the concept of which was formulated in 1970s in Washington by the "Institute of intelligent building" and sounded as follows: "A building equipped with a single automated system of interconnected modules and providing productive and efficient use of working space…".

The information sources highlight various subsystems of the "Smart House". For example, in work [4] Wonga J. K. W., Li H., Wang S. W. and in research [14] "From Buildings to Smart Buildings" Weng T. only four blocks are distinguished: ventilation, heating and air conditioning system; lighting system; information and technical equipment; various connected devices (electronic and electrical equipment). ABOK Corporation allocates the following parts of the smart building: telephone and computer network; access control to the premises; fire safety; dosimetry control; heating, air conditioning and ventilation control; video surveillance for security purposes; the possibility of video conferencing [1].

The "Smart Home" can be controlled with the built-in automation system, which provides monitoring and control of the modes of operation of the equipment in automatic or automated modes. Such systems implement the simplest control algorithms, created by integrators during implementation, and are aimed at improving the comfort and safety of people in predefined scenarios [6]. Building automation system is able

to recognize various emergency situations and react to them accordingly [14, 15], but in most cases the space of control signal states is very limited. In addition, such a system has no ability to predict changes in parameters, and is not connected with related systems.

Taking this into account, under CPS of a building we will understand a system which with the help of IoT-technologies will be able to reliably manage groups of objects and openly interact with the assets of adjacent systems.

A striking example of a CPS building is a robotic greenhouse project developed on the basis of the Massachusetts Institute of Technology. The example of such a system demonstrates the capabilities of hybrid technologies: autonomous robots and sensor networks, distributed nature of work with self-organization in real time, mobility and autonomy [16].

The basic version of the CPS scheme was developed at the Berkeley Institute [17]. It can be seen from the scheme that the CPS of the building has a developed network or distributed architecture, implemented using sensors and actuators adapted to work in real time, with the ability to predict the behavior of the system, as well as to ensure the required level of cyber security and reliability of the CPS. An approach based on neural networks is proposed, which is based on the analysis of statistical characteristics of signals allowing to identify changes in the state of local devices in the system. The problem of analysis of reliability and the process of restoration of CPS functioning after failures is solved in [18], the decision making diagram is developed, which allows making a reasonable choice of the variant of actions for returning CPS to the working state.

The questions connected with management of the environment of the intellectual task are considered in [19, 20]. Specialized platforms can be used to control CPS of a building. For example, in [19] it is suggested to use a scalable, distributed open source agent environment that easily integrates data, devices and systems.

In work [21] it is suggested to use REST architecture to provide interoperability. The interoperability problem can be solved by using the cloud architecture [22, 23] to integrate existing sensors with the cloud and create an open, extensible, scalable, interoperable and easy-to-use sensor network for different applications. In turn, the design methodology is the development of a specification of requirements, construction and analysis of system models.

The creation of a CPS building must be governed by the compatibility standards shown in Table 1.

Thus, CPS are more complex and require new approaches to design.

3 CPS Building Architecture Design Process

The CPS design process can include the following steps:

– Selection of typical equipment sets for CPS (sensors, controllers, actuators, etc.);
– Creation of the same type groups of devices with the same functions;

Table 1 Some standards to ensure interoperability of CPS building elements within smart city font sizes of headings

Standard	Description
NIST CPS framework	The framework describing the rules of interaction between specialists and CPS components. It is based on ISO 42010 and ISO 15288 standards that govern the organization of system approach and system engineering
NIST big data interoperability framework	A framework that describes data interoperability standards
BSI PAS 212–2016 automatic resource discovery for the Internet of Things. Specification	Standard for describing the automatic opening of a resource to the Internet of Things
National information exchange model (NIEM)	National model of information exchange in the USA. Designed to develop, disseminate and support corporate standards and information-sharing processes that will enable jurisdictions to automate information-sharing [24, 25]
Universal core (UCore)	The standard allows the exchange of information by defining an implementable specification (XML scheme) containing consistent views for the most commonly used and universally understood concepts of who, what, when and where [26]
Common alerting protocol (CAP)	The general alerting protocol is an XML-based format for the exchange of alerts and public warnings for all types of networks [27]
OpenGIS geography markup language (GML)	Geographic Markup Language, is an XML programming for expressing geographical objects. The standard is an open format for the exchange of geographical transactions on the Internet [28]
Time ontology in web ontology language (OWL)	The time concept ontology presents a dictionary to describe dates, times, lengths and time zones in the world or on web pages. The ontology can be used to identify conflicts in schedules, compare dates, and describe a specific time interval, calculating time at a specific geographical location [25, 29]
SOA ontology	Technical standard for service oriented architecture (SOA) ontology to develop and promote common understanding between business and information technology communities regarding SOA concepts and terminology [29]

(continued)

Table 1 (continued)

Standard	Description
CPaaS.io	The "Enhanced concepts and models for holistic data management" project aims to create an urban platform as a service (CPaaS) technology that can be combined to support regional or even global applications and can form the basis for the Smart City data infrastructure
Set of standards BIM, BEM, CFD, LEED, BREEAM, DGBN, GSBC, GreenStar, NABERS, HQE	Standards for sustainable design, building energy consumption modelling, building information modelling, etc

– Aggregation of CPS objects of a building into a tree structure, realization of information interaction with it as a single object;
– Replacement of real CPS objects of the building with special twin objects;
– Organization of monitoring and control of CPS building equipment according to scenarios;
– Transformation of measurement results and control signals.

To reduce the labor intensity of the design process it is proposed to use design patterns of classes/objects. The model of the system built in terms of design patterns allows to highlight significant structural elements and connections, to develop the architecture of the system, and also simplifies the subsequent refinement and scaling of the system for monitoring and control tasks [30, 31].

3.1 Set of Typical Architectural Solutions for Creating Instances of Building CPS Design Components

The initial creation of a building management project using CPS involves selecting from the full range of available combinations of sensors, actuators, operator panels, multimedia systems, control controllers, network devices and other equipment, the application of which will meet the maximum number of user needs in different types of premises. Thus, for example, to create sets of IoT devices for home or office you can use the generating pattern "Builder", Fig. 1.

Below is a sequence diagram for creating an IoT device set for a residential building, Fig. 2. The advantage of using the pattern is the ability to quickly vary the sequence of creating new objects depending on customer requirements. This is achieved by using the Director class, which defines not only the set of IoT devices, but also the order of their addition to the smart building project.

If it is necessary to provide creation of the same groups of devices with the same functions, but suitable for different conditions of operation, in this case it is more expedient to use the generating pattern "Abstract Factory", Fig. 3.

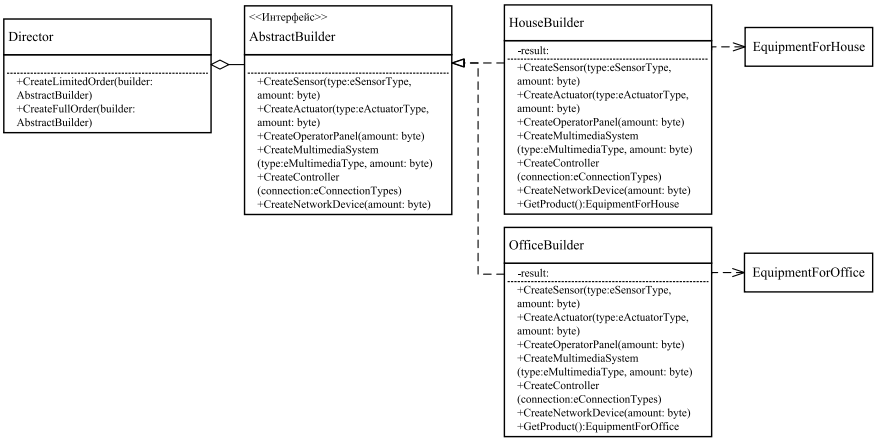

Fig. 1 UML class diagram of the CPS building constructor based on the "Builder" generator pattern

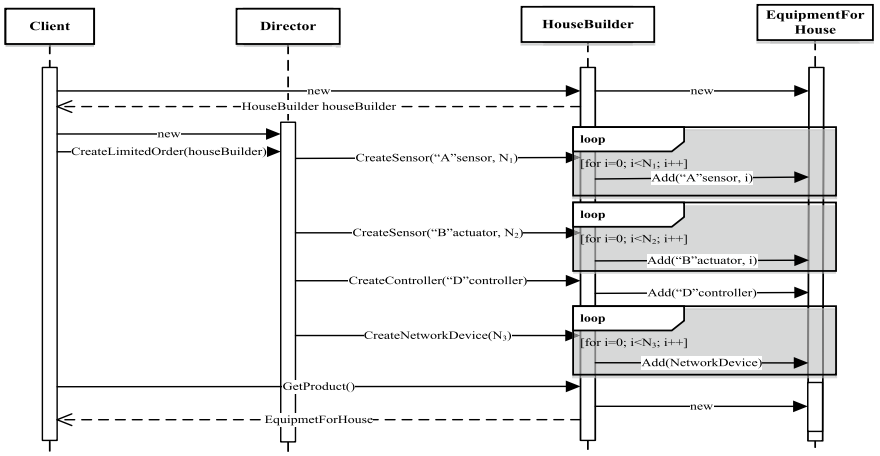

Fig. 2 UML sequence diagram for creating CPS equipment for a residential building based on the "Builder" pattern

Thus, various typical sensor sets can be formed, both for outdoor and indoor use, which imposes serious limitations on their design features.

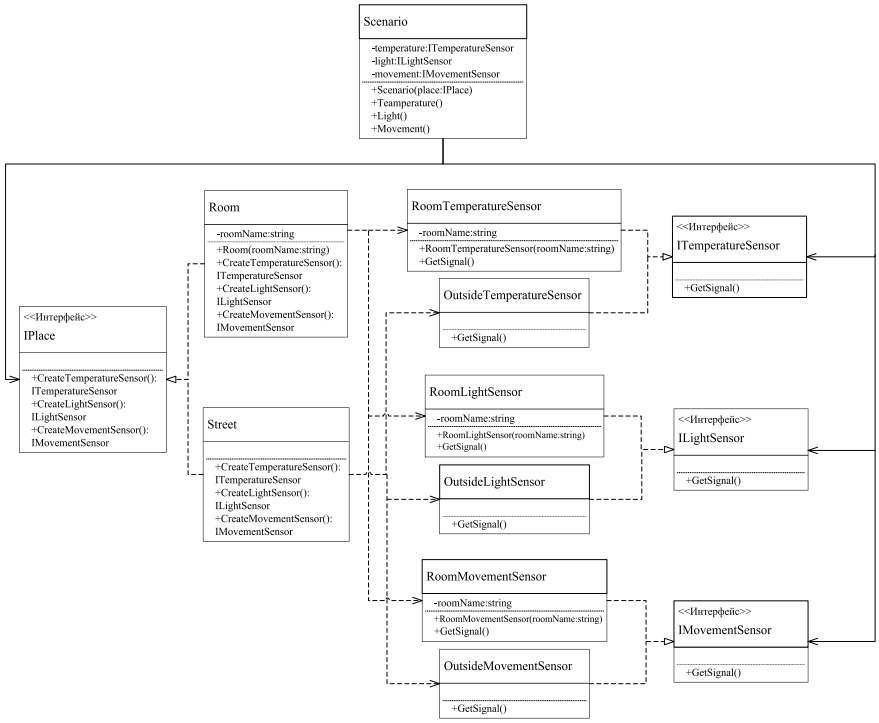

Fig. 3 UML class diagram of the CPS building constructor based on the "Abstract Factory" generating pattern

3.2 Set of Standard Architectural Solutions for Structuring and Interconnecting Instances of Building CPS Design Components

At work in conditions of created groups IoT there is a necessity of aggregation of set of objects CPS of a building in treelike structure, and then realization of information interaction with it as with single object. The given problem can be realised the structural pattern of designing "the Composer". So, individual and compound objects, for example, subnetworks of offices or group management functions, in such structure are treated uniformly by means of a recursive composition. The IoT controller can handle composite objects with descendants and simple objects without descendants in the same way.

Figure 4 shows a class diagram of the block, which implements the description of various functions of group control, obtained by a combination of sensors, actuators, operator panels, multimedia systems, control controllers, network devices. The linkers are NetworkDevice, which combines several IoT devices into one system,

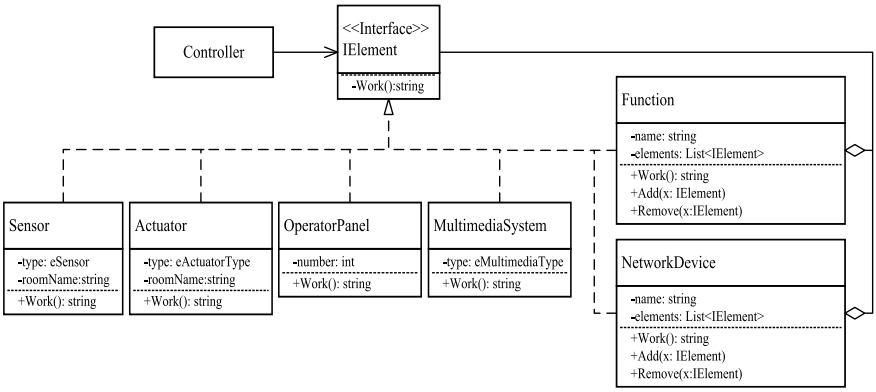

Fig. 4 UML diagram of device aggregator classes and CPS functions of a building based on the "Composite" structural pattern

and Function, which is a function for execution in groups of NetworkDevice and other unrelated IoT devices.

Figure 5 below shows an activity chart for adding an IoT device first to the NetworkDevice and then to the NetworkDevice F_i aggregation feature in which it participates.

Using the structural pattern of design "Proxy", it is possible to realize replacement of real objects of CPS of the building with special twin objects, which will be able to intercept calls to the original object and conduct operations of access control, logging of system calls, caching of objects, see Fig. 6.

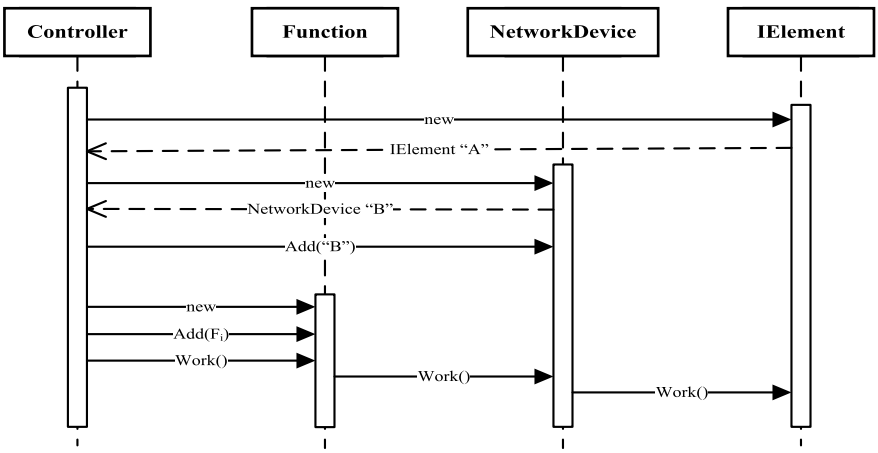

Fig. 5 UML diagram of the sequence of adding building CPS elements to network devices and group management functions based on the "Composite" structural pattern

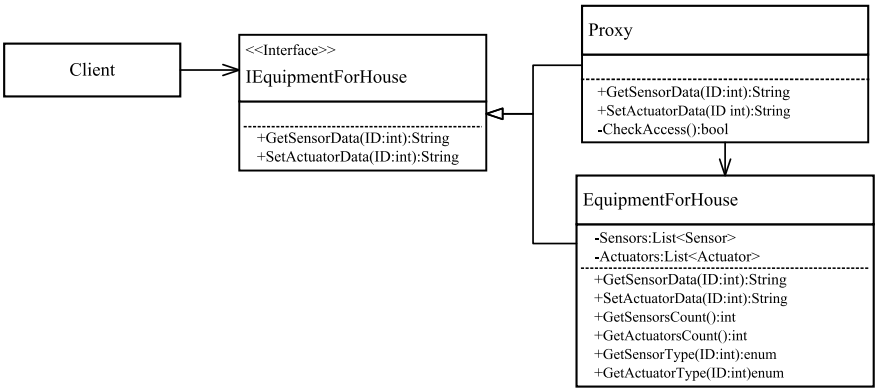

Fig. 6 UML class diagram of the block of access to IoT devices based on the "Proxy" structural pattern

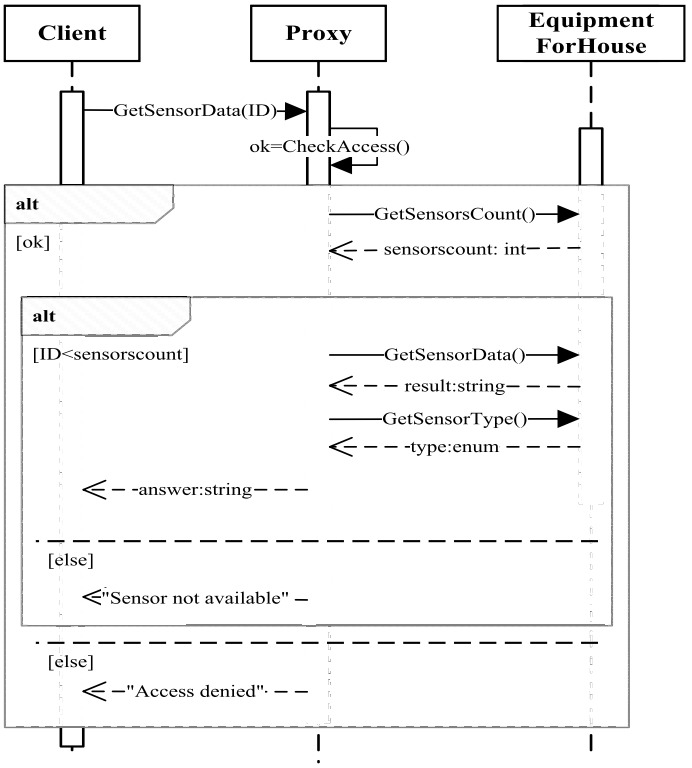

Fig. 7 Providing access control to IoT equipment data

Figure 7 shows the sequence diagram for implementing access control to data from sensors (Sensors) and actuators (Actuators) of the building CPS equipment, previously created using the Builder (see Fig. 2).

Due to the peculiarities of IoT devices operation, providing access to their data is more effectively implemented in caching mode. It is especially important to implement time delays (timeouts) when accessing the executive devices. Figure 8 shows the sequence diagram when accessing CPS equipment data via the "Proxy". In this case, when calling GetValue(), GetSensorData() and Act(), SetActuatorData() to the substituents repeatedly (interval less than timeout of 1 s), preparatory actions such as calling GetValue(), GetSensorData() or Connect() to the real object are not performed.

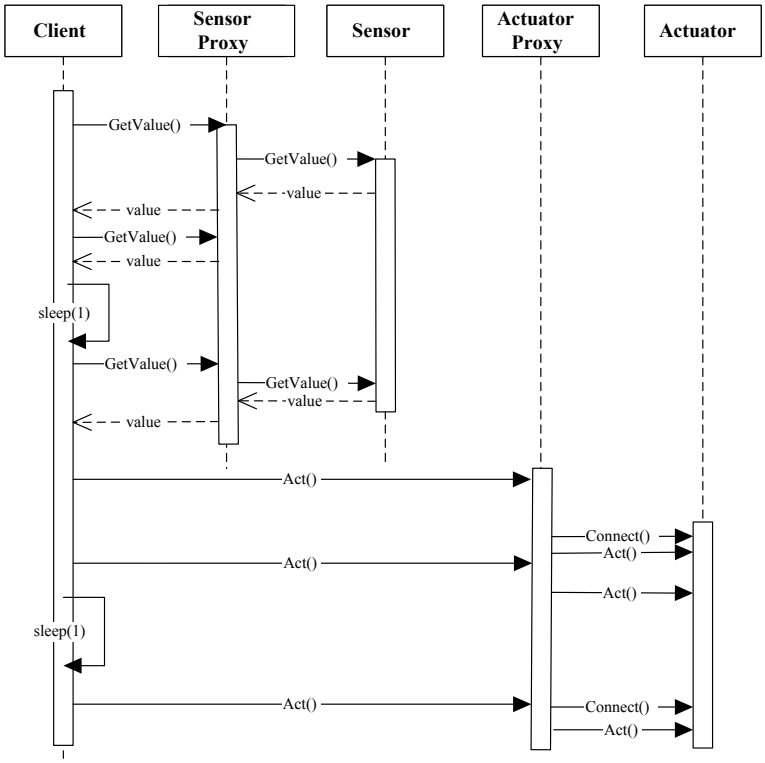

Fig. 8 Time caching of IoT equipment

3.3 Set of Typical Architectural Solutions for Implementation of Algorithms for Execution of Control Scenarios for Building CPS Components

In cases when it is necessary to process changes in the state of CPS objects in a building, the behavioral pattern "The observer" is best suited. With the help of this template it is also possible to implement data collection, including the possibility of transferring not one message, but several in one package; sending recommendations to the user.

Let's consider a variant of application of the pattern for realisation of the program for monitoring and management of equipment CPS of a building under scenarios. We realise observed object through objects Action and template representation of arguments of event. For storage of the status of active subscriptions on scenarios we use data structure Set. We implement a typical algorithm of climate control in the room: there is a temperature sensor and a controller that controls the fan drive of the ventilation system. Information about changes of objects should be saved in the database, entered in the event log as a.sv file separately and displayed on the control panel display. At certain temperatures it is necessary to turn on or off ventilation.

Figure 9 shows a class diagram for the implementation of the scenario management process, using the "Observer" as an example of ventilation in a building.

Figure 10 shows a diagram of the sequence of information transfer from the temperature sensor to the database, then to the event log and the digital display of the control panel. If there is an active control subscription, the data are transferred to the ventilation system controller, for example, with a command to enable ventilation.

If a subscription to the ventilation control scenario is made inactive, but a subscription to the data record in the database, the event log and the output on the control panel is saved, the control signals will not be generated. Thus, the "Observer" records the temperature change, which is reflected in all active subscribers. Subscribers themselves can connect and disconnect in the dynamic mode.

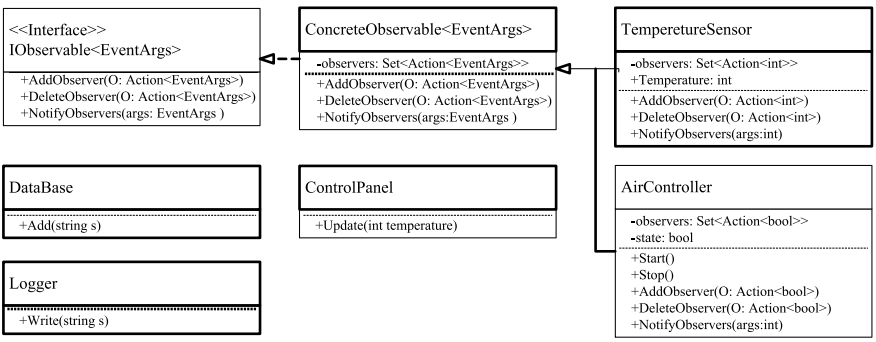

Fig. 9 UML class diagram for managing scripts using the "Observer" pattern

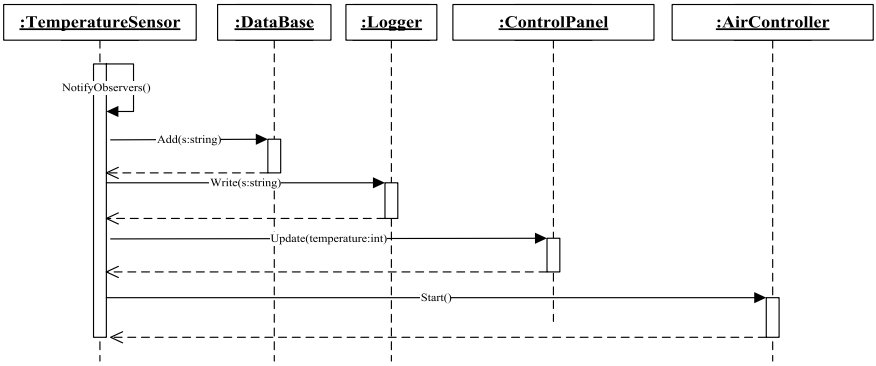

Fig. 10 UML sequence diagram for managing CPS building scenarios using the behavioral pattern "Observer"

Between the building's CPS components, measurement and control information is most often transmitted in a unified format, so it is necessary to ensure that the numerical values correspond to their physical equivalents. In addition, various IoT devices have their own unique value ranges of internal variables as well as their addresses in register maps, which significantly complicates the task of information compatibility.

For realization of such conformity and maintenance of transformations of measurements and control signals taking into account different maps of registers and ranges of values it is possible to use so-called grammars. The grammars describe the alphabets of all values of the variables that CPS of the building works with, they are effectively determined using the Interpreter pattern. During interpretation of a flow of commands of management or measurements, i.e. selection of conformity between data of IoT devices and their physical equivalents, it is possible to construct a parse tree from typical expressions of format conversion, Fig. 11, 12. As shown in Fig. 12, the values of measurements and control commands of an abstract IoT device are compared with the physical value of electrical power, which is important when ensuring the correct operation of scripts.

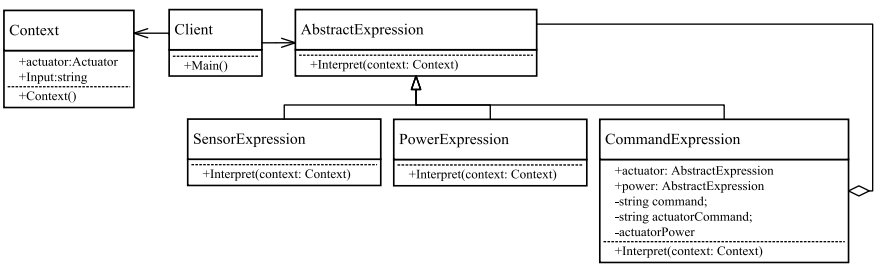

Fig. 11 UML class diagram of a block for converting CPS equipment control commands from one format to another

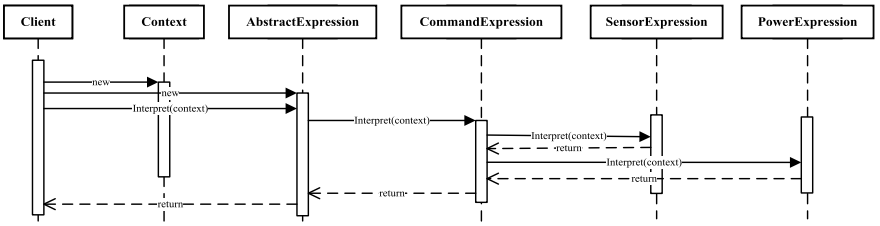

Fig. 12 UML sequence diagram of a unit for converting equipment control commands from one format to another

The presented patterns can be modified for a concrete task that is especially important for designing and development of platform technologies of software CPS of intellectual buildings.

Despite a considerable variety of templates, efficiency and expediency of application of the majority of them up to the end is not investigated. It should be noted that a large number of generating, structural and behavioral patterns have not been put forward in this work, as they have not shown in practice significant effects from their use.

The complexity of creating unified architectural solutions for building CPS software manufacturers is largely due to the peculiarities of the subject area and ensuring compatibility only at the interface level. The fact that the internal system architecture of the different software components is closed and significantly different from one product to another makes it still difficult to create large and efficient platforms within a unified Smart City concept.

4 Conclusion

Building's CPS is a basic element of IT architecture within Smart City approach. It is constituted by a set of integrated in premise control devices of life support systems, communication and computing facilities necessary for user services.

With the large number of building management products available on the IoT market, their system architecture is not compatible. Undoubtedly, this has an impact on the sustainability and operability of platform applications that combine software and hardware from different vendors in the same information environment. IoT presumes multiple ways of using design templates, so the conditions for selecting the best interpretation are necessary.

Presented requirements for building's CPS software and design pattern groups in practice significantly reduce the time spent on programming and setting up elements. Using the offered templates, software developers can operatively form new services, integrate and support them operatively. The patterns presented in the study are most effective in the implementation of services to control indoor and outdoor lighting,

power loads and electrical appliances, as well as systems such as heating, air conditioning, ventilation, security alarm systems, access control, water leakage control, audio and video equipment.

CPS software architecture design templates can be in demand for manufacturers of systems and services of management of private or apartment houses, developers of software systems of automation of commercial real estate objects and state organizations, developers and administrators of software of industrial constructions, objects of agroindustrial complex.

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Value Modeling for Digital Platform

Dinara Sadykova, Ekaterina Pylaeva, and Evgeny Zaramenskikh

Abstract The research considers the problem of business and IT languages difference while innovations implementation. That is why business and IT alignment plays a key role in digital transformation, brought value to organization's stakeholders. The paper deals with value modeling approach for network enterprise as a platform, which allows to create value for network enterprise. The paper is built in according to Design Science method. The most famous approaches to integration of different business models are considered in the paper. The developed approach is based on integration of Value Proposition Canvas and Value Delivery Modeling Language (VDML) and afterwards transforming them into the modeling language of the enterprise architecture ArchiMate. The approach allows to connect business strategy and value creation process in terms of Enterprise Architecture. Moreover, the approach was applied in real estate sales company as an owner of digital platform. Transformation to the network enterprise allows to create new services, which will bring value both for its clients and partners.

Keywords Value modeling · Enterprise modeling · Network enterprise · Digital platform · Meta models · Model integration

1 Introduction

The problem with value modeling is that nowadays Information Technology (IT) penetrate into business more and more, and innovations in IT sphere are rapidly changing the world. IT faces challenges with implementation of logic of value creation from the strategic level to the integration stage. The reason is that both sides use different languages and that is why it is very difficult for them to understand each other correctly and furthermore to adopt all the changes offered. The business

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side uses business models and related technology to address the business requirements and make new value proposition accordingly. However, usually this value, meant by business side, is created and modeled only for the business needs and business requirements of variable stakeholders satisfaction. Meanwhile, IT managers and specialists use other modeling techniques to construct the IT infrastructure, which are not fully understood by representatives of the business side. The functional difference between can lead to the difficulty of capturing each other's logics and mutual synergy.

This thesis constructs a value modeling approach with ArchiMate by mapping the concepts in ArchiMate with those in VDML to solve the problem mentioned above. By comparing the concepts, a series of value related viewpoints with ArchiMate are constructed, which can be applicable in the sphere of an enterprise with many members (network). These viewpoints covers different aspects in the value creation process. To efficiently use these viewpoints, a guideline of the Design Science method is provided to show the construction process of a value model, which means problem solving process, which has its own goals, perspectives, methods and stages.

In spite of that fact, that there are a lot of different research techniques and methodologies, applied in the IT sphere, such as positivist or interpretive approaches to IT researches, experimental, survey or critical research, Design Science method is applied in the paper, and there are a lot of reasons why. The research doesn't require strict conformity to standards, proposed in positivist approach, practical experiment in the real environment of experimental research, assessment of information systems in a social setting, proposed in critical research. The design science method was chosen, because, firstly, it involves creation of new knowledge through design of innovative artifacts, analysis of the artifact's use, and secondly it has a logic consequences of stages, such as analysis of the existing approaches in this sphere, design for the creation process of the artifacts, which should be made through generally accepted methods on the basis of already analysed researches, then evaluation stage, involved the verification of the created artifacts, whether they satisfy the earlier set objectives, goals and requirements, applying the methods stated in the research plan, and, finally, approbation stage to achieve the best possible results among the target groups and apply the developed business model in real conditions.

The aim of research is development of value modeling approach for the implementation of a network form as a digital platform.

Objectives:

1. To study various approaches and practices to value modeling;
2. Develop an approach to value modeling based on the creation of a pattern;
3. Consider the approach application by the example of the real estate sales company as a platform.

2 Analysis of Existing Researches

In order to propose new meta-model on creating of a template for business value it is necessary to analyse the papers which have been written before and discover what was laid down to the meaning of meta-models integration between and using the ontology in order to map several concepts.

For example, in [1] authors deal with analysis of different frameworks: Zachman, DoDAF, ARIS and other ones in order to capture strategic planning in EA. The problem, solved in this research paper, is described as strategic planning is currently not explicitly reflected in EA models. That is why NEMO research group deals with this gap by presenting a principled approach to support strategic planning modeling in EA, which means developing a conceptual model for strategic planning that is aligned with a foundational ontology and then proposed a language metamodel that incorporates the conceptual model into the ArchiMate modeling language.

In [2] authors present an ontological analysis of the concepts, focused particularly on the resource, capability and competence concepts. With the help of Unified Foundational Ontology (UFO) the researchers made the analysis of identification of the semantic features and developed a meta-model, which allows organizations to model their core capabilities and resources and to understand their current status or to improve the organization according to a capability-based planning approach., thereby improving the semantic clarity and usefulness of the proposed ArchiMate extension. As a result, the research covers the integration of the BSVC (Business Strategy Value Concepts) model with ArchiMate language. Also in [3] was covered the similar problem, meant investigation of the real-world semantics underlying risk-related constructs in one of such approaches, namely ArchiMate's Risk and Security Overlay (RSO) by means of ontological analysis. By means of the developed meta-model the researchers analysed it by means of the reference Ontological foundations with the concept of Common Ontology of Value and Risk and then proposed evolving the Risk and Security Overlay into ArchiMate language. The same work was made in [4], where for the motivation extension in ArchiMate meta-model was provided through ontological foundations in order to define all the necessary and additional blocks in the Motivation Extension. Moreover, in [5] a semantic analysis of service modeling fragments in ArchiMate trough developing a meta-model of Business layer taking as basis a reference ontology that is based on the notion of social commitments/claims for characterizing service relations presented, because service as "unit of functionality" hides some important social aspects inherent to service relations and makes some of the models that the language produces ambiguous.

Then, in [6] a formal mapping of the meta models to integrate DEMO and ArchiMate was proposed, accompanied by a rationale of why such a mapping is beneficial and a systematic application of the DEMO and ArchiMate meta models to map a model created in DEMO to a model of an enterprise architecture in ArchiMate. The authors used DEMO transaction patterns for process modelling and then translated DEMO process models into ArchiMate.

The papers [7] and [8] cover in the first research, mapping approach that integrates the value modelling technique of e3value modeling into the Enterprise Architecture language ArchiMate, and in the other one, the integration of the three meta-models: The Business Model Canvas, devoted to representing the business model of a company e3value, interpreted modeling of value networks ArchiMate, allowed enterprise architecture modeling, which considers three different layers: business, application and technology. In [9] a formal transformation of e3value into ArchiMate via DEMO is presented, because using DEMO as an intermediate between e3value and ArchiMate would also enable architects to use the semantically rich way of thinking of DEMO to create ArchiMate models starting from the economic transactions modelled in e3value. The different mapping techniques helps to show how to bridge between three different meta-models by use of ontologies or by use of constructing meta-models and which mapping method should be implemented in the different layer of organisation.

The paper [10] contributed to the identification of the relations between the strategic and operational aspects of the enterprise architecture applying an ontology-based approach, focused on facilitating the alignment between the goals and the operational elements of an organisation (such as processes, roles, and resources) through meta-model development.

Moreover, each paper covered here validates the developed or proposed mapping technique through a case study in the end in order to approbate the model.

As a result of the analysis phase, it is possible to highlight some points:

There are a lot of examples of using different business models and then integrate them together with application of different mapping techniques.

There is no research on the theme of integration of different approaches of creating value in network enterprise.

3 Value Modeling Approach Development for Network Enterprise

3.1 Analysis of the Existing Approaches to the Value Modeling

Value modeling process plays a key role in an any business, therefore currently variable approaches to the value creation process modeling in enterprise are developed. Below you can find a range of the approaches, which may be found oftenly.

Value Chain Model was proposed by M. Porter, Harvard Business School professor, for company performance development and a company competitiveness level increasing [11]. According to the concept, a company is considered as a chain of main activities, added value to the end service\product, and their optimization allows to reduce costs and increase profits.

Table 1 The result of the analysis of existing approaches to modeling value

Name	Link to the customer	Link to the products and services	Link to the business strategy	Link to value network	Link to the activities of the organization
Porter's value chain	–	–	–	–	–
Value proposition canvas	Yes	Yes	–	–	–
e3Value	–	–	–	Yes	–
VDML	–	Yes	–	Yes	Yes

According to the Value Proposition Canvas (VPC), proposed by A. Osterwalder and Y. Pigneur and connected to strategy management tool Business Model Canvas, basically correspondence of two blocks, such as client profile and value proposition, are presented in it [12].

E3value methodology is considered as a phased approach to the business development process for network of participants, which brings value to the participants from their mutual interaction [13].

Value Delivery Modeling Language was developed under the consortium OMG and considers a standard modeling language for enterprise activity analysis and designing, emphasizing on value creation and their interchange [14, 15]. The VDML concept consists of the range of the used patterns, which describe value creation for network participants. Moreover, VDML integrate other approaches, mentioned before, such as e3value and Business Model.

The existing approaches' analysis results are presented in the Table 1. The analysis results show that existing approaches to the value modeling are not connected to business strategy. This research paper mainly represents VPC and VDML approaches, because they allow to describe logics of value creation for network enterprise more precisely, and exactly ArchiMate modeling language allows to consider a connection with business strategy [16].

3.2 Development of Approach to Value Modeling

Value modeling approach, developed in terms of Enterprise Architecture, is presented on the Fig. 1. The mean of the approach lies in the integration of value description methods, such as Value Proposition Canvas and VDML, and in transforming these approaches to ArchiMate language.

Artefacts creation with VPC, VDML and ArchiMate allows to make connections among business aims, value creation logic, value creation network and value creation process.

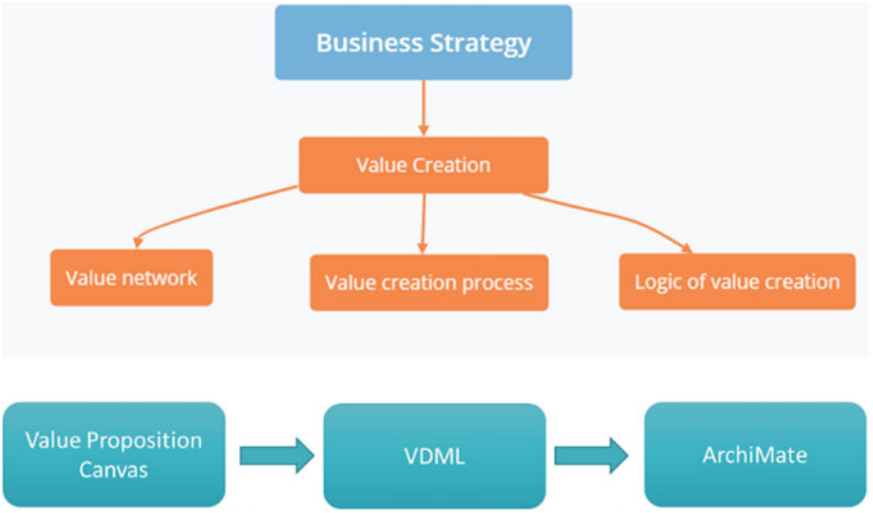

Fig. 1 Value modeling approach

For VPC and VDML modeling the research paper uses mapping technique for metamodels. In result, meta-models for such business models, such as VPC, VDML and ArchiMate's Business Layer were developed. The Fig. 2 shows mapping for them, reflecting connections among these three meta-models.

Table 2 shows connections among the different approaches, presented above.

3.3 Value Viewpoint Pattern Creation

The next step of the research paper is devoted to the Value Viewpoint pattern meta-model development in ArchiMate. Value Viewpoint is considered as a pattern for value modeling, allowed to notice the connections among stakeholders' aims, their requirements, value creation process through services using by the network participants, and the realization process through business services (Fig. 3).

4 Application of the Developed Approach Value Modeling on the Example of an Organization

The next stage of the research paper is the proposed approach approbation on the example of a real estate sales company as a platform owner. By a digital platform is meant a high-tech business model, which brings value by interaction between two or

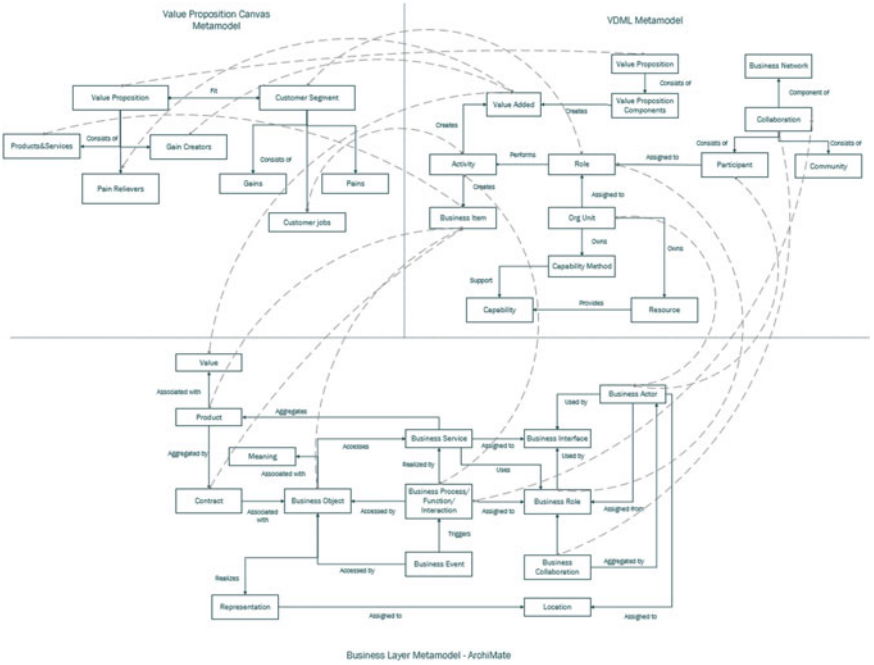

Fig. 2 Mapping technique for metamodels

Table 2 Link between objects in approaches

Value proposition canvas	VDML	ArchiMate
Value proposition	Value proposition	–
Customer segment	Role	Business role
Products and services	Business item	Product
		Business object
		Contract
Pain relievers	Value added	Value
Gain creators	Value added	
Gains	–	–
Pains	–	–
Customer jobs	Activity	Business process
		Function
		Interaction
–	Org unit	Business actor
	Participant	
–	Collaboration	Business collaboration

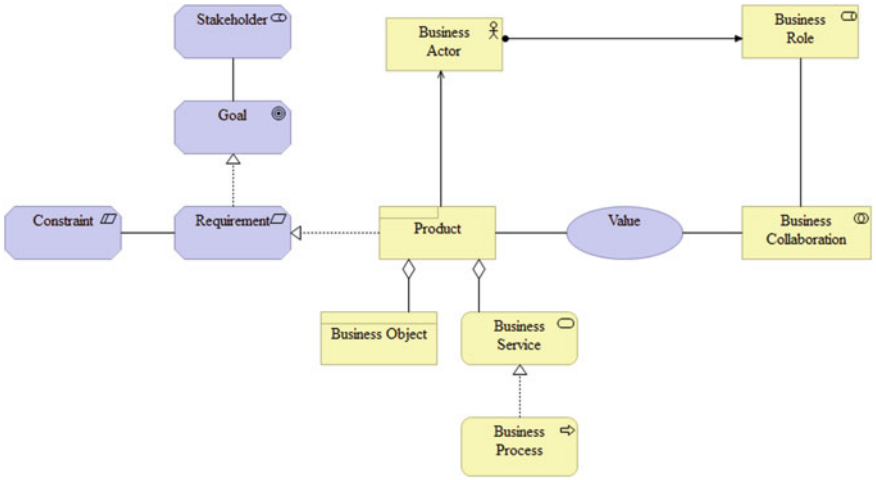

Fig. 3 Value viewpoint pattern meta-model

more its independent participants [17]. The new real estate sales company business-model has its own net of participants, which allows to provide some additional services for real estate sales company customers, for example, property searching property insurance or property repair service.

The result of value modeling of the real estate sales company as an owner of a digital platform may be considered the Value Proposition Canvas. The VPC is formed around the two main blocks, such as a client profile and value proposition of the company. The main type of clients here is individuals (Fig. 4).

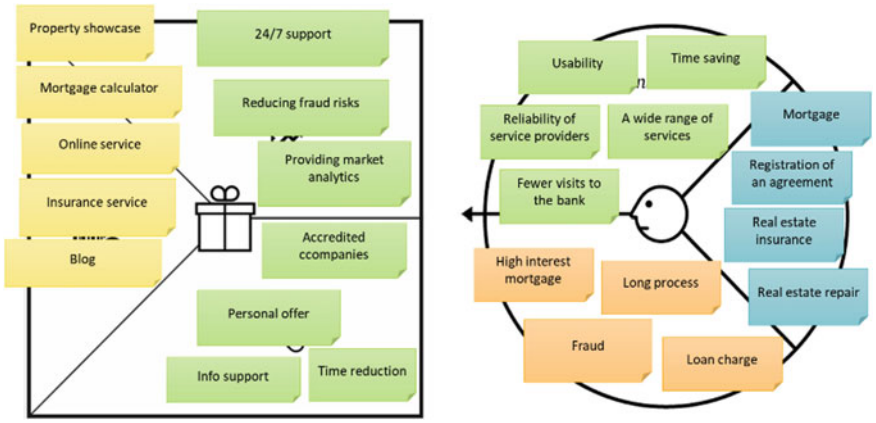

Fig. 4 Value proposition canvas

Then Value Proposition Exchange diagram and Collaboration Structure diagram in VDML were developed, which define both main participants of the network and products/services provided (Figs. 5 and 6).

While value modeling process description in enterprise architecture a model Value Viewpoint in ArchiMate was proposed. The model allows to define the logic and the process of the value creation and services through participants interaction. The model considers network participants' aims, their requirements and products/services range, which realizes the requirements (e.g. the client's aim is to get a service, satisfied with his requirements of a wide property choice and with a possibility to a proposition at the best price, and such requirements are met in the product "Property shop window"). Moreover, the business services, which make up each product/service, are distinguished. The product development through business processes distinguishing allows to define business processes, IT-systems and IT-infrastructure in the company for value realization in a network (Fig. 7).

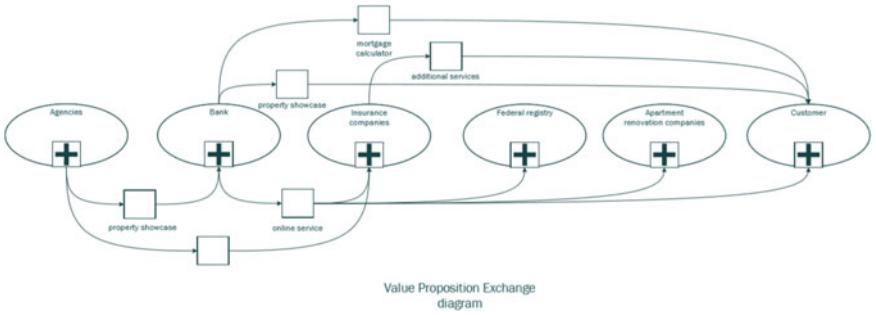

Fig. 5 Value proposition exchange diagram

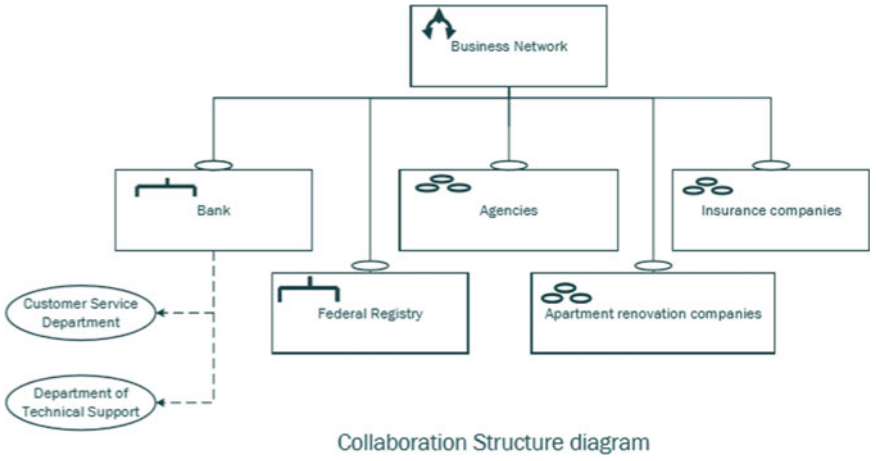

Fig. 6 Collaboration structure diagram

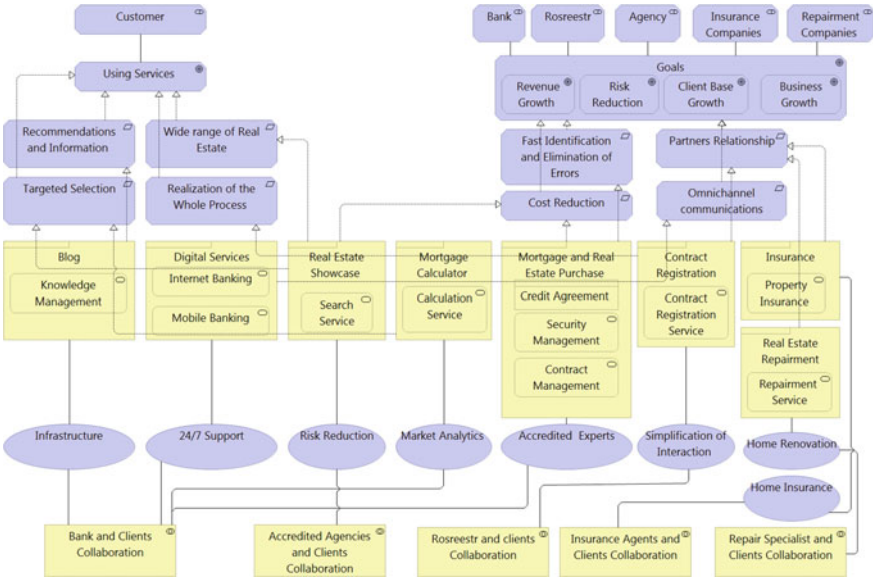

Fig. 7 Value viewpoint model

The picture above shows the Layered model of the enterprise, which allows to consider the enterprise cutaway three layers, such as business layer, information systems layer and infrastructure layer. Through value creation with Value Viewpoint business and IT now are able to define, which services, processes and systems should exist in the enterprise architecture.

5 Conclusion

To sum it up, different approaches and practices for value modeling were investigated. The aim of the research was completed, which meant development of value modeling approach, based on the integration of VDML, Value Proposition Canvas and ArchiMate, application of this approach was considered by the example of a real estate sales company. The approach to value creation process modeling in the context of the enterprise architecture ensures the implementation of the entire value creation logic from the strategic level to the implementation stage, thereby answering the question whether ArchiMate is able to construct a value model for enterprise. This will not only achieve alignment of business and IT, but also manage the development of a digital platform throughout the life cycle.

The paper contributes the sphere of Business Informatics field with raising a question of the importance of value creation process in the enterprise. And the methodology of value modeling approach, proposed in the paper, will allow constructing

company value model, and afterwards understanding the value of a company with net of participants. But there are still open questions the paper has not covered, such as verification of the value creation model, application of value model in real environment, the VDML distribution into business and IT layers of enterprise Architecture. The approximate future work is described above.

The implementation of the network form will allow the real estate sales company in the future to create new services that are valuable both for the client and for the company's partners.

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Planning an Information Project Portfolio for Developing Infrastructure of an E-Government in a Megapolis

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Abstract In this article we consider a method of forming an information project portfolio for developing infrastructure of an E-Government in a megapolis. The method is based on using mathematical programming aimed at working out an optimal plan in the conditions of limited resources, high-level uncertainty of the input data. A mathematical putting of a multi-criteria problem of optimization is introduced, recommendations of using are made clear. Testing their functionality and verification is carried out with example of developing the information infrastructure in St. Petersburg.

Keywords E-Government · State information systems · Information system project · Soft wear · COCOMO method · Mathematical programming · Multi-criteria problem · Method of sequence concessions · Mote-Carlo method · Estimation of parameters

1 Introduction

The results of the analysis carried out by the UNO Department of Economical and Social Issues show that all the countries of the world pay special attention to developing an E-Government. Nowadays the greatest progress is made in online public services, providing citizens with state services online. This direction has become the main driver in developing infrastructure of E-Government in most country of the world including Russia as a country with a very high level of it [1]. There appeared a positive tendency in appropriate public services for the most vulnerable citizens, and in minimizing the existing digital barriers. The UNO Report is aimed at fulfilling the agenda and the Road Map adopted in 2015 and directed at sustainable developing of the world.

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The policy in developing an infrastructure of an E-Government implies not only decisive steps from the State but also from the local authorities. Thus a pilot project aimed at assessment of E-Government in 40 cities of the world with Moscow as the winner. This research of online municipal services made it possible to formulate the indexes and indicators which helped to estimate the information and services and to formulate a rating of cities-participants. These results can be considered as requirements of the international community to technologies, content, public services and involvement of citizens. The modern infocommunicative infrastructure of megapolises, and the above mentioned requirements determine necessary conditions for perfecting E-Government.

The infrastructure of E-Government is made up by the Federal and Regional State Information Systems united into a territorial network. For example, only in St Petersburg 68 such systems are at work. For their upgrading and support, widening their functional abilities new project portfolio is formed. In the expenditure part of the budget of megapolises their financial costs are included.

Due to the limited planned expenses emerges the problem of their rational distribution. Such a task can be considered as the optimization problem, realized in conditions of limited resources. In the article [2] it is seen as a problem of the integer linear programming. The suggested optimization model is determined and implies full information about these projects in the portfolio. Traditional questions of Marcovits' theory consider formation of investment projects [3]. Benefits/risks proportion is investigated in them. In addition a covariance matrix of profitability is used for a certain period. In designing information projects such data are missing due to their innovative character. The cone of indefiniteness in assessment in the beginning of the project cause bad mistakes. The assessments scatter is from 4 to 16 times. That is why such assessment is cold "black art", meaning its difficulty and uncertainty [4].

Unfortunately, in spite of the great attention to the problems of risk-management a lot of projects are carried out only partly or end up in failure. The yearly Chaos Report, published by Standish Group [5] says that the number unsuccessful projects remains very high in spite of different models of their life cycle and great efforts, 71% in 2015 and the average number of unsuccessful projects is 19% from 2011 to 2015.

In the PMBOK guidelines [6] general characteristics of the tools for risk assessment in managing projects is given. One of them is mathematical modeling [7], where a random quantity- coefficient of increasing the duration of the project for every risk. Imitation modeling of its values allows to form a histogram of distributing the duration of the project and to estimate the risk of failure using Monte-Carlo method.

For solving complicated problems of systematic engineering in conditions of multi-criteria those of the most popular methods are the method of Hierarchy analysis (AHP) and method of analytical nets (ANP) by Saati [8]. The hierarchical or net models help to determine the priorities of some criteria and choose the best of the analyzed alternatives. These methods are based on the eclectic approach including methods of expert questioning, linear algebra and the theory of taking decisions in the conditions multi-criteria. The range of research and a great number of examples

in using these methods allows to form hypothesis of the possibility to use them in solving the problems of planning.

So, urgent is the task of working out instrumental tools for defining a information project portfolio in the conditions of uncertainty limited resources and multi-criteria. Monte-Carlo method can be methodological basis for fulfilling the task, and also systematic and programming engineering, the methods of mathematical programming and modelling.

2 Materials and Methods

Suppose, that the required list of IT-projects which is reasonable to fulfill while realizing the formed portfolio. Such a portfolio can be presented by binary vector $X = (x_1, x_2, \ldots, x_n)$, where n-the number of the required projects, x_i—binary variable which takes a singular value, is the project is included in the plan and zero, if it isn't planned to realize.

Let's assume that the target function, which value is optimized as a result of solving the problem of mathematical programming, is a linear form

$$\sum_{i=1}^{n} w_i x_i \rightarrow \max \tag{1}$$

where w_i—a global priority i—project, what can be defined with the method of the Hierarchy analysis. 3-level Hierarchy, including criteria and indicators of the properties of the IT project importance, priority, difficulty and novelty for designing is shown on Fig. 1. On the final level of this Hierarchy there is a multitude of projects under consideration.

For estimating the global priorities it should be taken into consideration, that benefits should be increased and expenditures—to be decreased. The global priority of i-project will be defined with the help of the equation

$$w_i = (w_b ben_i + w_u un_i)/(w_c comp_i + w_n nuv_i) \tag{2}$$

where w_b, w_u, w_c, w_n—values of local priorities of significance, urgency, complexity and novelty accordingly;

beni, uni, compi, nuvi—values of indicators of significance, priority, complexity and novelty for designing, measured on the scale from 1 to 5. The minimum value of an indicator corresponds to the minimum indicator of the given scale, its maximum value—to the maximum.

Specific values of local and global priorities wi depend on the current situation of planning, accepted rules, projects and programs, the degree of completion of the information infrastructure of a megapolis.

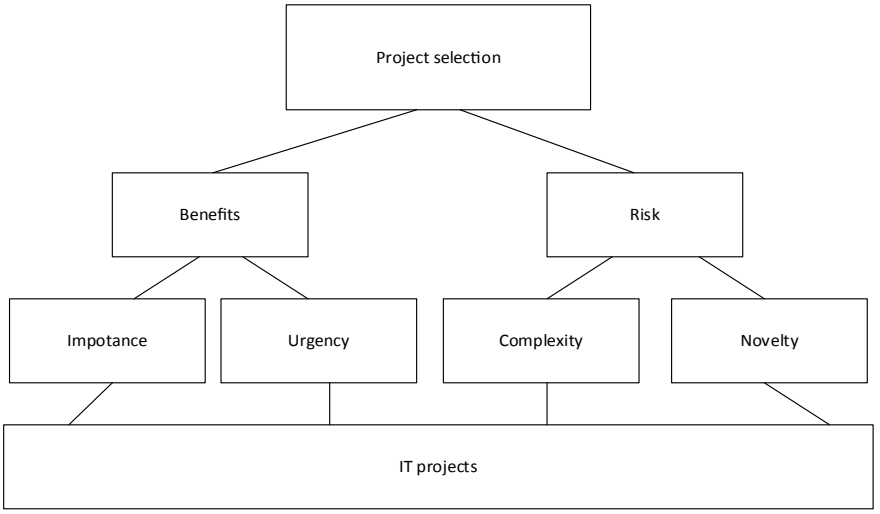

Fig. 1 3-level hierarchy

A one-criterion problem of optimization in light of the limited resources looks like:

$$\begin{aligned} &F = \sum_{i=1}^{n} w_i x_i \rightarrow \max; \\ &\forall i : x_i \in \{0, 1\}; \\ &\sum_{i=1}^{n} C_i x_i \leq C_B, \end{aligned} \tag{3}$$

where C_i—budget i-project, C_B—expenditure part of the megapolise's budget, allocated for developing the infrastructure of an E-Government.

This problem is determined and it can be solved by the methods of an integer mathematical programming. However, C_i—are random values. That's all the limitations of this problem contain a random quantity in its left side. The problem in general is of stochastic nature. To solve it you must know their laws of distribution which can help to define the mathematical expectation $E(C_i)$ and to proceed from a stochastic problem to the determined integer one of linear programming. Ignoring the dispersion of random quantities in this case decreases the value of the problem under consideration.

As [6] the tools of quantitative analysis of the period, the cost of fulfilling the projects a 3-point estimation is suggested. It implies choosing a random quantity by three values: minimum, maximum and the most probable one. Such estimation implies an assumption of a triangle law distribution, for which the mathematical

expected values are calculated with the help of the correlation:

$$E(X_i) = 1/3\left(x_{i_{\min}} + x_{i_{\max}} + x_{i_{\text{HB}}}\right) \quad (4)$$

where $x_{i_{\min}}$, $x_{i_{\max}}$, $x_{i_{\text{HB}}}$—minimum, maximum and the most probable (the distribution mode) value of a random quantity X_i.

For further specification of the problem of the mathematical programming we will introduce a time limit for designing, supposing that each project is worked on not longer than a year. Thus, the limitation "$Time_i \leq Year$" is an additional limitation which in a general case reduces of the optimization problem, where Timei—the duration of fulfilling the i-project, in months; Year—the number of months in a year.

To solve the optimization problem we will use the basics of Barry Boem' theory, who worked out the basics of software economics. It should be noted that this scientist-programmer continues his active creative activities at South-California University. By now there exists a toolbar for estimation the cost of the software COCOMO (COnstructive COst MOdel), based on using two-stage regressive models. The first one makes it possible to estimate the required labor, costs in man-month on designing software of a required size. The second one allows to define the period of designing in months, using the calculated values of labor costs. Two-generations of the models (COCOMOI, COCOMOII) are aimed at cascade and spiral models of the life cycle of designing. For measuring defining required expenditures there are a great number of software applications, online calculators, considered, for example, in [10–13].

To get the required values of the preplanned IT-project portfolio we will use the COCOMOII model and the software application System Star.[1] This choice is made because the system is based on the spiral model of a life cycle of designed which is now one of the most up-to-date, flexible models of designing. The selective regressive models used for calculation look like this:

$$\begin{aligned} Effort_i &= 2.94 \cdot EAF_i \cdot (KSLOC_i)^{1.0997}; \\ Time_i &= 3.67 \cdot (Effort_i)^{0.3179}, \end{aligned} \quad (5)$$

where $Effort_i$—labor costs of working out the software (fulfilling IT i-project), in months;

$KSLOC_i$—the size of IT i-project in kilolines in process;

EAF_i—correcting factors of costs, owing to the specific character of a project, the team, the platforms of the project and the product in work. These factors make it possible to decrease or increase labor costs in comparison with the rated values, implying EAF = 1. In further calculations we will accept that this correcting factor is missing (for certainty);

$Time_i$—time, the required time for completing IT i-project.

[1] http://www.softstarsystems.com/.

As the size of the software is not none in advance we will accept that it is the random quantity distributed according to the triangle distribution law.

A 3-point assessment implies inputting three values of size, minimum, maximum, and the most probable: $\left(KSLOC_{i_{\min}}, KSLOC_{i_{\max}}, KSLOC_{i_{\mathrm{HB}}}\right)$.

Due to the given regressive models the time limit looks like this:

$$\begin{aligned} Time_i &= 3.67 \cdot \left(2.94 \cdot \left(KSLOC_{i_{\max}}\right)^{1.0997}\right)^{0.3179} \\ &= 5.17 \cdot \left(KSLOC_{i_{\max}}\right)^{1.0997} \leq Year = 12. \end{aligned} \tag{6}$$

This limitation implies that a three point assessment of the size of the software used as a role predictor in regressive models is used while defining the input data for the optimization problem. There exists a "student syndrome" of the designing and shortage of the timing money, so we will use the maximum value of the $KSLOC_{i_{\max}}$-size.

Owing to the fact that in the optimization problem limitations are random we will use Monte-Carlo method. For this we will make a synthetic selection of N-size each j-observation of which is a vector of values of random quantities—the size of the IT-project. The problem of mathematical programming for j-observation looks like this:

$$L_j = \sum_{i=1}^{n} C_{ij} x_{ij} \to \max \tag{7}$$

$$F_j = \sum_{i=1}^{n} w_i x_{ij} \to \max;$$

$$\forall i : x_{ij} \in \{0, 1\};$$

$$\sum_{i=1}^{n} C_{ij} x_{ij} \leq C_B, \tag{8}$$

where j—the observation number;

C_{ij}—the cost value of completing i-project for j-observation. To determine this value the tariff-rate of a man-hour in megapolis—c, should be taken in to consideration and also the number of working hours in a month—m. In further calculations we will take m = 152 according to Boem's recommendations:

$$C_{ij} = c \cdot m \cdot Effort_{ij} = 2.94 \cdot c \cdot m \cdot EAF_i \cdot \left(KSLOC_{ij}\right)^{1.0997} \tag{9}$$

As a result of repeated solutions of optimization problem we receive a selection of values of binary random quantities each of which can be described by Bernully distribution with the parameter p—probability of the project to be included in the

plan. The assessment of this probability can be done by finding the average as for Bernully distribution the expected value of the random quantity is p.

The result of the optimization problem is a vector of the values of probability $\widehat{P} = \left(\widehat{p}_1, \widehat{p}_2, ..., \widehat{p}_n\right)$, where the assessment of the project's probability to be included in to the plan is calculated with the help on mathematical average

$$\widehat{p}_i = 1/N \sum_{j=1}^{N} x_{ij} \tag{10}$$

where x_{ij}—the value of binary quantity x_i for j-observation.

The accuracy of probability assessment is determined by the size of synthetic selection received by Monte-Carlo method.

So, in contrast to the deterministic approach to the problem of planning in methods of linear programming and in contrast to using expected value of random quality in stochastic problems of mathematical programming we suggest a different approach based on not on the only value but on the law of distributing binary random quantities. A person who takes a decision can make a plan based on the assessment of probability p_i. In this case he can justify his decision, which increases trust to him.

As a rule solving complicated problems such as developing infrastructure of E-Government megapolis goes in conditions of multi-criteria determined not only by singularity of target that must be achieved. As the expenditure part of the budget is a low it must be fulfilled. That as why besides the mentioned target and one appropriate function F(vector of independent functions F_j) we have the second target—maximum implement of the budget or minimum unused budget:

$$L = C_B - \sum_{i=1}^{n} C_i x_i \to \min \tag{11}$$

Having done some algebraic transformations and using Monte-Carlo method we have

$$L_j = \sum_{i=1}^{n} C_{ij} x_{ij} \to \max \tag{12}$$

So, the problem of making up a plan is multi-criteria and for j- observation looks like this:

$$F_j = \sum_{i=1}^{n} w_i x_{ij} \to \max;$$

$$L_j = \sum_{i=1}^{n} C_{ij} x_{ij} \to \max;$$

$$\forall i : x_{ij} \in \{0, 1\};$$
$$\sum_{i=1}^{n} C_{ij} x_{ij} \leq C_B. \tag{13}$$

In a general case the mentioned objectives have different priorities. That is why this problem of multi-criteria optimization can be solved by the method of consequent concessions. But the quantity of concession must not be less than an assessment mistake to distinguish *it on the background noise.*

Let function F be more prior to function L. In this case this problem can be presented by two problems of linear programming. The first problem (N-problems) is for determining maximum value of the target function F (F_j for Monte Carlo method):

$$F_j = \sum_{i=1}^{n} w_i x_{ij} \rightarrow \max;$$
$$\forall i : x_{ij} \in \{0, 1\};$$
$$\sum_{i=1}^{n} C_{ij} x_{ij} \leq C_B. \tag{14}$$

The mathematical formulation of the second problem looks like this:

$$L_j = \sum_{i=1}^{n} C_{ij} x_{ij} \rightarrow \max;$$
$$\forall i : x_{ij} \in \{0, 1\};$$
$$F_j = \sum_{i=1}^{n} w_i x_{ij} \geq F_j^* - s;$$
$$C_B - \sum_{i=1}^{n} C_{ij} x_{ij} \geq 0, \tag{15}$$

where F_j^*—maximum value of the target function F_j found on the first step of optimization problem; s—average square deviation of the random quantity F received from the synthetic selection formed by Monte Carlo method.

Algorithm of solving the problem of forming an optimal portfolio is a sequence of the following steps.

Step 1. A list of IT-projects which can be included in portfolio is formed.

Step 2. The source data of the problems are defined. The parameters of each IT-project- candidate in the project portfolio are given.

Step 3. The optimization problem is solved by the method of consequent concessions.

Step 4. Laws of distribution of binary random quantities are formulated.

Step 5. A decision is formed taking into consideration the received assessment of random quantities.

3 Results

To check the adequateness of the tools we will use quantitative data about the planned list of the works fulfilled for St. Petersburg. The choice of this megapolis is determined by comparatively high level of E-Government in this city, a great number of local state information systems and a great number of IT-companies which are able to realize IT-project aimed at the development of infrastructure of E-Government regionally.

On the list of possible projects without projects related to struggle against cyber-crimes and ensuring safety of critical information systems 24 IT-projects are included. To solve the optimization problem characteristics of importance, urgency, complexity and novelty were defined, and a 3-point assessment of the size of the software of IT-projects.

In Fig. 2 we can see the values of the periods for fulfilling IT-projects calculated with the help of regressive model.

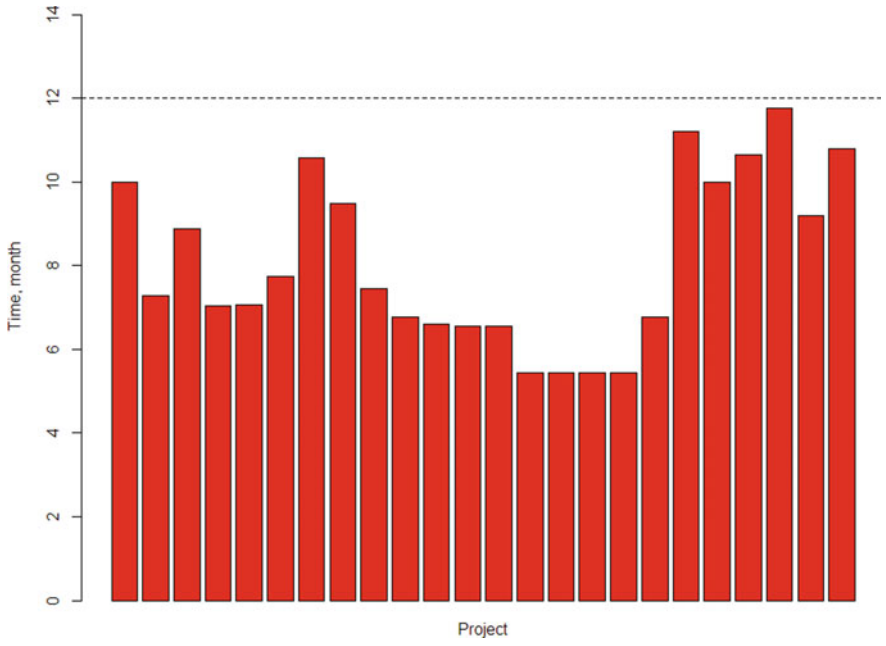

Fig. 2 The values of the periods for fulfilling IT-projects

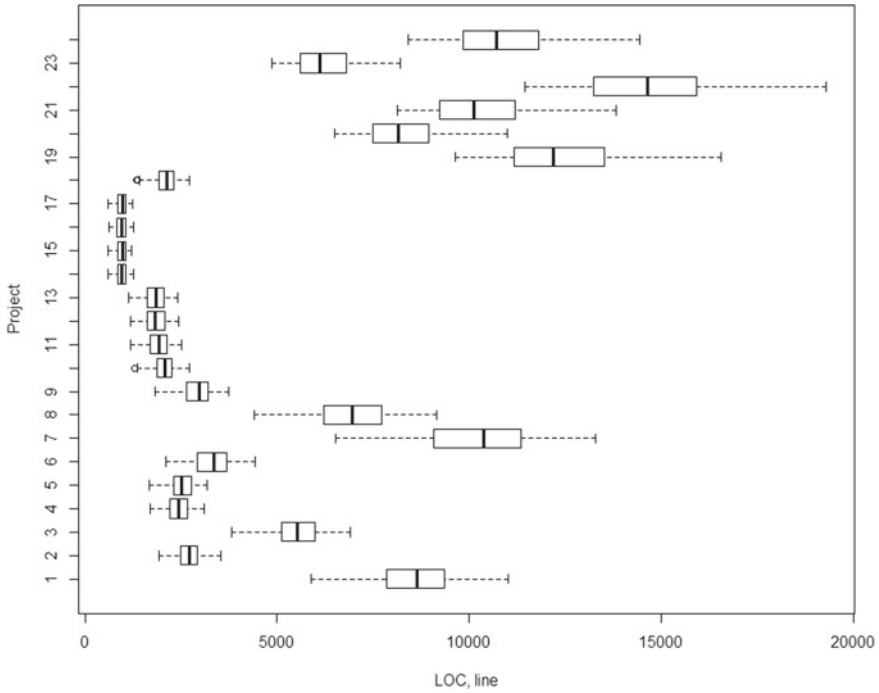

Fig. 3 Box diagrams of random quantities—the size of the project in lines

In Fig. 3 we see box diagrams of random quantities—the size of the project in lines based on synthetic selection formed with the help of Monte-Carlo method. The diagrams show a great scatter of values, presence of small and medium projects. The distribution of IT-projects in these groups is about a same. The diagrams show asymmetry of distribution of random quantities that confirms hyposesis that solving the optimization problem using expected value in limitation is not always rational because the results may be displaced.

The formed synthetic selection contains 50 observations which helps to find errors in assessment of probabilities in included IT-projects into the plan $\sqrt{\widehat{p}_i\left(1-\widehat{p}_i\right)/50}$.

As a maximum mistake occurs in the case when probability is 0.5, this error isn't more than 0.07. If it is necessary to increase the accuracy of assessment the size of synthetic selection can be made bigger.

The results of solving a one-criterion optimization problem helped to determine vector $\widehat{P}_1$ of assessment of probability to include IT-projects into the plan. In Fig. 4 is the column diagram sorted out according to the probability value. This diagram shows that for projects have zero probability to be included into the plan, four more projects have probability less than 1. Thirteen projects are recommended to be included into the plan at probability of 1.

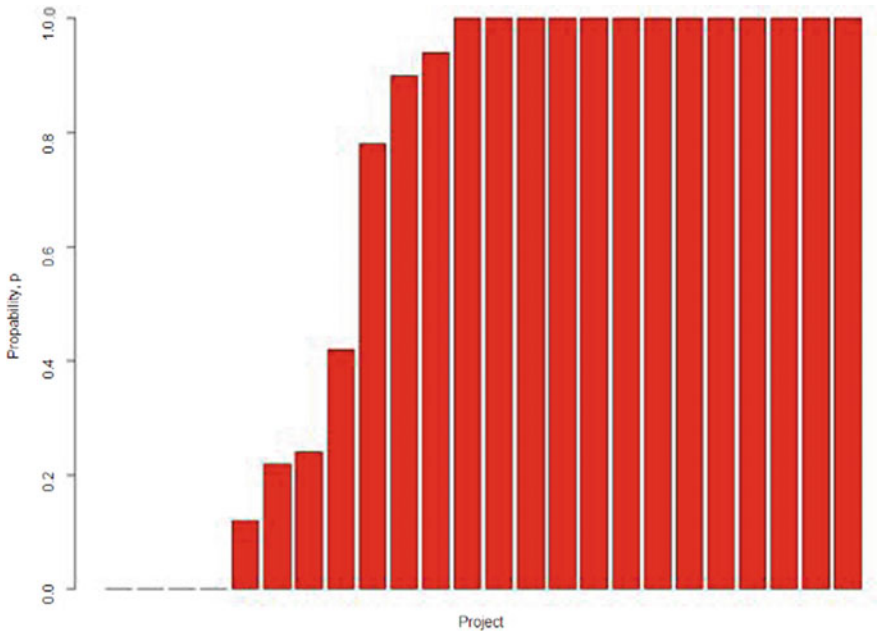

Fig. 4 Diagram of distributing probability to include IT-projects into the plan: results of one-criterion optimization

In this plan there is variation of values of target function F and integrated cost of all the projects in plan C. In Table 1 are given descriptive characteristics of random quantities received from the selection of 50 observations.

These statistic data show that there is asymmetry if the received laws of distribution. The square deviation of integrated cost is 624, 42 thousand rubles and the range is nearly 1 mln. rubles.

These values confirm reasonableness of solving multi-criteria optimization problem. As a result we have got vector $\widehat{P}_2$ of probability assessment, the column diagram for which is given in Fig. 5. This diagram shows essential differences in the results of solving optimization problem. The obtained statistics for estimating the value of integrated cost shows that the average deviation from allocated budget is about 20 thousand rubles. The range of all possible values for the selection of 50 observations is only 99 thousand rubles i.e. that is almost ten times less than by solving one-criterion optimization problem.

Table 1 Descriptive statistics of values *F*, *C*

Value	Mean	Var	Sd	Skewness	Kurtosis	Scope
F	59.491	0.44	0.66	0.87	1.04	3.3
C	59,088.71	389,894.7	624.42	−0.83	0.004	2585.66

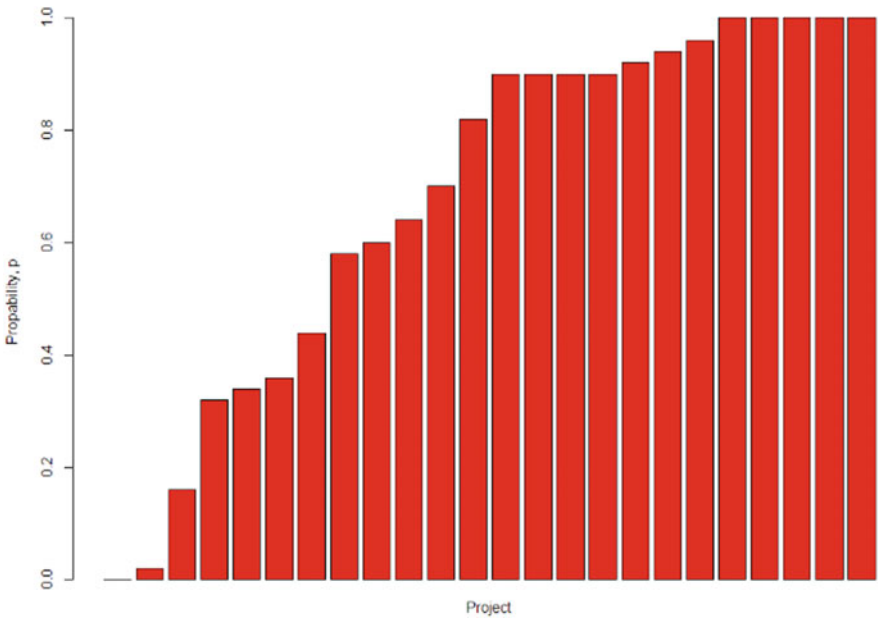

Fig. 5 Diagram of distributing probability to include IT-projects into the plan: results of two-criterion optimization

To prove the significance of the results of planning by using one- and two-criteria optimization problems a contingency table 2 × 2 was made. Two possible decisions became the lines of the table: to include or not to include a project into the portfolio. Let's call this two situations TRUE, FALSE accordingly. The columns of the table are similar situations corresponding to the results of the two-criteria problem. The form of such contingency table is Table 2.

In this picture TP (true positive) is marked as the total number of situations when both methods recommend to include to project in to the optimal plan. In the cell FN(false negative) is the number of situations when the one-criterion optimization problem recommends to include the project into the plan but not to include by the two-criteria problem. Two more cells of the picture are marked FP (false positive), TN (true negative). They correspond to the situations when the one-criterion optimization problem recommends not to include the project into the plan but the two-criteria problem includes FP or doesn't include TN (Table 3).

Table 2 Contingency table

One-criterion optimization	Two-criteria optimization	
	TRUE (positive)	FALSE (negative)
TRUE (positive)	TP	FN
FALSE (negative)	FP	TN

Table 3 Table of contingency for comparative analysis of results of planning

One-criterion optimization	Two-criteria optimization		Sum
	TRUE	FALSE	
TRUE	722	98	820
FALSE	98	282	380
SUMMA	820	380	1200

For estimating the significance of differences in the results of solving two optimization problems the criterion χ^2 was used. The observed criterion value is found with the help of the correlation.

$$\begin{aligned}\chi^2 = &\frac{(TP-(TP+FN)(TP+FP)/N)^2}{(TP+FN)(TP+FP)/N} \\ &+\frac{(FN-(TP+FN)(FN+TN)/N)^2}{(TP+FN)(FN+TN)/N} \\ &+\frac{(FP-(FP+TN)(TP+FP)/N)^2}{(FP+TN)(TP+FP)/N} \\ &+\frac{(TN-(FP+TN)(FN+TN)/N)^2}{(FP+TN)(FN+TN)/N} = 465,17 \end{aligned} \tag{16}$$

This criterion value shows a considerable difference of results in solving problems by different methods.

4 Discussion

Digital transformation of the society, the digital revolution, rapid development of IT-technologies aimed at achieving targets of steady development, determined by the UNO resolution lead to strong uncertainty of planning problems and managing the development of E-Government' infrastructure on the federal and municipal levels. For this purpose the article suggests tools based on using Monte-Carlo method and also methods statistical processing the results of solving specific problems of multi-criteria optimization for each observation of synthetic selection.

The suggested approach to solving the problems of planning IT-project portfolio for developing E-Government's infrastructure in megapolis allows to determine a list of IT-projects in conditions of multi-criteria. The comparative analysis of optimal plans received by solving one-criterion and multi-criteria problems, shows the high significance of the differences. Such results determine the importance of a complex multi-criteria approach to solving the problems of planning infrastructure development.

Verification of the tools was carried out on the example of St. Petersburg. The results confirm the full functionality steadiness in the conditions of existing errors in assessment and practicality. Further research may be reasonably carried out in developing other tools which allow to solve the problems of steady development of a megapolis, a country and society as a whole.

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Design Patterns for Digital Platforms

Evgeny Zaramenskikh and Alexander Oleynik

Abstract The architectural approach allows you to achieve the reuse of knowledge in the development of a digital platform through the use of modelling patterns, which is especially important in the conditions of digital platforms spread and the enterprises' needs in obtaining the competitive advantages that digital platforms provide to their owners. This article deals with questions of multi-level conceptual models formation, considering the subject area of the organization, which are further used as a conceptual basis for designing a digital platform. The possibility of using three levels of modelling abstraction including meta-metamodel, metamodel, and directly the enterprise architecture model of a digital platform, is considered in detail. Demonstrated practical experience of applying modelling patterns for a large service company digital platform development, which provides services to transport companies, suppliers of sensors and equipment, as well as delivery customers.

Keywords Digital platform · Ontology · Conceptual modelling · Design pattern

1 Introduction

Currently, digital platforms are used and can be used in various spheres of economic and social activities, including manufacturing, entertainment, medicine, logistics, public administration, etc. [1]. Despite the costs associated with the transition from legacy and outdated information systems, digital platforms can not only reduce the financial costs of organizations, the products they create, and the services provided but also can provide fundamentally new opportunities for communication and cost reduction [2].

User information and aggregated data processing will provide a better understanding of the different digital platform user groups' preferences and adapt services

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to suit their needs [3]. Digital services implemented on the digital platform basis can adapt to the needs of consumers and have broad prospects for scaling [4].

The transition to a digital platform will require the aggregation of data from disparate sources and the implementation of the transition to data shared access. There is also a clear need to change processes and integrate numerous inherited information systems [5].

The digital platform is a platform on the basis of which numerous digital services are provided to individual consumers, businesses, the state and non-profit organizations. Since the digital platform should initially be developed considering the presence of many subject areas, it is possible to virtualize a significant part of the main and auxiliary processes [6].

Such virtualization becomes a tool for creating an additional enterprise value for its counterparties and consumers since the process of virtualization implies sharing of digital services [7].

Digital platforms of large companies can be integrated with digital ecosystems of other enterprises. There are numerous examples of the areas of entertainment and commerce: Netflix, iTunes, Amazon, eBay, etc. Digital platforms are also successfully used by industry (Siemens' MindSphere, General Electric's Predix, Caterpillar's Cat Connect, etc.).

There are various definitions for the digital platform. Accenture Technology Company defines it as: "Digital platform—is a group of technologies that are used as the basis for the creation of specific and specialized digital interaction system."

A digital platform is a type of enterprise that provides mutually beneficial multilateral interaction for producers and consumers. The digital platform provides an open infrastructure for participants and establishes new rules for interaction [8].

A digital platform is a collection of digital technologies, products, or services that create the basis on which external companies can create their own complementary products, technologies, or services [9].

2 Related Work

Today there are numerous studies on the fundamental ontological conceptual modelling foundations [10]. The basic issues of conceptual modelling are also highlighted in the theory and methodology of enterprise ontology forming work [11]. Also of interest is the work on domain modelling of large and medium-sized enterprises [12].

An ontological analysis of abilities and resources that were added in later versions of the ArchiMate language was made in [13]. The paper presents a proposal of the metamodel formed on the basis of current language version. The author's metamodel includes an additional Competence object, which can be considered as a specialization of the Resource object. Considering the specifics of the subject area, the metamodel also includes Risk objects (standard for ArchiMate Assessment object specialization) and Value.

In similar work, authors studied the issue of strategic planning applying methods in conjunction with an architectural approach based on conceptual modelling methods and proposed an enterprise strategy and strategic planning model [14].

In [15], the translating DEMO process models to ArchiMate is described. The study demonstrates the possibilities of translating DEMO models into ArchiMate models based on the mapping technique. The presented model demonstrates the DEMO methodology and the ArchiMate modelling language objects interconnection. In general the method of selecting abstraction levels in the simulation of socio-technical systems and the definition of the relationship between the levels are developed by the OMG group in the Meta Object Facility standard [16] and supplemented in research projects [17, 18].

The process of a meta-metamodel constructing and its connection to models at lower levels of abstraction corresponding with the ideas of modelling and design, developed in [19, 20], as well as published in the materials of research groups NEMO, EIL, OMiLab, CIAO!

3 An Example of the General Description Development of the Target Digital Platform

3.1 Implemented Architecture Digital Platform Metamodel

Presented metamodels with the required depth of covered architecture segments study were used in designing a company working in the service industry in a group of transport companies.

Figure 1 shows the enterprise architecture main layers, the used meta models, and the general connections between it. The metamodel of enterprise architecture modeling is based on ArchiMate, the process modeling metamodel is based on BPMN 2.0 notation.

Figure 2 shows the author's metamodel for modeling enterprise architecture. The metamodel is formed on the ArchiMate architecture modeling language elements basis and architecture representations that are proposed by the Open Group consortium [21]. The selected language elements and links between it are adapted to the subject area and the enterprise architecture management current level maturity.

Object Management Group (Business Process Model and Notation 2.0) materials [22] were used next to form the business process modeling meta-model. The materials of the Object Management Group (Unified Modeling Language, version 2.5.1) [23] were also used to form the use case modeling metamodel.

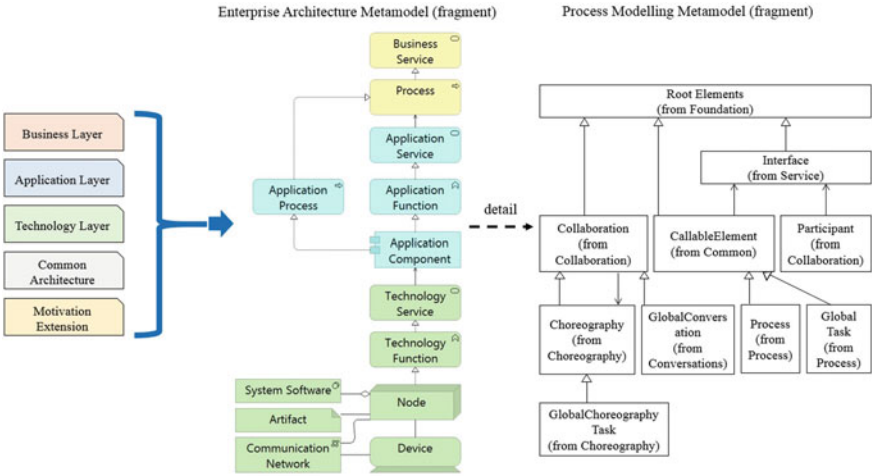

Fig. 1 Layers of enterprise architecture, metamodel, and links between it

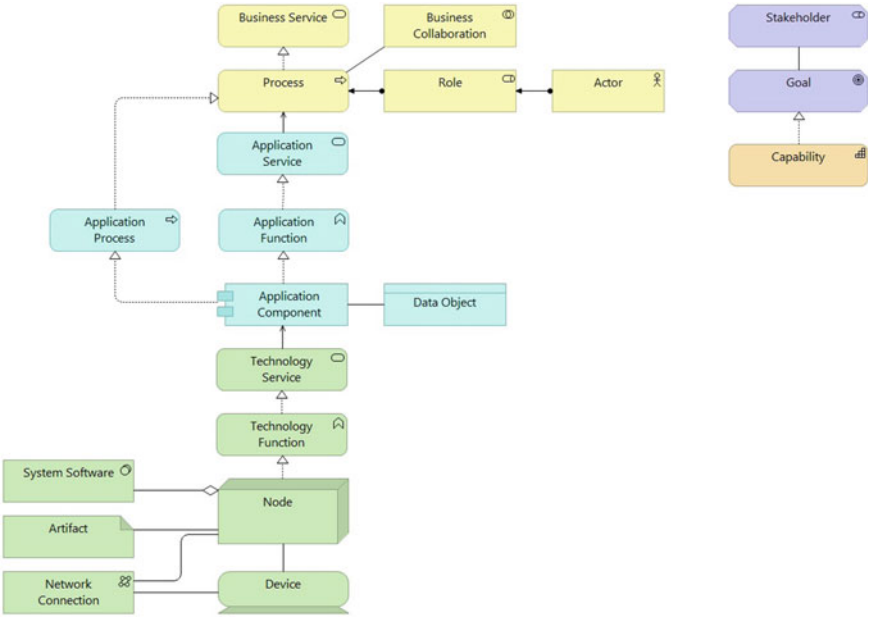

Fig. 2 Formed meta-model for modeling the enterprise architecture

3.2 Modeling Abstraction Levels

For enterprise architecture description, three levels of abstraction were identified. (Fig. 3): M1—the level of models describing the enterprise architecture; M2—the level of metamodels, which determine the possible level M1 models' types; M3 is the meta-metamodels level, which interconnect all metamodels and creates the basis for an agreed multidimensional enterprise architecture description.

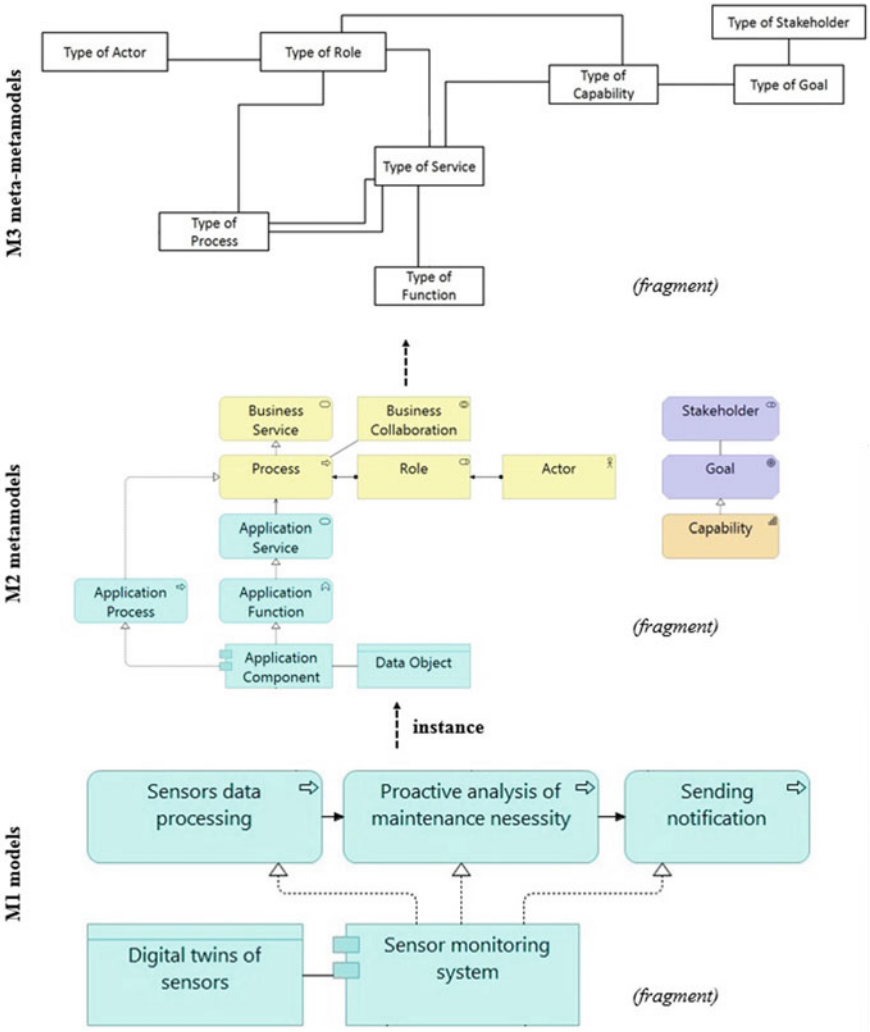

Fig. 3 System models' classification and communication

The M2 level metamodels provide M1 level enterprise architecture models integration, describing their general characteristics and key concepts. In turn, M2 level metamodels allow a holistic look at M1 level models and provide the foundation necessary for their formation. Each element of the M2 level metamodel is an instance of some meta-metamodel element (M3), and each metamodel is a meta-metamodel instance.

A meta-metamodel (level M3) contains types—predicates that characterize all instances of a type with a certain set of inherent properties. Figure 4 shows the meta-model of LLC "Service company" architecture.

Meta-metamodel elements are LLC "Service Company" subject domain modeled basic abstractions which provide semantic links between the models of underlying levels.

All the meta-model elements were conditionally divided into four groups, reflecting various company aspects: strategic, organizational, applications and technology (Table 1). These enterprise aspects were formed basing on the described in detail in W. Frank works [24] model basis.

The TOGAF standard metamodel [25] was taken as the basis for the system conceptual meta-metamodel, since this framework is the most common for describing an enterprise architecture. Metamodel TOGAF allowed the creation of "Service Company" conceptual meta-metamodel, which was used for company architecture description, considering its specificity.

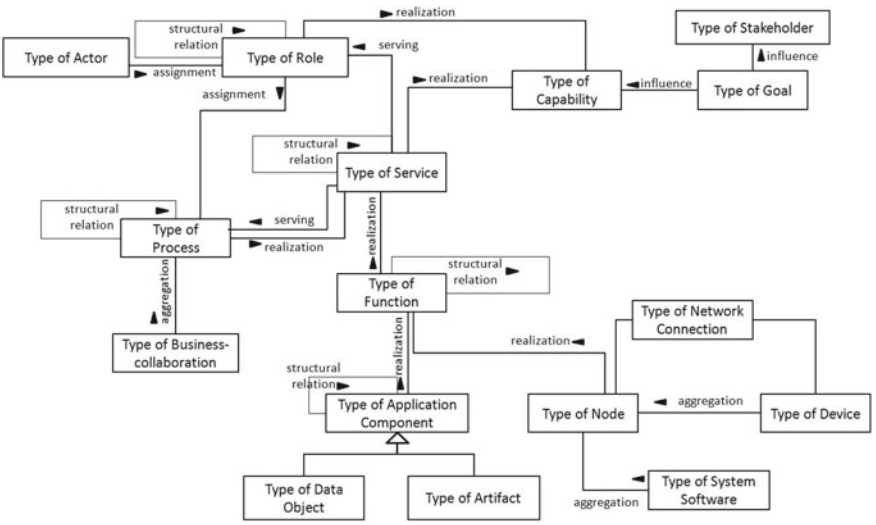

Fig. 4 LLC "Service Company" architecture description meta-metamodel

Table 1 Key concepts for the digital platform higher-level architecture description

Strategy	Organization	Applications	Technology
• Goal • Stakeholder	• Role • Actor • Digital service • Business service • Business process • Business function • Capability • Business-collaboration	• Application service (IT-service) • Application component • Data object • Application function • Application process	• Technology service • Node • Device • Artifact • System software • Network connection • Node function

3.3 Selecting Patterns of Digital Platform Simulation

Figure 5 shows an example of the relationships visualization between elements of the M1, M2, M3 levels. Earlier, on the M1 level models, digital services of the platform were allocated. The digital services "Monitoring of data from sensors" are also related to the digital services of the platform. In the metamodel of the M2 level (see Fig. 2), several different services were distinguished, an instance of which is the group of digital services of the platform under consideration. Accordingly, the "Sensors Data Monitoring" service is an instance of the "Digital service" type, and the "Digital service" type is one of the services types allocated in the metamodel at the M2 level. In turn, the M3 meta-model level, on which the "Type of Service" is highlighted, defines the basic relationships that can hypothetically be observed among the "Service" category objects. And the services reflected on the M2 level models are Type of Service instances from the meta-model.

A meta-metamodel can be used to obtain repetitive modeling structures (or patterns). Figure 6 shows a simulation pattern example for Type of Process. This simulation pattern restricts and defines direct interaction of processes in the M2 and M1 level models. The links reflected in Fig. 6 correspond to the Process Type links reflected in the meta-model in Fig. 4.

Meta-metamodel (M3) allows you to get many other modeling patterns, and then specify them using the metamodel (M2). Figures 7 and 8 show the main modeling

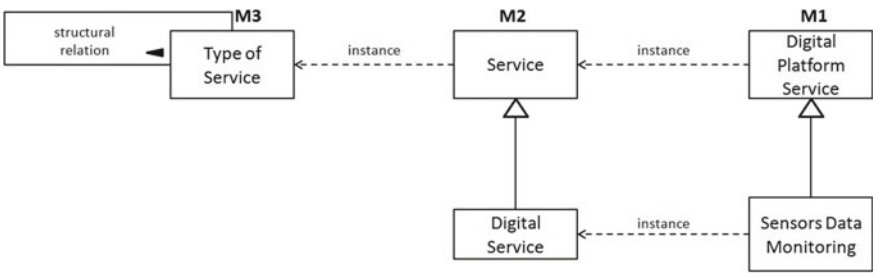

Fig. 5 An example of Service concept use on the different levels of abstraction

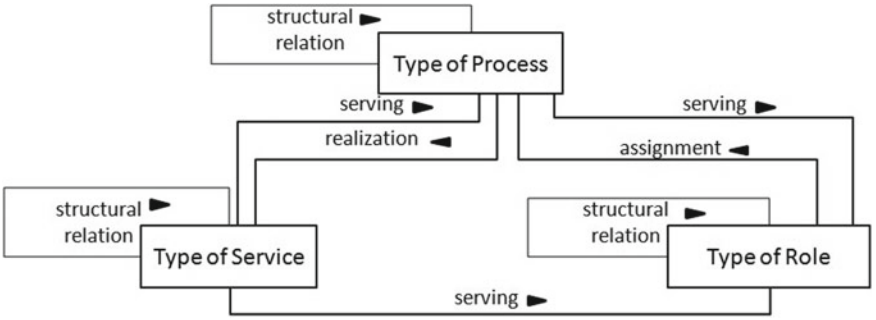

Fig. 6 Process type generalization

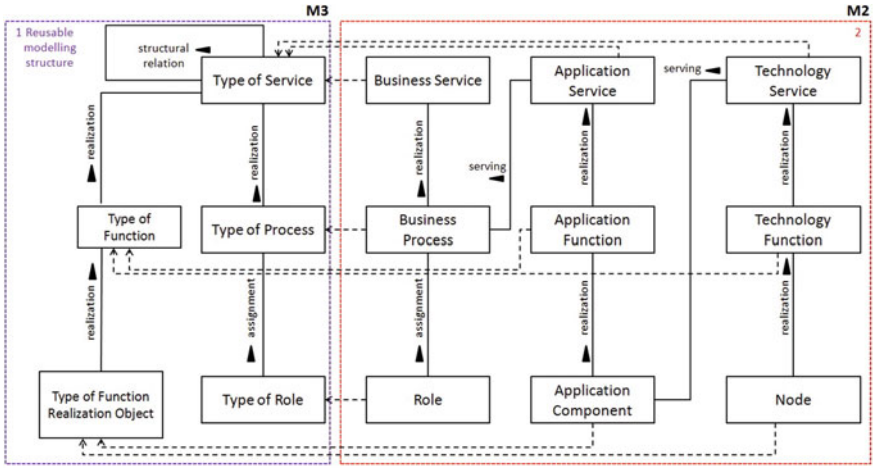

Fig. 7 Business service modeling pattern

patterns that were later used in building M1 level models on the business layer, information systems layer, and the technology layer.

In Fig. 7, two areas of the pattern are highlighted. Region (1) contains meta-metamodel elements. It is argued that, in the most general form, a Service Type is implemented by the Function Type or Process Type. At the same time, to execute a Process Type, some Role Type is assigned, and the Function Type is implemented by some Object Types intended to implement the function.

Region (2) illustrates the M2 metamodel level elements. This part of the modeling pattern demonstrates that the Business Service is implemented through a Business Process, for the execution of which a certain Role is assigned. At the same time, the Application Process is used to support the Business Process. The Application Service is implemented by the Application Function, which is implemented by the Application Component. The technology service supports (serves) the Application

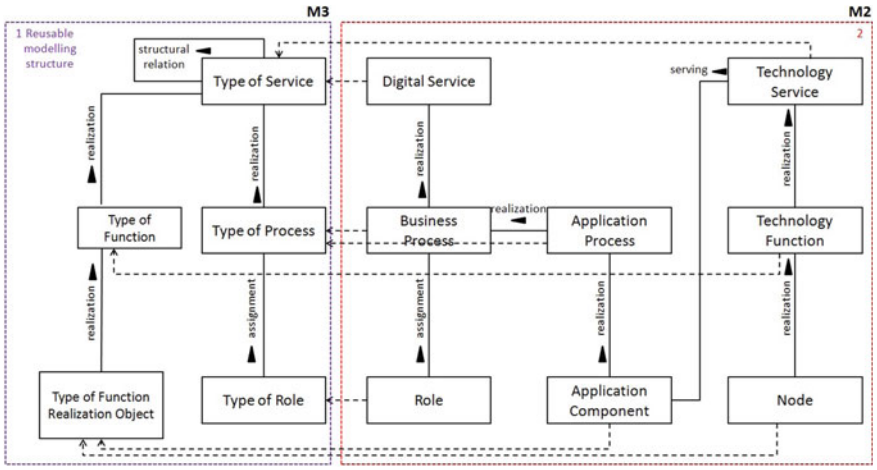

Fig. 8 Digital service modeling pattern

Component, and its implementation requires the Technological function of a specific Node.

Modeling Pattern has significant differences from the Business Service Modeling Pattern (see Fig. 8). Area (1) does not have significant differences from the modeling pattern presented earlier in Fig. 7. However, area (2) has several differences. It is stated that Digital Service is implemented by some Business Process to which some Role is assigned. In this case, the Business Process is implemented by the Application Process. In turn, the Application Process is implemented by the Application Component. The technology service supports (serves) the Application Component, and its implementation requires the Technology function of a certain Node.

Thus, Figs. 7 and 8 illustrate the differences in Business Service modeling and Digital Service patterns and are used in the formation of M1 LLC "Service Company" enterprise architecture models.

The modeling patterns presented in Figs. 7 and 8 can be translated within the framework of ArchiMate notation as follows (see Fig. 9).

4 Demonstration and Approbation of the Proposed Methodology

4.1 Enterprise Architecture Layered Model

Digital platform modelling patterns were used in the service company digital platform development. Currently, the developed and implemented digital platform has been in operation for over 3 years. Over the past time, more than a dozen digital services

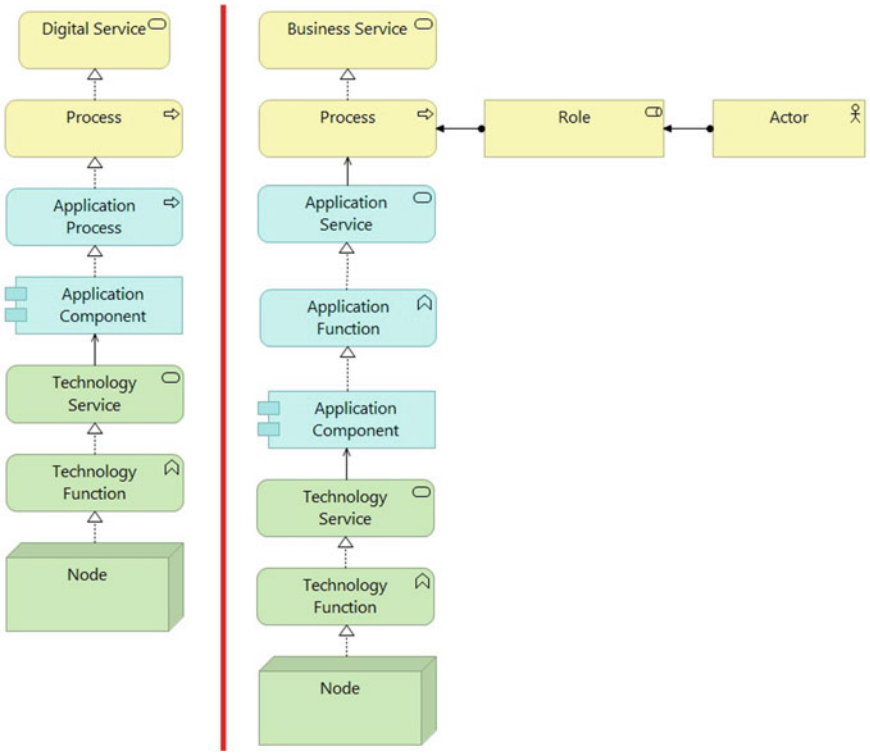

Fig. 9 Business service and digital service implementation description in ArchiMate notation

were additionally implemented within the platform framework, the development of which was also carried out on the initially formed patterns basis [26].

The considered enterprise LLC "Service Company" works with the following categories of counterparties: customers; transport companies (more than 100 companies, park of each includes up to 20–50 cargo vehicles); sensor suppliers (about 10 suppliers of GPS trackers, tachographs and other sensors); service companies (more than 120 contractors who are engaged in the equipment maintenance).

In order of further company development, LLC "Service Company" top management has decided to switch into "business platform as a service" format. As a result, each group of counterparties gained access to specialized digital services.

Transport companies got access to the digital sensor data monitoring, digital analytical reports, digital order receipt, digital payments, digital support services, etc.

Sensor suppliers got access to the digital diagnostics service, remote diagnostics, digital maintenance notification service, digital technical support service.

Delivery customers have gained access to the digital order payment, digital reports generation, digital support, digital delivery monitoring, and digital ordering services.

These digital services have replaced part of the main business processes that were previously performed by the LLC "Service Company", transport companies or sensors suppliers specialists. Auxiliary processes have undergone minimal changes and are still performed primarily by company employees.

The key digital platform IT services can be considered logistics and planning; mobile application; software development and integration; personal area; analysis and visualization; assets integration and management; sensors and devices digital twins; access to aggregated data IT-services, etc.

Digital platform portal includes the following components: official website, accounting system, mobile data system, data storage system, monitoring system, development system, AI system and ERP-system, which includes logistics system, accounting system and CRM-system. All components interact through the enterprise service bus.

The digital platform portal components function at the expense of basic technological services. The digital platform portal components are deployed at the corresponding nodes. For software development by the company contractors and its subsequent integration, a software development environment has been developed, deployed on a virtualization server.

Figure 10 shows the LLC "Service Company" layered architecture model.

4.2 Pattern-Based Digital Services Modelling

Let us give an example of the digital service «Maintenance notification» implementation. The service is provided to customer—sensors suppliers and is implemented by sensors and equipment wear-off factors proactive analysis business process.

The sensor monitoring system in proactive mode implements three processes: sensor operation data acquisition and processing; the need for maintenance proactive analysis; notification sending. The data is automatically analyzed once a day by a need for maintenance proactive analysis. This process considers not only the received and processed data, but also some external data, loaded sensor and equipment specifications, statistical models. If the probability of failure in the next two weeks for some sensor exceeds the threshold value, then the notification is sent to sensor supplier employees.

Figure 11 shows the "Maintenance notification" digital service implementation model.

5 Conclusion

Practical experience has demonstrated the high efficiency of using the developed digital platform modelling patterns. Formed models were used to implement a digital platform and later became the foundation for the development of new digital

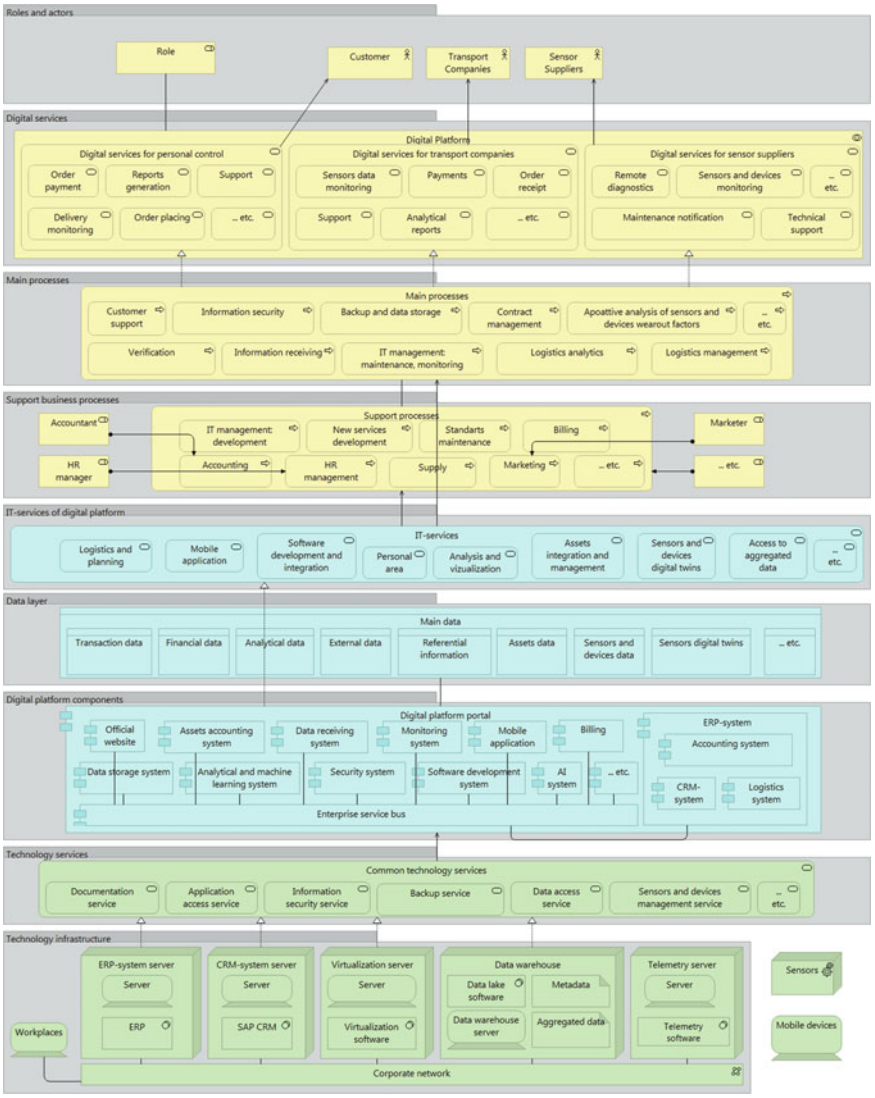

Fig. 10 LLC "Service Company" layered architecture model

services. At the same time, the architectural approach provided an opportunity for the enterprise to further scale up the digital platform.

As part of this study:

- The relationship between the enterprise architecture layers and used digital platform metamodels is demonstrated. An enterprise digital platform architecture modelling metamodel is formed.

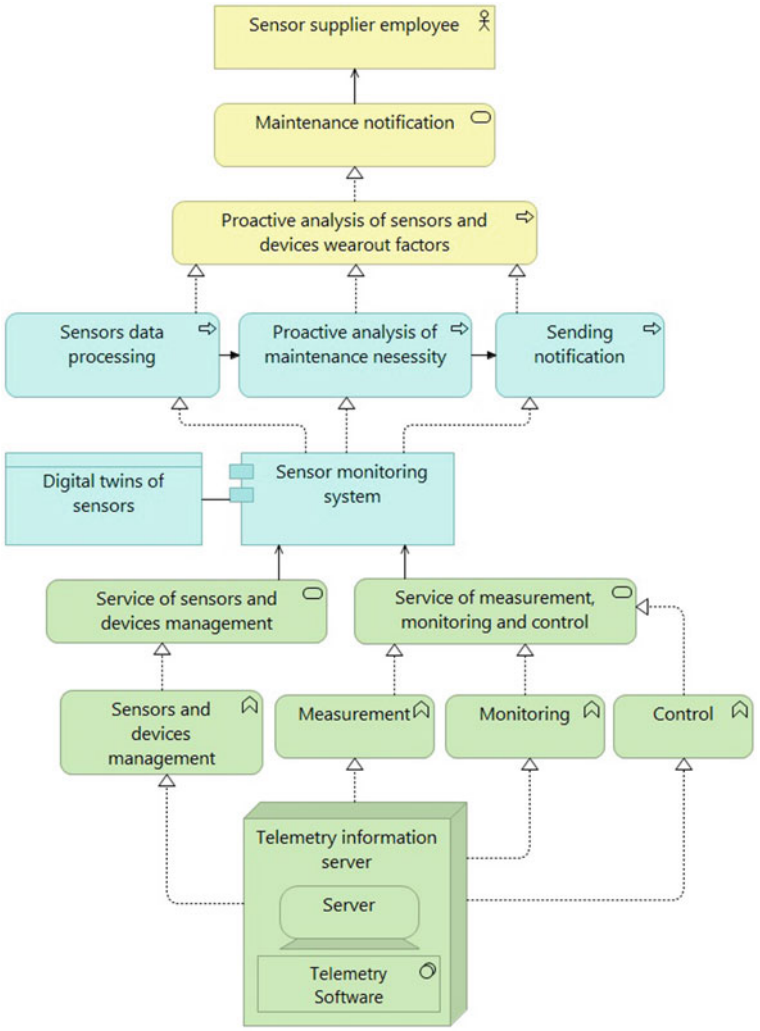

Fig. 11 "Maintenance notification" digital service implementation model

- A three-level enterprise architecture abstractions modelling model is presented.
- An enterprise digital platform architecture modelling meta-meta-model has been formed.
- Digital platform modelling patterns and digital services implemented by this platform, with details to the level of the modelling language used, general formation logic is presented.
- An example of successful implementation of a digital platform in a service company (including the presentation of the enterprise architecture layered model,

including the created digital platform high-level architecture) and the experience of using a digital service modelling pattern is demonstrated.

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Society, Labour and Employment Alterations Under Digital Economy

Digital Economy: Isolation or Collaboration?

Elena Dobrolyubova, Oleg Alexandrov, Nikolai Kazantsev, Soizhina Yangutova, and Elizaveta Kuzevanova

Abstract National digital strategies contain measures to facilitate development of data-intensive businesses and protection of citizen-related data and thus build digital economy. The question remains, to which extend should such strategies be national (thus isolative), rather than be realized a collaboration between countries? This paper provides a comparative analysis of national digital strategies and reflects if there is a rationale for cooperation whilst developing a digital economy.

Keywords Digital strategy · Collaboration

1 Introduction

Over a decade, international data flows have raised the world GDP by 10.1% and data flows account for $2.8 trillion of this impact. Per capita ICT spending varies with the US, UK, and Japan being among the leaders [1]. Increasing competition for leadership in the digital globe urges both developed and developing economies to invest a lot not only in digital government per se, but also in digital infrastructure, R&D, and cybersecurity [2]. 50% of the services worldwide have already been

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digitized and could be consumed by citizens of any country. Such spendings may support selected sectors of national economy, but is costly for the rest. Both inflows and outflows matter for growth, as they "expose economies to ideas, research, technologies, talent, and best practices from around the world" [3]. As developing such services in a coalition has a potential to reduce costs on building and running infrastructure (e.g. data centres), to ensure sustainable production and fair outsourcing work conditions. Thus, this paper investigates if countries could implement national digital plans coherently. The main research question is: what are the benefits of collaborative implementation of digital economies? As a main method we use content analysis of digital strategies of Australia [4], China, Germany, Estonia, Russia [5, 6], UK [7], USA [8], South Korea, Taiwan (Table 1)—countries that are different in geography, political systems, population, size, GDP but manifest devotion for digital transformation. This analysis intends to identify commonalities and differences in national approaches to supporting digital economies and form the basis for discussing the possibilities of more intensive international collaboration in this area.

2 Funding Priorities of Digital Strategies

The financial priority of digital strategies demonstrates high investments into digital infrastructure, including broadband and the new generations of mobile networks, such as 5G in majority of countries. Over 75% of the value is created by bridging traditional industries [13]. The United States remains the largest player in the Internet-backed ecosystem and has the most diverse structure in global ecosystem, including equipment, software, services and telecommunications, capturing more than 30% of global Internet revenues [13].

The second most important priority is supporting digital research and development (R&D). National governments fund or co-fund initiatives ranging from climate change analysis using supercomputers in Australia [14] to Digital Catapult[1] in the UK that support early adoption of digital technology in Small-Medium Enterprises, Family-run businesses and start-ups. Governments also support some sectoral projects aiming at promoting digitalization of selected sectors, such as Internet of Things or smart grids for utility services and autonomous transport. R&D centres also aim at efficient investments distribution to adopt digital platforms to major industries.

The importance of cybersecurity grows with an increase in the digitization of the economy that represents the third priority. Countries develop new approaches to tackle hackers attacks, e.g. via public–private partnerships for developing a safe and secure environment for citizens. To ensure business growth and attracting investors, they address the issue of cybersecurity in the national digital strategy. Table 1 summarizes governmental priorities in digital strategies.

Table 1 suggests countries invest both in supporting the areas of digital economy where they compete with each other (especially in R&D) and in developing digital

[1] https://www.digicatapult.org.uk/ (accessed 23.08.2018).

Table 1 Key government spending priorities in supporting digital economy. *Notes* the data for Russia is for 2017–2020 (based on the federal budget)

Country	Broadband connection/5G	Research and development	Information security	Various sectors
Australia [3]	National broadband network (AU$ 43 bln for 8 years) regional digital fiber optic network (up to AS$ 250 mln)	Supercomputers for analysis of climate change (AU$ 50 mln.)	AU$ 180 mln	Smart grid AU$ 100 mln (Smart City Project)
China	USD 320 bln in 2015–2020 [9]	No data	No data	No data
Germany	EUR 1.1 bln on broadband [10]	EUR 5.4 bln on innovation R&D	No data	EUR 2.5 bln on innovation technology, and new mobility, incl. EUR 550 mln on Industry 4.0
Estonia	EUR 27 mln for new broadband network, including government broadband	No data	No data	EUR 28 mln for developing digital skills, EUR 6.6 mln for improving digital literacy
Russia [6, 11]	US$ 7.3 bln	US$ 823 mln (including funding for developing regulatory framework for digital economy)	US$ 554 mln	No data
UK [4]	Broadband (1.7 bln pounds), new generation networks, incl. 5G (740 mln pounds) and full fibre (400 mln pounds)	600 mln pounds for digital R&D per annum	No data	100 mln pounds—autonomous vehicles, 30 mln pounds—IoT
USA [12]	US$ 70 bln (as part of infrastructure plan and transformative projects program)	No data	No data	No data

infrastructure which may be seen as a competitive advantage for attracting investment or improving business climate, but which is not a subject of competition per se. Therefore, developing better collaboration and joining efforts in the area of digital infrastructure seems to be an opportunity which, on the one hand, could help to get some additional resources to supporting technological innovation, and, on the

other, could improve the ICT access globally and, hence, increase the mutual digital dividends.

Most of countries are building their strategies in tangible periods of time, being designed up to 2025–2030, which is explained by the fairly rapid development of new trends in digitalization. It allows excluding situations when some tools working and being the engine of development in 2017, may become obsolete and unprofitable in 10–15 years. We note that most of the countries analyzed rely on educational programs and staff training, which is a "preparatory" stage to digital age in which a qualified human resource will not be less important than an innovative software solutions. Undoubtedly, at this stage of the strategy great importance is attached to the security of information, infrastructure and the adaptation of big data sets. All of the listed countries aim at improvement of the quality of digital infrastructure, especially improving of communication networks in the national economy. Such countries as China [15], South Korea and Germany [16] emphasize the importance of business integration in the digitalization of the economy right now, which will be positive and will give them an advantage in future steps to develop and increase economic performance. The creation of a digital government segment in many countries stands out as a big block of works, which once again the fact that in the next 30–40 years the society will receive new methods of communication, interactions and technologies used in all processes of human life.

However, the observed countries differ in approaches to transparency of governmental structures and different levels of citizen involvement into decision-making. Considering development of Taiwan [17], South Korea and Estonia [18], we note that the major strategic goal is to develop e-government practice with citizens, where countries consider raising e-Governance and citizen's digital skills as an integral part of digital economy implementation. Australia and the United States [19] aim to develop transparency and accessibility of data that may realize quick collective decision-making with equal impact of participants, while Russia does not prioritize this direction. At the same time, strategies do not provide information regarding individuals' and companies' attitudes to real-time data exchange and the accumulation of their data in the long term. Table 2 shows that digital strategies tend to build more on the national advantages rather than address relative weaknesses in digital development. For instance, the countries which prioritize e-government in their strategies (i.e., South Korea and Australia) are rated the third and the second in the 2018 UN e-government rating and also have high rankings in the 2016 WB digital adoption index. At the same time, the countries which somewhat lag behind in e-government development (i.e., Russia and China) do not highlight this area in their national digital development plans [20]. Similarly, the lowest digital adoption index by businesses in the selected group of countries is in China (0.41) and in Russia (0.48). However, it is Germany and Australia that prioritize the development of digital entrepreneurial capabilities and new business models in their digital strategies.

There are evidences that overlapping programs haste digital initiative. For instance the rapid development of South Korea since 1999 included World Cup 2002 (with Japan) and Winter Olympics Games in 2018 that enhanced development of 5G mobile network and a variety of G2C services for improving interaction with cities. The

Table 2 Digital economy development and digital strategies' priorities in selected countries

	USA	South Korea	China	Russia	Germany	DRC-Taiwan	Australia
GDP growth 2017 (%)	2.27	3.06	6.9	1.55	2.51	2.86[a]	2.28
Life expectancy	81.1	85.4	77.5	77.1	83.5	80.2[b]	84.6
Digital economy indicators							
United Nations e-government development index—2018	11	3	65	32	12	N/A	2
World Bank digital adoption index 2016 (total)	0.78	0.89	0.62	0.71	0.78	N/A	0.71
World Bank digital adoption index 2016 (business)	0.69	0.78	0.41	0.48	0.66	N/A	0.63
World Bank digital adoption index 2016 (people)	0.90	0.89	0.77	0.85	0.87	N/A	0.89
World Bank digital adoption index 2016 (government)	0.77	0.99	0.67	0.80	0.80	N/A	0.60
Priorities in national digital strategies ("+" equals "included")							
Global IT services	+	+				+	+
Modernizing labor market	+		+				
Cyber security	+	+	+	+			+
Digital skills	+	+		+	+	+	+
Supporting people with disabilities		+					
Reorganization of value processes	+		+	+	+		
Reductions of the bureaucracy				+			

(continued)

Table 2 (continued)

	USA	South Korea	China	Russia	Germany	DRC-Taiwan	Australia
Digitization in major infrastructure areas	+	+	+	+	+	+	+
New business models					+		+
Entrepreneurial capability					+		+
E-Governance		+				+	+
Smart city						+	+
Circular economy						+	
Human rights						+	
E-Health							+
Privacy	+				+		

[a] *Source* https://www.taiwannews.com.tw/en/news/3363637 (accessed July 31, 2018)
[b] *Source* https://www.taiwannews.com.tw/en/news/2986750 (accessed July 31, 2018)

same effects had Winter Olympics 2014 and World Cup 2018 on Russian Federation. Unfortunately, in most cases building digital economy is considered a national competitiveness factor, which limits the possibility and readiness for international cooperation.

3 Collaborative Digital Strategy

The impact of digitalization across countries and sectors is uneven. Developed economies enjoy higher economic benefits by almost 25%, although they tend to lag behind developing economies in creating jobs with similar profits. The main reasons for such different indicators are the economic structures of developed and developing economies. Developed countries rely heavily on domestic consumption, so digitization increases already existing productivity and has a significant impact on profit growth. On the contrary, developing countries are oriented on export and tradable sectors, as a rule, they receive more from the impact of digitization on employment. Governing bodies can use these different effects through three main measures that go beyond the usual management measures. First, they must create digitization plans for the most promising sectors in which it is possible to maximize the impact of digitization. Secondly, they should encourage the development of the necessary facilities and means to achieve these digitization plans. Finally, the coherent work of the industrial

sector, consumers and public institutions should be established to create an inclusive ecosystem of information and communication technologies that encourages the wider introduction and use of digital services. Globalization of digital business calls, at least to some extent, for globalizing the government efforts in supporting the digital economy development. Otherwise, in the much more connected and therefore globalized world, some jurisdictions may fail in sustaining investment, economic growth and digitally skilled population.

Some initial steps in international digital collaboration include 'Digital Five'/'Digital Seven' initiative—a network of leading digital governments with the goal of strengthening the digital economy which currently includes Canada, Estonia, Israel, New Zealand, South Korea, Uruguay, the UK. These countries signed the Charter which, inter alia, includes promoting open digital standards, knowledge sharing and mutual learning.[2] Getting more digital dividends would call for further international collaboration for international research and scientific organizations. Deploying international cooperation schemes used, for instance, in CERN, to solving specific digital infrastructure problems (such as satellite broadband connection for rural areas) could be a mutually beneficial solution. For instance, the amount of cross-border bandwidth that is used has grown 45 times larger since 2005. It is projected to increase by an additional nine times over the next five years as flows of information, searches, communication, video, transactions, and intracompany traffic continue to surge. In addition to transmitting valuable streams of information and ideas in their own right, data flows enable the movement of goods, services, finance, and people. Virtually every type of cross-border transaction now has a digital component. Such rapid development calls for international cooperation and makes a case for joint investment in digital infrastructure.

Although, international cooperation is not factored as a basis for building digital government,[3] the review of national digital strategies demonstrates that countries consider digitalization as a factor of national competitive advantage. In this context, even the countries which are members of integration unions and blocks (the most evident example—the European Union) do not foster collaboration with their peers. Also, these countries focus on promoting their advantages in digital sphere rather than address the elements of digital adoption which are lagging.

National analytics rarely consider costs which countries bear separately while they deploy infrastructures of the digital economy, such as, for example, data centers. As demonstrated in Sect. 2, these investments are very significant. Particularly, in South-East Asia countries, such as Japan, South Korea [21] and Taiwan [22], the capital and operating costs of supporting such infrastructure are expected to be higher than in the US, due to the cost of energy resources and additional cooling requirements for server installations. The creation of such infrastructure in Siberia or the Far East of Russia could reduce these costs, but in this case intergovernmental approvals are required

[2] https://www.digital.govt.nz/dmsdocument/28-d7-charter/html (accessed July 31, 2018).

[3] http://www.oecd.org/gov/digital-government/recommendation-on-digital-government-strategies.htm (accessed July 31, 2018).

as well as assessments of all possible risks caused by storing data of individuals in the territory of another state.

Since the digital divide among different countries (and sometimes even regions of the same country) is high and the available budget resources are limited, the need for developing ICT infrastructure may, inter alia, call for significant variance in costs of access to ICT. For instance, the broadband prices differ several times among the EU states[4]; thus, duplicating investments in ICT infrastructure is, in the end, born by the consumers.

Obviously, in the short term, countries will have different access to information exchange, that will be determined both by the political weight of the country, and by its degree of digitization, approach to management and economic state. However, given the current trends for digital strategy globalization evident for businesses, it is likely that the market of digitalization services for Third World countries will appear, it will be regulated by provider-countries. To this end, developing joint digital standards and fostering inter-operability would foster competition and increase the digital dividends to both the developed and the developing world. On the contrary, in case each country or an integration block (i.e., the US, China, Russia and Eurasian Union, the EU, etc.) comes up with its own digital standard, the costs of digitalization to the society would be higher. Following those examples above international collaboration could be strengthened in blocks, for instance, the Russian Program could add collaboration in the framework of the Eurasian Union and BRICS. This seems to be especially important given the fact that some other digital unions emerge (such as Digital 5/Digital 7).

4 Conclusion

In this paper we consider if there is a potential in collaborative implementation of national digital strategies. We conclude that the focus on '*national'* rather than '*international'* nature of digital economy can also lead to '*digital protectionism'* reflected in different standards among countries and limiting (or increasing the cost of) accessing up-to-date technologies from abroad. To this end, the trends of replacing ICT import may limit the access of the public authorities (and, to some extent, also private companies) to the up-to-date technologies and applications. Noteworthy, the review of the digital strategies performed in this paper suggests that general national approaches to supporting digital economy have more common than different points; thus, these strategic documents may become a basis for the future international collaboration in promoting global digital transformation. In this paper we do not outline the constraints and disadvantages of collaborative strategies, such as political and cultural tensions, geography and other factors.

[4] European Commission, EU (2018) Digital Economy and Society Index Report. URL: http://ec.europa.eu/information_society/newsroom/image/document/2018-20/1_desi_report_connectivity_DFB52691-EF07-642E-28344441CE0FCBD1_52245.pdf (accessed July 31, 2018).

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Concept of the Labour Digitalization Phenomena as the Social Pollution Factor

Alena Fedorova, Maria Menshikova, and Mauro Gatti

Abstract There is no doubt that the digitalization of the labour activity, along with its positive influence has a negative impact on employees. Nevertheless, the issues of assessing the impact of these processes on employees' well-being have not yet received sufficient attention in HRM research and practice. The relationship between the digital transformation of the labour, as well as HRM practices and employees' well-being is examined in the paper. The research methodology involves the analysis of data obtained by means of literature review, sociological surveys, narrative and descriptive analysis. The results of our study identify the problematic issues resulting from expanding the practice of applying digital technologies in HRM system, proving the negative impact of digitalization processes on employee well-being (along with positive effects), and, therefore, the need to develop management solutions aimed at preserving well-being in the workplace.

Keywords Digitalization · Labour relations · Human resource management · Employees' well-being · Social pollution

1 Introduction

Under the influence of digital transformations of the economy and business, various trends have emerged in the labour sphere. Studying expert opinions allows us to identify the main ones.

The development of digital technologies has contributed to the appearance of a new tendency: the state's concern for maintaining the number of jobs and employee performance standards is a thing of the past: priorities have shifted towards increasing

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the efficiency of enterprises, organizations and institutions, even though achieving it entails a reduction in jobs and compulsory redundancies.

Numerous sociological studies show that there is a growing fear of losing a job due to the rapid introduction of digital technologies in the labour sphere. 62% of working Russian citizens do not support the robotization of production [1], and 65% are afraid of losing their jobs due to the development of new technologies [2]. The theory of total unemployment in the context of digitalization assumes that a small number of people, a kind of digital elite, will be enough to support the economy in the future, and the majority of the population will receive benefits or salaries just sufficient for surviving. But there is another opinion that unemployment does not arise because of increased labour productivity and the introduction of artificial intelligence technologies, but because of the discrepancy between the current competencies of the population and the changed requirements of the economy [3]. The consequence of the labour digitalization is an increasing stratification of labour activity in terms of its intellectual and creative components. Routine work that does not require creative and intellectual skills is replaced by tools of artificial intelligence. At the same time, as a result of automation of routine labour processes, there are more opportunities for creative work. The need for highly qualified professionals will only increase, although their work will mostly be collaboration and research. In other words, artificial intelligence, overtaking the human mind in terms of productivity, creates the conditions for the emergence of collective intelligence.

Nowadays, there are examples of successful implementation of digital technologies and robotization of production with the subsequent increase in production capacity, saving resources and even increasing the number of jobs. At the same time, retrained workers have become more flexible and mobile. This is, for example, what happened with the implementation of the "1C: Accounting" software program. At the very beginning, many professionals were sure that it would ruin their profession and lead to a sharp reduction in the number of accountants in companies. However, there was no reduction in demand for accountants, their mobility increased, and opportunities for additional income opened for them from bookkeeping for small businesses. A similar example is Uber: there were serious concerns that using a mobile taxi application would seriously harm the industry, as this would inevitably lead to a reduction in taxi operators and the number of taxi drivers. Over time, it turned out that there was no need to dismiss taxi drivers and operators, the demand for taxis and the company's net profit increased. At the same time, the mobile taxi application allowed attracting new drivers for whom taking passengers is an additional income in their free time [4].

At the same time, new information and communication technologies in conjunction with robotization and automation have made human presence unnecessary in many technological processes. In other words, digitalization entails, on the one hand, the disappearance of professions, on the other hand, the emergence of new technologies is accompanied by the appearance of new professions. It should be noted that, due to the high cost and the availability of iterations, technologies are being introduced gradually, current processes are associated not with the replacement of professions,

but only certain functions, using machines to perform some tasks, and replacing old jobs always creates new, more technological ones.

Nevertheless, massive redundancies due to digitalization are already observed in some industries, especially in the banking sector. One of the first Russian companies publicly announced redundancies in connection with the robotization of a series of processes was Sberbank. From January to September 2018, 14.1 thousand people, or 4.6% of the bank employees' total number, were relieved of their duties. The staff that performed simple work was replaced by artificial intelligence (for example, today a robot lawyer independently draws up statements of claim). In other industries, according to experts, robots will replace humans primarily with hazardous (nuclear, mining), dirty (mechanical engineering, mining, construction, agriculture) and routine work (security, concierge, administrators, hostesses, guides), requiring to perform simple tasks where high qualifications are not necessary [5]. However, the successful development in Germany of Industry 4.0, as an integral part of the digital economy, did not lead to a reduction, but to an increase in the number of jobs in the industry.

In general, among the most significant factors in the labour sphere transformation under the influence of digitalization, the following can be distinguished:

decline in the production sector with a simultaneous increase in the number of people employed in the services sector;
globalization of the labour market, the spread of distance work practices (including cross-border);
transformation of the structure and content of professions, the emergence of a new form of labour activity—transfessions.

It should be noted that due to the high speed of digitalization within single profession in a very short period—the period of one generation's life—some competencies completely disappear and are replaced by others [6]. Thus, each working person is faced with the need to constantly update their professional competencies. Based on the synthesis and convergence of social and professional competencies belonging to different specialized fields, a new type of labour activity is currently formed—transfession [7]. The predictor of successful mastery of digital competencies, flexible orientation of the individual in the digital professional world is the formation of trans-professionalism as a qualitatively new qualification characteristic. Trans-professionalism is the simultaneous coexistence and combination of several types of professional qualifications acquired through individual educational paths in primary and secondary professional education, as well as throughout the subject's professional life [8].

Another highly important aspect of the transformation of the labour sphere under the economy digitization is related to the emergence of non-standard employment forms and flexible personnel management technologies. Thus, the development of the global labour market has led to the spread of the practice of remote work, when the necessary physical presence in the workplace does not play any role. In these

conditions, every potential employee inevitably faces higher competition. Consequently, the modern employee also needs to possess a number of universal information and communication skills, which can be considered mandatory in the digital age. According to experts, the professional profile of a modern employee includes a set of competencies in which, along with professional knowledge, systemic and creative abilities are important, as well as abstraction and the ability to quickly process and select information. An employees' digital literacy becomes crucial: the ability to use a computer, mobile devices, the Internet, various applications and programs in the professional field. In its most general form, for successful employment four basic types of competencies are required: professional, communicative, informational and digital [9].

The new model of labour and employment "Work 4.0" contains new opportunities, but also risks, both for the economy and the employee. The content of this model has not yet been fully determined. Researchers single out the following as its main features: firstly, new requirements for employee training, which apply to all professional groups without exception, and secondly, the erosion of the classical labour organization and the usual employment patterns. The process of blurring the boundaries between typical and non-typical work is determined, on the one hand, by the development of digital labour markets, such employment becomes mass (crowd–working), and there is high competition and labour division. On the other hand, automation and informatization change the essence, meaning and values of work in an organization, and their main characteristics are autonomy and flexibility. Many actions in the information space are carried out using a personal computer, mobile devices and applications, which themselves become the subject and/or means of labour. The space of labour application is expanding; new forms of labour relations are emerging. In such employment system, the initial unit is not the job, but the presence of wage-ranked professional activities in a particular sector of the economy (for example, the European Job Monitor now uses this methodology, conducting labour and employment surveys) [10].

The following employment forms have emerged since around the year 2000 [11]:

- Employee sharing: an individual worker is jointly hired by a group of employers to meet their HR needs, resulting in permanent full-time employment for the worker;
- Job sharing: an employer hires two or more workers to jointly fill a specific job, combining two or more part-time jobs into a full-time position;
- Interim management: highly skilled experts are hired temporarily for a specific project or to solve a specific problem, thereby integrating external management capacities in the work organization;
- Casual work: an employer is not obliged to provide work regularly to the employee, but has the flexibility of calling them in on demand;
- ICT-based mobile work: workers can do their job from any place at any time, supported by modern technologies;
- Voucher-based work: the employment relationship is based on payment for services with a voucher purchased from an authorised organisation that covers both pay and social security contributions;

– Portfolio work: a self-employed individual works for a large number of clients, doing small-scale jobs for each of them;
– Crowd employment: an online platform matches employers and workers, often with larger tasks being split up and divided among a 'virtual cloud' of workers;
– Collaborative employment: freelancers, the self-employed or micro enterprises cooperate in some way to overcome limitations of size and professional isolation.

These wide-ranging new employment forms have an equally wide range of implications for working conditions and the labour market. Employee sharing, job sharing and interim management seem to offer beneficial working conditions, combining enhanced flexibility for workers with a good level of job security. ICT—based mobile work offers some flexibility, autonomy and empowerment, but also incurs the danger of work intensification, increased stress levels and working time, and blurring of the boundaries between work and private life. It may also outsource traditional employer responsibilities, such as health and safety protection, to employees. For freelancers and the self-employed, portfolio work, crowd employment and collaborative employment may enrich work content through diversification. Voucher-based work entails some job insecurity, social and professional isolation, and limited access to HR measures and career development, but offers the opportunity to work legally, better social protection and perhaps better pay. Casual work is characterized by low income, job insecurity, poor social protection and little or no access to HR benefits. The high level of flexibility might benefit some workers, but for most it is too much and they would prefer more continuity.

Another characteristic feature of "Work 4.0" is the digitalization of human resource management technologies, so-called HR-tech. Companies' HR departments actively master the digital tools, especially in matters of recruiting, retention and involvement, and staff development. The modern HR-tech market offers various digital tools: services aimed at automating recruitment processes using artificial intelligence, gamification services for routine processes, online training, conferences and software that can evaluate productivity.

It should also be noted there is a growing trend of increasing the scale of introducing new forms of labour organization into the management practices of modern companies, such as smart working and agile. For example, in 2017 the Council of Ministers of Italy approved a law on self-employment and smart working. The law defines smart work as "a flexible mode of employment aimed at increasing productivity and facilitating the reconciliation of the life/work balance". The law stipulates the list of functions that staff can perform both in the office and outside it, which correspond to the working hours established by the contract. However, the widespread use of smart working is associated with some concerns: new technologies have huge potential that can be used not only for the benefit of employees, but also to their detriment. Information and communication technologies and remote work can create psychological problems and cause a feeling of loneliness among employees. Employers also run the risk of gaining negative experience: an increasing sense of isolation can lead to reduced employee engagement.

Not only IT companies, but also companies in the financial sector, as well as the Internet and telecommunications sector, actively turn on to agile. One of the specific features of work organization using agile approaches is open-plan offices. However, many employees claim that such offices are not really productive, as it is difficult to concentrate in them. Agile approaches are often misapplied and require transparency of work, which staff often find humiliating. Scrum, as one of the agile approaches, is considered a good way to identify "lagging employees." In fact, this is a tracking system in which individual performers show their work progress in detail with an assessment of productivity. It should be noted here that the fact of observation changes behaviour in the workplace. Continuous monitoring of work indicates a lack of trust and low social status, and the most sensitive to status people, such as older workers, women, racial minorities and people with disabilities, are the first to suffer from increased monitoring and quickly lose their motivation. In addition, agile is not related to building a career, getting involved in long-term projects, which makes working in this system precarious.

In our previous studies, the phenomena of social pollution from companies' economic activities was identified, the essence of which is damaging welfare, as well as employees' physical and socio-psychological well-being [12]. Among the main factors of social pollution, we distinguish precarious labour relations associated with a decrease in the level of social protection and precarious employment [13]. The growing trend of staff flexibility can be economically viable and profitable, but the cost is the failure to meet basic human needs—a sense of security and confidence in the future [14]. The search for managerial solutions to reduce the negative effects of the economy digitization on the labour sphere is a pressing issue of the digital economy in the content of the New Labour Economy [15]. Systematic monitoring of the real processes of labour relations transformation will allow us to identify the emerging risks and contradictions that worsen the quality of the working life and, therefore, require new methods and tools to counteract.

2 The Introduction of Digital HR-Technologies in Russian Organizations: Survey Results

Companies, using various tools, are at different levels of mastering digital technologies in the field of HR. While some are just beginning to introduce some HR technology, others are already abandoning it. The analysis of the digital technologies and products in the field of personnel management that are being implemented and are losing their relevance was conducted with the participation of the authors as respondents on the basis of data presented in the "Dying and Emerging HR Technologies" report conducted by the Talent Code group from March 20 to April 30, 2017. The study involved 159 Russian companies divided into 13 groups by

industry: retail trade—9.4%, manufacturing—8.8%, banking and financial sector—8.8%, information technology—8.8%, transport and logistics—5%, power engineering—4.4%, metallurgy and mining industry—3.8%, telecommunications and communication—3.1%, real estate and construction—3.1%, oil, gas and chemical industry—2.5%, service industry—2.5%, hotel and restaurant business—1.9%, other industries—38%.

During analysing the HR technologies implemented by participating companies, the prevalence of the use of digital technologies in various industries was identified (Table 1).

Based on the survey data, conclusions can be drawn about the prevalence of digital HR-technologies in various sectors of the surveyed enterprises: HR-analytics—in the oil, gas and chemical industries, transport and logistics, and power engineering; mobile solutions—in the metal and mining industries, oil, gas and chemical industries, retail; E-recruitment—in the field of transport and logistics, manufacturing, telecommunications and communications; E-learning—in the field of transport and logistics, oil, gas and chemical industries, retail trade; bots—in the field of telecommunications, power engineering; Real-time feedback—in the banking and financial sector, in the field of information technology; E-assessment—in the hotel and restaurant business; video interviews—in the banking and financial sector, retail; HR automation in general—in telecommunications, in the hotel and restaurant business; agile—in the field of power-engineering, telecommunications; talent management software—in education; workplace automation—in the hotel and restaurant business; HR dashboards—in the hotel and restaurant business.

In general, the introduction of such digital HR-technologies as workplace automation and HR-dashboards were noted only in companies in three industries. 12 (85.7%) of the 14 digital HR technologies presented in the table are used in the banking and financial sector, as well as in the service sector. The least covered by digital HR technologies are oil and gas and chemical industries, as well as education.

While companies are introducing any HR technologies, they discard others that are outdated and have lost their relevance. Based on the report data, HR-technologies were identified which are abandoned by the largest number of companies. 15% of the surveyed companies abandon paper workflow, 5% of the companies also abandon manual calculations and reporting, including the use of Excel. As for the personnel assessment process, 5% of the total number of companies give up assessment centres, 3.1% stop using the 360-degree assessment system, about 4% of companies no longer conduct staff performance appraisal, and 2.5% no longer use personal questionnaires for personnel evaluation. In the system of personal training and professional development, long-term training programmes (3% of surveyed companies) and full-time studies (8% of surveyed companies) are rejected. About 4% of the companies surveyed prefer not to use in-person interviews when recruiting.

Table 1 The use of digital HR-technologies in Russian companies-participants in the 2017 survey

Economy branch	HR analytics	Mobile solutions	E-recruitment	E-learning	Bots	E-Assessment	Agile	Workspace automation	HR-dash-boards	Other
Retail	6.7	33.3	6.7	20	13.3	20.0	0.0	0.0	0.0	6.7
Manufacturing	14.3	7.1	21.4	7.1	0.0	0.0	7.1	21.4	0.0	7.1
Banking	21.4	28.6	0.0	7.1	14.3	0.0	14.3	14.3	14.3	7.1
IT	7.1	14.3	7.1	7.1	7.1	0.0	0.0	0.0	7.1	14.3
Transport and logistics	42.9	14.3	28.6	42.9	14.3	14.3	0.0	0.0	0.0	0.0
Power-engineering	42.9	0.0	0.0	14.3	28.6	14.3	28.6	0.0	0.0	14.3
Metallurgy	33.3	33.3	16.7	0.0	16.7	16.7	0.0	0.0	0.0	33.3
Telecommunications	40.0	20.0	20.0	0.0	40.0	0.0	20.0	0.0	0.0	40.0
Education	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	20.0
Oil, gas and chemical industry	66.7	33.3	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0
Services	7.5	2.5	15.0	10.0	2.5	2.5	5.0	0.0	0.0	10.0
Hotel and catering	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3	66.7	0.0

Source Authors

3 Assessing the Impact of HR-Technologies' Digitalization on Employee Well-being: A Narrative Analysis

3.1 Methods

To study the impact of HRM digitalization on employee well-being, a narrative analysis of accounts by people working in different organizations that have introduced digital technologies was conducted. Narrative analysis, as a qualitative research method has certain advantages compared with quantitative methods, as it allows evaluating the subjective perception of HRM digitization by employees, highlighting the positive and negative effects of HR-technologies on physical and psychosocial well-being in the workplace. The difficulty of using the method of narrative analysis is due to the significant time spent on its implementation, associated with the audio recording of narratives and the subsequent decoding of data. Therefore, in order to obtain the relevant information, during the narrative interviews, the respondents were asked to write down their thoughts on the topic we set. When writing a narrative, a person, as a rule, cuts off all the unnecessary and focuses on the most important information regarding the described phenomenon. As a narrative impulse, we proposed the following phrase: "Please describe how information and communication/digital technologies affected your work and how their introduction in the organization could affect your future." The analysis of collected narratives was carried out through the integration of bottom-up and top-down approaches. In interpreting the data, we relied on some of the questions proposed by Linde [16], given that the reason for the account was the request of the researcher: (1) who tells the story, (2) what main events characterize the story, (3) what the narrator's assessment is.

Based on the analysis of the scientific literature on this issue [17–23] we identified three main thematic cores for interpreting the results:

(1) General evaluation of digitization in the field of labour / labour relations;
(2) Possible concerns related to the introduction of information and communication/digital technologies in the labour organization;
(3) Reflections on the possibilities of improving the introduction of information and communication/digital technologies in the labour organization.

We conducted narrative interviews and studied written accounts of 57 respondents, 35 women and 22 men, aged from 22 to 41, working in various sectors of the economy, including education, health care, personal services, management and finance, commerce, construction, social sphere, IT and communications, civil service.

3.2 Results

The following results were obtained on the thematic core "General Evaluation of Digitalization in the Sphere of Labour and Labour Relations". More than half of the

respondents (59.6%) distinguish both positive and negative aspects when evaluating the introduction of digital technologies in their activities, and 40.3% respondents associate the digitalization of their activities with positive aspects exclusively. The positive aspects of digitalization pointed out by the respondents are: facilitating the production process, speeding up work, saving time, increasing the speed of communication with colleagues and clients, the possibility of remote employment, the possibility of storing large amounts of data, minimizing the influence of the human factor, etc. The negative aspects are health problems associated with working on a computer, visual impairment, physical inactivity, and even computer addiction (Table 2).

According to the thematic core "Possible concerns related to the introduction of information and communication/digital technologies in the organization of labour," the following data were obtained. Most of the respondents (86%) are afraid of work stoppages associated with an unexpected power outage and "freezing" of computer software; 52.6% of the respondents fear that older people will remain without work due to difficulties in mastering new technologies; 17.5% of the respondents point out the high cost of new technologies and low-quality software they use. The risk of unemployment due to robotization worries 21% of the respondents; 14% indicated possible risks due to the loss of databases. There were also individual concerns related to the degradation of thinking ("a computer will think for us and our thinking will degrade"), a negative influence on the ability to express our thoughts in a grammatically and syntactically accurate way, as well as fears of a decrease in "humanity" in the social sphere (Table 3).

The thematic core "Reflection on the possibilities of improving the introduction of information and communication/digital technologies in the organization of labour", in contrast to the cores described above, was represented in 8.8% of the respondents' narratives. This may be due to the fact that the majority of the respondents do not fully understand future digital technologies, and disclaim responsibility for their distribution and improvement or their participation in this process. The resulting statements are connected with mastering new skills and restructuring thinking, with certain personal qualities necessary to adapt to changes, with the search for a golden mean between digitalization and traditional methods of work, as well as with the conviction that "live" human communication will never replace a computer or robot (Table 4). An interesting fact is that none of the participants indicated the need to introduce health-saving technologies aimed at overcoming the negative effects of digitalization, despite the fact that poor health is one of the main negative consequences of digitalization, according to the respondents.

Thus, the results of the narrative analysis allow us to draw the following conclusions. The overwhelming majority of the respondents are positive about the introduction of digital technologies in the organizations' activities and believe that progress cannot and should not be stopped. The negative aspects of the introduction of digital technologies are related, according to the respondents, to their imperfections and high cost, as well as to the negative impact on the health of employees. Possible concerns are associated with the insufficient reliability of technology and difficulties in mastering new technologies that older people face. The respondents in the sample

Table 2 An example of narrative analysis by thematic core "General evaluation of digitization in the labour sphere"

Evaluation	Keywords	Quotes
Positive	The convenience of work, saving time, fast communication, inevitability, technology, increased profits, the need for digitalization, distance learning, development, minimization of the human factor	"We live in the age of information technology, which means digitalization is inevitable and necessary, it facilitates work" "Digital technology is everywhere, we cannot do without it" "The introduction of digital technology increases the company's profits" "Keeping records electronically significantly reduces the time spent searching for information" "Digitalization has had a positive effect on my life: I learned a lot of things, I work with dozens of cleverest programs" "The importance of distance learning is worth noting. People with disabilities have a chance to get an education and developmentally"

(continued)

Table 2 (continued)

Evaluation	Keywords	Quotes
Both positive and negative aspects are identified	Labour facilitation, acceleration of work, saving time, convenience, deterioration of health, deterioration of vision, hypo dynamic, osteochondrosis, remote employment, computer addiction	"I believe that the social transition to new technologies and to new information systems is positive, as it speeds up the work processes, and makes work easier and saves time. The downside is the negative impact on human health" "Convenience and reduction of working time, but a large amount of working time is spent at the computer, which leads to loss of vision and physical inactivity" "The advantages are quick to access to information, the ability to communicate at a distance, developing logical thinking, reduced risk of error. But my eyesight and posture deteriorated, my interest in personal development was lost, I became dependent on PC" "On the one hand, the working chat is convenient to communicate with colleagues; on the other hand, to be always connected is stressful"

Source Authors

Table 3 An example of narrative analysis by thematic core "Possible concerns related to the introduction of information and communication/digital technologies in the organization of labour"

Concern	Keywords	Quotes
Technology malfunctions	Electric power, program glitches, technical errors, freezing, impossible to work	"I work as a teacher. The equipment may fail at any time, the computer may glitch, a power failure may occur, an animation will not work due to the difference in office software. Therefore, it's not a fact that the classic board is not useful"
		"One has only to turn off electricity, and all the work in our office is paralyzed"
Inadequate equipment quality	Cost, price, small budget, software quality, high-quality equipment	"The quality of the equipment is not always adequate; our organization cannot afford expensive equipment and high-quality software"
		"Unfortunately, for full labour digitization, there are not enough quality programs. Those available work slowly and freeze"

(continued)

Table 3 (continued)

Concern	Keywords	Quotes
Difficulties in mastering digital technology older people face	Retirement age, difficulties of mastering skills, elderly people, pensioners' adaptation, adult generation	"Older people will find it harder and harder to get a job because they have little in terms of digital skills"
		"The adult generation does not keep up with the technologies (taking into account the increase in the retirement age, it is difficult to adapt)"
Unemployment due to the disappearance of jobs	Job loss, robotization, the disappearance of professions, unemployment	"Robotization threatens the disappearance of a number of recruitment functions"
		"I am afraid that a number of professions will disappear due to robotization and digitalization, and I will have no place to work"
Database loss risk	Hackers, data loss, data theft, personal information	"In our work, there is always the risk of data hacking, theft of copyright technologies"
		"Once, an employee in our office, when he was dismissed, copied the client base for his personal use, and it was not possible to prove anything"

Source Authors

Table 4 An example of narrative analysis by thematic core "Reflection on the possibilities of improving the implementation of information and communication\digital technologies in the organization of labour"

Concern	Keywords	Quotes
Mastering new skills	Learning, training, skills, changes, ability to learn	"If a person has change management skills, then they will be a success"
Restructuring thinking and adaptability	Restructuring thinking, adaptation, adaptability, "new" people, the new way of life, new working conditions	"We all, most likely, will have to learn to live in the world of robots, smart machines, which will require a tremendous restructuring of thinking, business approaches and lifestyle from a large mass of people" "We need to learn to adapt to rapidly changing working conditions"
The advantage of a "living" person	Creativity, humanity, soul, heartfulness, "live" communication, inner world, feelings, emotions	"I am convinced that one of the main advantages of a living person compared to an electronic copy is creativity, the ability to find an individual approach to employees and the ability to act in unusual situations, because we are engineers of human souls who can feel the inner world of the applicant, which no gadget in the world can do."
Finding the golden mean between digitalization and traditional labour methods	Balance, the golden mean, new technologies, traditional methods, off-line and online communication	"It is necessary to find a balance between new technologies and traditional methods" "You cannot trust all the mathematical calculations to the program, sometimes you need to calculate by yourself"

Source Authors

are less concerned about improving the introduction of information and communication/digital technologies in organization but note the need to adapt to the rapidly changing working conditions.

4 Conclusion

Theoretical and descriptive analysis allowed the authors to form a systematic view of the current processes of digitalization of the economy and transformation of the labour sphere, which can be represented as a conceptual model (Fig. 1).

Digital technologies strongly influence the company's business strategy and the business model and are being perceived by many as a real threat for human employees' work and jobs. Companies concerned with the digital transformation of the business sphere should align their strategic vision and mission to the philosophy

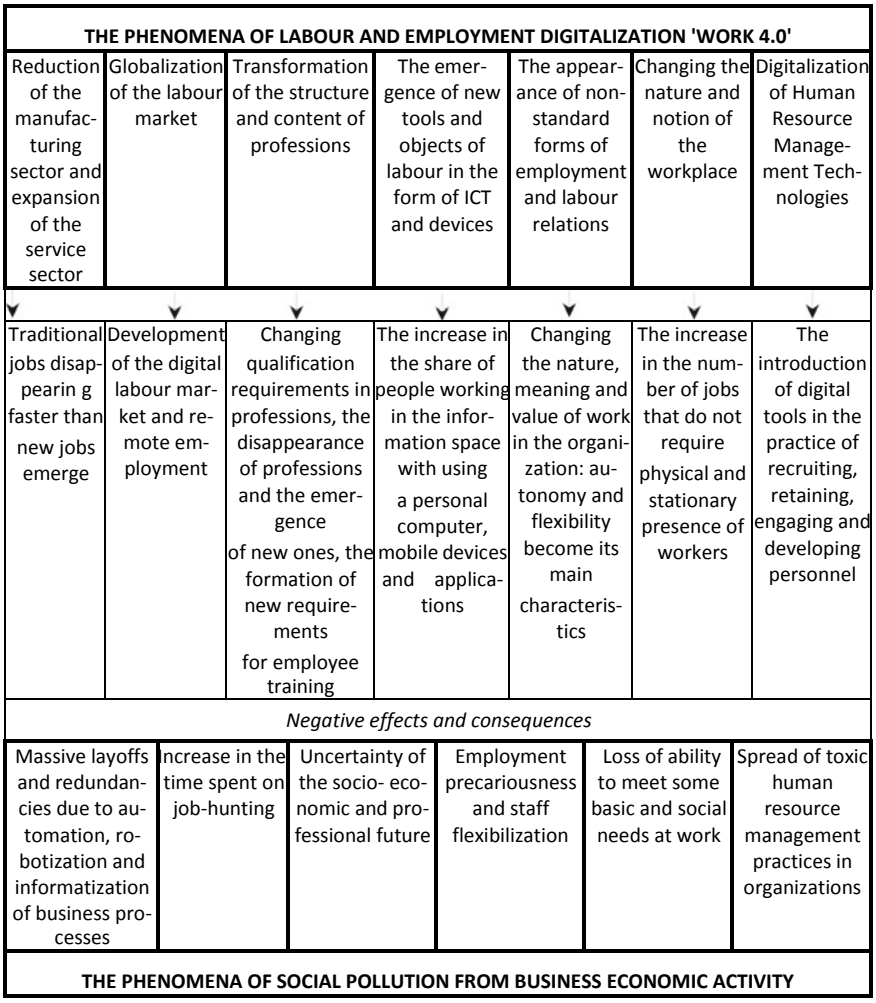

Fig. 1 Conceptual model of the labour digitalization phenomena as one of the social pollution factors (*Source* Authors)

of HRM. All HR processes are affected by digital technologies, as they represent promising tools for enhancing HRM effectiveness and efficiency. But, in order to cope with a much more complex environment and competition, the extensive adoption of digital technologies must fit with the organizational culture and the company's core values, and be supported by a proper combination of HRM practices. The integration of digital technologies into HR policies and practices must bring benefits to the overall employee well-being and must be evaluated not only in terms of their effectiveness and efficiency but also in terms of perceived equity and fairness by all employees.

Digital technologies are drastically modifying the way employees respond to different stimuli and signals. They are influencing: cognitive processes (perception (what stimuli/signals people pay attention to and how people receive stimuli), elaboration, and interpretation), mindset structure (attitudes, motivations, emotions, intentions, preferences, stereotypes), and responses (behaviours, interactions, learning).

This, in turn, impacts performance (productivity, absenteeism, turnover, citizenship, innovation, etc.), individual satisfaction (well-being, work-life balance) [24], and organizational climate. The need, therefore, arises to consider the employees' potential responses to new incentives. Every work arrangement and /or modification must be accompanied by appropriate internal communication, to avoid withdrawal behaviours (e.g. disengagement) and low job performance. Managers are therefore required to take into account their employees' needs, to identify their level of stress and burnout.

The increasing prevalence of digital technologies influences the way people approach their work. A new digital workforce is developing. The digital workforce can be divided into two categories [25]: (1) digital natives: those that cannot remember the first time they accessed the Internet, and (2) digital immigrants: adults who have readily adopted technology as it has been available. The increased use of digital technologies has influenced competencies, self-awareness, and relational expectations of the digital workforce.

The study presented in the article reflects the results obtained in the course of a sociological survey and narrative interviews of respondents belonging to the category of digital immigrants. This category is currently the most vulnerable, most acutely perceiving all the difficulties of the transformation process, forced to constantly adapt to changes in the labour sphere occurring at a high speed. The limitations of this stage of the study are primarily due to the insufficient sample size, which does not allow for the identification of age, gender and other similarities and differences in the perception by employees of the processes of labour digitalization. In future studies, we plan not only to increase the number of respondents but also to develop a psychodiagnostic method for assessing the extent to which social contamination affects the employees' physical and psychosocial well-being. Our research is aimed at long-term monitoring of changes in the labour sphere that lead to worsening employee well-being and working life quality, which requires searching for new management decisions and developing new management models in organizations that introduce digital technology.

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Socio-cultural Consequences of Population Adaptation Towards Dynamic Development Caused by Digitalization

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Abstract The article deals with the identification and systematization of population' adaptation methods to rapid economic and social changes caused by digitalization, and their sociocultural consequences. The aim of the study was to summarize the available theoretical and practical information. The information sources were scientific publications, as well as the sociological studies results made by the most respected public opinion research companies in the country and statistical information. The theoretical basis of the article is the Thomas Friedman's idea about the fundamental changes taking place in the world. These changes can have different consequences in different countries due to the sociocultural behavioral characteristics. In the available publications about the population' adaptation to current changes in Russia, such consequences are studied without a systematic approach, occasionally, so there is a need to summarize the information. The research methodology is a logical analysis of sources, the sociological studies results and statistical data. The author revealed such population adaptation methods as hoarding, sharing economy, insurance, birth rate reduction, the whole-life education, gig-economy, alcoholism or a healthy lifestyle, womenomics development and others. The author has systematized the revealed sociocultural consequences of the population' adaptation to dynamic changes into two groups. The first group has positive significance, such as an increase in the share of leading a healthy lifestyle, female business development. The second has the negative ones: the demographic situation worsening, changes in the population's lifestyle, its differentiation, the specific social diseases appearance, the mosaic nature of modern culture, an instant change in a person's social status.

Keywords Dynamic development · Digitalization · Population' adaptation · Sociocultural consequences · Demographic situation

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1 Introduction

The modern world is a rapidly changing arena of action. The population is experiencing a rapid changes and stepwise economic growth era in the early twenty-first century, when new industries are being created or being destroyed one's that have existed for ages in a few years. New economies are industrializing fast thanks to expanding digitalization, which provides virtually unlimited access to information. Against the background of the ongoing changes, the population expectations are growing; population requests become the new technologies engine; creative people and ideas become the most demanded, the government work mechanisms are changing.

The driving forces of dynamic socio-economic changes are:

- The intellectual capital (knowledge) that has become a strategic development factor. For example, there are more than 20 million individual entrepreneurs in the US business currently who use intellectual capital and do not attract wage labor, have a turnover of more than $ 1 trillion annually, which is about half of Russia's GDP.
- The globalization process based on IT and the Internet, which take place not only in trade and production, but also in research and development, technologies, communications, which has led to a global hyper-competition of businesses and the evolution of markets: from producer to consumer, and from the employer to the employee.

Soon and continuous changes reduce predictability and create risks and uncertainty [1]. Dynamic changes in the economy and society affect the lifestyle and psyche of the population, which is forced be adapted. In this regard, we consider it important to study the sociocultural consequences of such population adaptation.

The aim of the study is to generalize the main ways of adapting the Russian population to the dynamic development caused by informatization, and to study the socio-cultural consequences of such adaptation. The main author's hypothesis is the idea that the negative consequences of population' adaptation prevail at the present stage of digitalization.

Since the population' adaptation to changes is carried out both on the basis of conscious logical decisions, and intuitively, a tool for studying the ways of adaptation is to scrutinize changes in the population behavior and their attitude to what is happening. The structure of the article contains a theoretical basis, a description of research methods, identified ways of adaptation with confirmation by empirical methods, as well as the consequences of such adaptation.

2 Theoretical Basis

The research is based on a behavioral approach to the study of population adaptation. The adaptation process is explained by researchers of the behavioral approach (K. Cameron, S. Issakharov, G. Levenshtein, T.O. Donoghue, L.V. Korel, E.M. Avraamova, E.A. Yakovleva, E.A. Rylskaya, Yu.M. Pasovets, M. Rabina) by changes in the behavior as a set of interrelated actions based on the rationality of subjects. Within the framework of this theory, the internal sources of changes in human behavior are identified (Tereshchenko); the behavior is justified by the direct action of an external physical stimulus on the person and his/her response to this stimulus (E. Thorndike and J. Watson, A. Weiss, E. Gazri, E. Holt, W. Hunter); or indirect influence taking into account intermediate target, motivational variables (Skinner, Hull) and etc.

The theoretical basis of the article is the idea that the world had changed fundamentally, this was stated by Thomas Friedman [2] (cited from Z.Matson). He laid out a trio of rapid accelerations: digital globalization; climate change, biodiversity loss and other ecological changes; and Moore's Law, the exponential growth of computer speed and memory [2].

The theory is not complete yet, since world fundamental changes awareness have occurred not so long ago, so the author develops the theory in the sphere of studying the population adaptation methods and its sociocultural consequences.

Digitalization is a new external stimulus in Russia; therefore, science has not yet identified ways to adapt to this stimulus.

The dynamic changes sources are:

- New technologies, primarily digital, that cover all areas of production and services. Digital technologies have reached the oldest industries and fields of activity: medicine and education, where distance learning is carried out from anywhere in the world at any time convenient for students. Modern automated technologies calculate the animal feed volume and carry out automated cage cleaning in animal husbandry, provide plants' drip watering with imported water in the desert. Such significant changes in technology cannot but affect the labor content. Breakthrough technologies appear and develop, the goods and technologies life cycle are reduced;
- The social networks development on the Internet that change the social relationships of relatives and friends. A joke from social networks observes that "Like has become the hardest currency in the world."

3 Methods

The solution of the tasks posed in the study was carried out on the basis of the general scientific theoretical research methods application: analysis and synthesis, classification, abstraction. These methods were used to review available publications

on a selected topic. To test hypotheses about the most common ways of adapting and to identify possible socio-cultural consequences of the Russian population adaptation towards the prompt digitalization of society, empirical methods were used, such as studying various information sources, a critical analysis of the received information, as well as methods of comparative and logical analysis.

Surveys of the population were used as sources, which were conducted in 2016–2019 by the most respected organizations in Russia—the All-Russian Center for the Study of Public Opinion and the Levada Center. These companies interview large samples (at least 1,500 people) and have a generally positive reputation as organizations conducting sociological surveys. The statistics of the State Committee for Statistics and the Central Bank of Russia were also used.

Classification methods were used to systematize the possible consequences, when information was distributed on the basis of comparison and divided into groups based on common features. The method of induction allowed moving from isolated cases of consequences to the study of the whole phenomenon, and the method of abstraction allowed us to escape from the emotional perception of the rapid digitalization in order to reveal its objective consequences.

4 Results

Before studying the consequences of adaptation, it is necessary to generalize the ways of population adaptation to rapid changes in the economy and society. The author has identified the following common paths in the Russian Federation.

4.1 Methods for Population Adaptation

Analyzing approaches to the population' adaptation process towards all speedily changing events, the author revealed that the population chooses one of two opposite ways of adaptation in two directions.

Hoarding/Sharing Economy. One part of the population, especially the older age, seeks to accumulate reserves for a rainy day. These stocks consist not only of money, but also of products (cereals, salt, matches, etc.), clothing, and essentials (soap, medicine, etc.).

Another part of the population, primarily young people (the millennium generation) chooses not to own things, but to use them; therefore, they participate in the sharing economy development. Sharing Economy or Collaborative Consumption is a new culture and economic business-model, when the population exchanges or rents any assets using technology and online platforms [1]. The logic of such an economy not only limits the young people's spendings using the principle of "why to buy,

if you can just rent, and use something newer and more attractive one tomorrow," therefore, this logic takes care of the ecology and the natural resources rational use.

Alcoholism/Healthy Living. Dynamic changes cannot but affect the people psyche and often lead to stress. To combat stress, people often start drinking alcohol. According to the World Health Organization, Russia is among the 20 most drinking countries in the world in obedience to alcohol sales volumes and population surveys. Despite the general downward trend in alcohol consumption in the country, alcohol consumption increased by 8.3%, or 1.1 L per person in 2018, according to the Center for Research on the Federal and Regional Alcohol Markets (CIFRRA).

On the other hand, the share of healthy lifestyle citizens is growing, which includes a healthy diet, systematic physical activity and the rejection of tobacco and alcohol. According to a survey of the Russian Public Opinion Research Center conducted in all federal districts and all types of settlements November 2018 (1.2 thousand respondents were surveyed, the error is within 3%), 37% of Russian people lead a healthy lifestyle, and 23% have bad habits. The rest do not adhere to a healthy lifestyle, but do not ruin their health with bad habits.

Other population adaptation ways to a rapidly changing environment are:

The Insurance. It is a traditional method of population adaptation to a dynamic environment, in Russia too.

The total insurance market volume grew by 15.7% and amounted to 1.48 trillion rubles at the end of 2018, compared with 2017 (see Fig. 1) [3].

In reality, however, Russian population use little insurance to adapt to the changes and risks. The main contribution to the market growth is made by life insurance, which amounted to 452 billion rubles and ensured a growth rate of 36.5% in 2018 compared to 2017. Sooth to say, life insurance is prerequisites for a loan obtaining at a bank, which brinks to high debt load within the population. Banks account for almost 34% of premiums attracted by insurance companies today, and this share exceeds 88% in the life insurance sector. Thus, this type of insurance is not truly voluntary, but rather forced; therefore, the author is not inclined to consider insurance as an important element of the population adaptation measures system to the changes and risks.

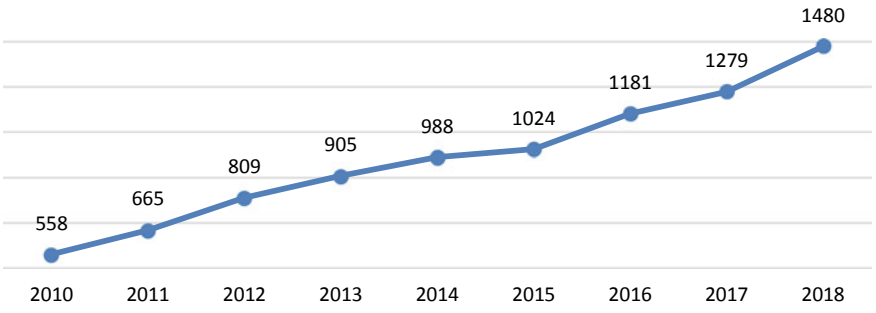

Fig. 1 Annual insurance premiums dynamics excluding compulsory health insurance, billion rubles (Compiled by the author according to the Central Bank of Russia)

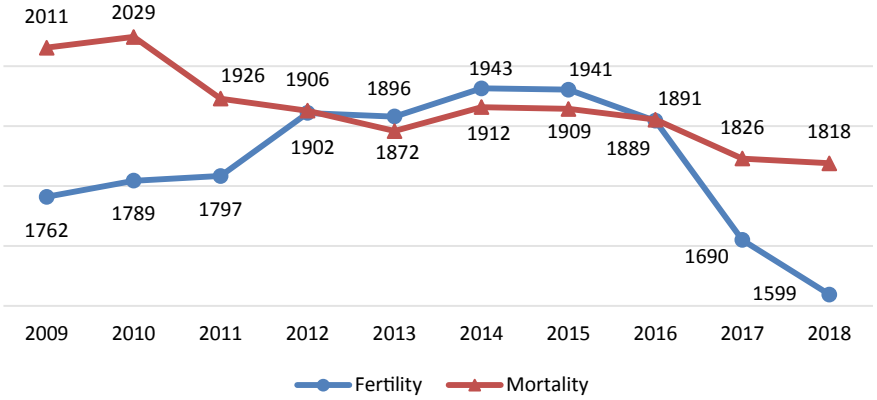

Fig. 2 Fertility and mortality rates in Russia, thousand people (Compiled by the author according to the state statistics committee of Russia)

The Fertility Reduction. The fertility reduction, accompanied by an increase in the number of pets that help fight stress. Families reduce the number of births due to uncertainty: there are fears for the children' future, fears about the possibility of their material support, education, etc. Figure 2 shows the dynamics of the birth rate over the past 10 years in comparison with the mortality rate.

As can be seen from the figure, the birth rate grew during the period of relative stability from 2009 to 2014–2015 (taking into account the Crimea accession and the time lag necessary for the childbirth), and since 2016 it has began to decline, when stability in Russia decreased significantly.

On the other hand, according to the initiative all-Russian survey conducted by NAFI June 2016, where 1600 people were polled in 140 settlements in 42 regions of Russia, half of Russians keep pets (50%), and in large cities where the population is more than 500 thousand people, the share is 57% [4]. At the same time, in accordance with the calculations of NAFI experts, "Russians spend almost 950 billion rubles on pets annually. This is 2.19% of the household consumption expenditures structure and 1.17% of Russian GDP at current prices."[4] Moreover, these expenses increase year by year, and the owners are cutting their own consumption during the crisis, not pets.

The Whole-life Education. It is necessary to keep up with the technology development. Not only the owners and managers of large companies organize continuous training for employees in Russia at present, but also the population itself actively uses educational videos on the Internet, webinars, and attends trainings and courses. According to statistics from YouTube, the main platform with recordings of educational videos, trainings and webinars, 8 out of 10 people aged 18 to 49 watch YouTube monthly [5]. It covers 82% of the Russian population aged 18–44 years, and the statistics are similar for both large and small cities. For example, in Moscow this indicator is 80%, and in cities with a population of 100–400 thousand inhabitants—78% [6].

Moreover, the category "science and education" was on the 8th position in popularity in 2018 with a slight lag behind the leaders. YouTube is no longer just an entertaining platform. A survey conducted by GfK, CINT and SSI showed that 87% of Russian users always or often watch videos on the topics, they want to study; 70% of respondents from Russia admitted that video hosting helped them learn professional skills and learn how to organize their lives [6].

The Gig Economy Development. The gig economy "covers the labor market, characterized by the predominance of short-term contracts or freelance work on permanent jobs, or a work environment that offers flexibility in working hours" [7]. An employee may carry out work with an employment contract, with a civil law contract or as an individual entrepreneur in the gig-economy sphere. More than 1 million freelancers are registered on the most popular Russian freelance exchange "Weblacnher.net"; these are people who provide their services for temporary work. The most famous gig-economy representatives in the Russian market are Airbnb, Uber, Skyeng, Blablacar. J'son & Partners Consulting' experts estimated that 20% of jobs in Russia will be virtual by 2020 [8]. Gig-economy allows: to work at a time convenient for the employee from anywhere, independently set a price for his/her work, refuse unpleasant work, combine several professions or work and raising children; such an employee cannot be fired, which increases his psychological stability.

Womenomics. It is a new concept of the national economy revitalizing by the active female part of the population participation, enshrined in the 2014 Japan Economic Development Strategy. Unlike Japan, where women were involved in productive activities a bit [9], and involving such a significant resource contributes to economic growth; the share of women is 48.7% of the total employed population in Russia. However, the proportion of women represented in government significantly lower: 16% in the State Duma, 17.6% in the Federation Council, 4.7% among the leaders of constituent entities of the Russian Federation. Therefore, women are increasingly opening their own businesses in Russia in recent years to adapt to the modern dynamic world. According to the all-Russian public organization "Russian Academy of Business and Entrepreneurship", Russia occupies a leading position in the world in the share of female business executives today. At the same time, women's business is developing 1.7 times more dynamic than men's in our country [10]. Starting their own business contributes not only to the family financial support and the employment for women, but also to their self-realization.

4.2 Socio-cultural Consequences of the Population Adaptation to the Changes

The fertility decline can be considered both as a method of adaptation to the unstable economic and social situation in the country, and as an unfavorable socio-cultural consequence of this adaptation. For the state and society, a decrease in the birth rate

means a reduction in the number of labor forces after two decades, further aging of the population, additional difficulties in providing pensions, maintaining the state borders, and migration problems.

Another sociocultural consequence is the lifestyle change connected with the work-life-balance violation in the direction of reducing the time devoted to the family and increasing the working-time.

Thus, according to a young people' aged 18 to 35 years survey, conducted in 2006 in 18 regions of Russia, "over a quarter (27.4%) of the participants noted that they were not on vacation for several years, and 5.5% in general believe that vacation is a waste of time" [11]. This trend is only exacerbated: according to a survey conducted by specialists of the Russian Federal Service of Labor and Employment August 2019 (the number of respondents was 5 thousand people), about a third of our compatriots continue to work even during their holidays [12]. The result of such a change in balance can be emotional burnout—a state where an employee cannot perform basic duties due to a strength lack and depression. Subsequently, psychosomatic diseases are added to emotional depression, which ultimately negatively affects the population life expectancy.

Changes in lifestyle also occur in the direction of rich and poor groups' lifestyle deep differentiation. Such differentiation of the population living standards is not limited only to purchasing goods and services ability, but also affects the social activity of various groups: participation in public life, the work and leisure nature.

The rich and the poor lifestyle polarization gives rise to various social diseases as another socio-cultural consequence of adaptation. The term "social diseases" is used in modern scientific literature in two contexts: (1) to refer to a number of medical diseases caused mainly by socio-economic conditions; (2) to describe the many social problems, deviations which the society has [13]. In the second meaning, the poor social stratum today is characterized by such social problems as alcoholism, apolitical, marginalization, lack of rights, poverty, homelessness, hooliganism, etc., because of the destructive or passive survival strategies usage. Social problems are different for the rich layer: oligarchism, authoritarianism, narcotization, immorality, mafia, "laundering" (of money), commercialization, falsification, clannishness, etc.

The next of the revealed sociocultural consequences is the mosaic culture of the modern society. The reasons for its occurrence lie in the possibility of the simultaneous choice of several options for coding, perception and creative processing of information in the digital society [14]. The Internet changes the person's way of thinking, makes it like a clip [15]. The widespread use of hypertexts as a specific nonlinear sequence of text fragments located at different levels and connected by hyperlinks [16], turns modern culture "into a mosaic of random, poorly connected and structured semantic spaces. Mosaic culture is perceived by a person in the form of pieces snatched from a person's stream of messages. A new cultural images representation is formed in the form of unrelated, inconsistent, logically unformed package information" [14].

The above-mentioned hypertext has one more important feature—the ability to "jump", the unexpected user's position movement in the text. This caused such a sociocultural effect as rapid changes in the person's social status, an instant (from

the point of society view) transition from one stratum to another. This concerns the questions:

- Marriage and divorce rate: reduction to a minimum, sometimes up to 1 day, of preparation for a wedding periods or the decision to live separately in a civil marriage;
- Migration: sometimes the decision to move is made and carried out in the shortest possible time by people who are not burdened with property;
- Career path: when a young man is appointed to a leadership position, bypassing several steps of the career ladder, or, conversely, an objectionable employee is removed from his position, up to and including dismissal and work loss, without interconnection with his qualification level.

5 Conclusion

Thus, the driving forces and dynamic social and economic changes sources have been identified in modern Russia, some of them are objective and cannot but push for changes; the other is caused by the subjective people influence on public life. Objective driving forces, for example, the digitalization of all spheres of production and services, require the various adaptation measures application by the population.

The goal of the study can be considered achieved, since a generalization of the population adaptation ways to the rapid changes that are currently taking place in Russia and the consequences of such adaptation are carried out. It is proved that adaptation measures can be either positive or negative. So, the transition to a healthy lifestyle, the rejection of bad habits can be attributed to positive measures which lead to positive sociocultural consequences. Other measures, such as reducing the number of children in modern Russian families, may have negative consequences in the future.

At the same time, the hypothesis was confirmed that there are more negative consequences at the moment than positive ones.

For the purpose of further scientific research on this topic, it is important to conduct a specialized sociological study about ways of the population adaptation to rapidly changing conditions. Such a study would reveal which part of the population uses this or that adaptation method, and the reasons why they chose this particular method. This article may be used as a basis for the question's compilation. In addition, it would be interesting to compare the subjective citizens' opinion with statistical indicators characterizing a particular mode of behavior.

The proposed case study requires financial investment, however the socio-cultural consequences analysis of population adaptation to a dynamic environment is necessary to adjust the Government's decisions regarding the Strategy development, National projects and State programs aimed at population saving.

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Gender Digital Inequality: Conceptualization and Practices

Galina Bannykh

Abstract One of the most likely social risks associated with the development of the digital economy is the growing gender inequality in the labor sphere and in society as a whole. In the context of the digital transformation of social relations, various forms of inequality appear, change and continue to be broadcast: from physical to material and intellectual. The purpose of the article is to try to conceptualize the concept of digital gender inequality based on the study of the forms of its manifestation in a digital society. The methodology includes the use of the concepts of social inequality, the information society, digital capital, and the theory of gender inequality. The research methods were analysis of theoretical literature, an analysis of statistical data, analysis of accounts and the context of social networks. As a result of the study, the concept of the "digital gender inequality" is formulated and a conclusion about the widespread use of the form of gender digital inequality in modern labor, professional and personal interactions of people is drawn. In modern Russia a political and legal framework has been adopted to overcome both basic and modern factors of gender inequality and promote a gender balanced and gender sensitive digital economy. However in reality there is a gender gap in the equal opportunities of women of different ages, masculinization of the IT industry, disproportionate representation of women in senior political and managerial positions, inequality in wages and other forms remains. Partial impact through the implementation of certain measures to overcome this contradiction is impossible.

Keywords Gender inequality · Digital divide · Gender digital inequality · Digital capital · Digital transformation · Gender exclusion · Social inequality · STEM · Gender segregation · Gender asymmetry

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1 Introduction

The digital transformation of social relations has led to the emergence of new opportunities and the relative "equalization" of the situation in the social-economic system of individual groups of the population. For example, residents of the northern territories of Russia have gained the opportunity to consume a much larger quantity and range of goods and services thanks to online trading and various Internet services. You can apply for a vacant place in the public service system, for positions in large corporations and simply search for "suitable" vacancies for their applicants or employers on a 24/7 basis from any territory with access to the Internet. The opportunities for entrepreneurship for all groups of the population have expanded, educational resources have become even more accessible for the entire population, etc.

However, in many respects, unequal statuses or opportunities of people not only survived but also took on new "digital" forms both at the level of access to information and communication technologies and at the level of development and "attribution" of these technologies in everyday personal and professional life.

Digitalization deduced the factors of social stratification from relative statics, giving them dynamism, unattainable for part of the population. Particularly dramatic to the process of this new, digital stratification is the reinforcement of its gender component.

Digitalization in all aspects of life at first glance, allows women to get more opportunities for education and employment, combining the responsibilities of professional, marital and parental, and more. However, equalization of opportunities often occurs in areas that are relatively prosperous in social-economic terms, or remains so for the population belonging to part of the base and middle stratum; for others, digitalization is an even more serious factor of the "gap" in such opportunities and their own position in social-economic structure of society.

Therefore, the purpose of this article is to try, firstly, to describe and comprehend the phenomenon of digital gender inequality, and secondly, to consider the features of its manifestation in the public relations of the modern Russian Federation.

The main research questions are:

- What is digital gender inequality as a type of inequality that manifests itself in a digital economy and digital transformation,
- What forms of digital gender inequality stand out,
- What factors influence the stability of this type of inequality,
- What forms are manifested and available for study and further understanding of digital gender inequality.

To search for answers to the questions posed methods of analysis of theoretical literature, statistics, accounts and the context of social networks were used. The selection of theoretical sources took place on the Scopus and Web of Science platforms, Google Scholar and Elibrary for the keywords "gender inequality", "gender-oriented inequality", "digital inequality". Some sources (mainly, the end of the twentieth century–the twenty-first century) related to the conceptualization of the term, most

modern sources (2016–2019) are devoted to studying the forms of digital gender inequality and how to overcome it. Secondary and statistical data used were data from the International Gender Inequality Index (Gender Gap Index), World Bank studies on gender asymmetry, official statistics (Federal State Statistics Service), data from sociological studies published by research organizations and research teams on gender inequality topic.

The first part of the article provides an overview of modern literature on digital gender inequality, the definition of characteristics, features and forms of its manifestation, which results in the formation of the concept of the concept itself. The second part of the article presents empirical data characterizing the manifestation of forms of gender inequality in the digital economy of the Russian Federation. In conclusion, generalizations and conclusions are presented, and prospects for overcoming the digital gender inequality are also proposed for discussion.

2 From Gender Inequality to Digital Gender Inequality: A Literature Review

In general, questions of the social structure of society, in which the theory of inequality is reflected, the issues of economically determined causes of inequality are actively considered by researchers during the 18–19 centuries. However, questions of gender asymmetry, as inequality on gender characteristic, are beginning to be studied in detail in the framework of sociological science in the 70 s, at which time the term "gender approach" appears. At that time, the gender approach is a variant of the stratification approach, which explains the occurrence of inequality on the basis of attributed sex, about relations of domination-submission, exclusion-recognition of people whom society refers to different categories of sex. Gender becomes a "useful" multilevel category of social analysis [1], which "works" at the level of analysis of identity, interpersonal relationships, systemic and structural level [2].

Later, with the development of the ideas of feminism, the concept of a "double system" appears in the social sciences, which explains the reasons for the unequal position of women in modern society compared to men. So, if in the Marxist feminist tradition the inequality of material resources and the life opportunities of men and women are considered as structurally determined (by capitalism and/or patriarchy), and the "women" and "men" themselves are regarded as relatively undifferentiated categories; then in modern social relations of exploitation (patriarchy) women as a class are discriminated against in the public sphere.

Rubin G. introduces the concept of a gender system. This concept has become one of the main ones in the gender approach. According to her, "in every society, there is … a sex/gender system—a specific organization through which the biological" raw material "of a person's sex life and reproduction undergoes human, social intervention and takes on certain conventional forms". In other words, the gender system is "a set of mechanisms by which society transforms biological sexuality into products

of human activity and within which these transformed sexual needs are satisfied" [3].

Bem S. proposed her own version of the gender approach: values and meanings invested culturally and economically are played in roles, and the content of these roles can be changed. The author proposed her own methodology for measuring the degree of masculinity and femininity [4] in society.

Gender is also perceived as a socially constructed relationship associated with the categorization of individuals based on gender. The theory of social construction of a tender is based on the distinction between biological sex and the social category of gender. Gender is defined as the work of society on attributing sex, which produces and reproduces relations of inequality and discrimination.

Currently, the study of gender relations is becoming one of the elements of understanding social transformations in the context of digital transformation. So, Goedhart, N., Broerse, J., Kattouw, R., Dedding, Ch. In their study, they argue that the introduction of information and communication technologies (ICT) plays a role in enhancing existing social inequalities for women in the Netherlands [5]. The main factors contributing to inequality, the authors call poverty, motherhood, the complexity of the development of ICT and the presence of immigrants in the first generation.

Mariscal, J., Mayne, G., Aneja, U., Sorgner, A., who talk about the phenomenon of global digital inequality based on gender, agree with them [6]. Researchers draw their conclusion on the basis of the results of a study that recorded the spread of gender inequality in access and ownership of digital devices, digital fluency, as well as the ability to make conscious use of access to technology.

Another group of scientists from the Netherlands demonstrates how the diversity of access to devices and peripherals, device-related capabilities, and the running costs required to service hardware, software, and subscriptions influence existing inequalities in Internet skills across gender groups [7].

Digital gender inequality is manifested both in the use and content of social media content. The logic of "visibility" as the main characteristic of a digital society encourages users of social networks to demonstrate themselves, their lives. However, Duffy, B. and Hund, E. argue that such a demonstration of themselves in social networks is perceived by users unevenly [8]. In particular, for women, the public nature of online Instagram is fraught with risk, opening up the possibility of ridicule, hatred, and harassment.

Researchers from the HSE confirm that users—parents in their posts on social networks mention sons more often than daughters, and posts with sons receive on average more likes [9].

Danish researchers, studying the behavior of Facebook users, got the results of the fact that there is inequality on the basis of gender and age on the social network due to representation, identity, the presence of images, etc. [10].

Studies of the inequality of the position of men and women in the labor market in terms of the need to rationally manage time were conducted by Woodman, D. and Cook, J. [11]. They believe that women tend to bear a disproportionate burden of coordinating their household schedules and work operations. Even for middle-class young people with relatively high levels of safety in hiring, increasingly challenging

working conditions to shift existing inequalities in the division of temporary labor by gender in a way that reinforces a sense of temporary instability.

Studies of women's employment in a technologically driven work environment in general, and in certain areas of its manifestation (in particular, Digital Humanities) convincingly show the imbalance in the employment of men and women [12].

At the junction of this area of research is the results of the work. Hopkins, J., which claims that blogging is a form of homework for married women with children, and the form and channel of communication make social networks themselves more feminized [13].

Gender-related digital inequality is also associated with gender stereotypes and historical differences in the patterns of behavior of men and women [14]. Thus, summarizing the above, it should be noted that in modern science the following vision of the phenomenon of digital gender inequality has developed:

- As a natural continuation of the functional difference between male and female roles,
- Socially constructed gender differences manifested in online representation and translated into social relations in the form of unequal opportunities and life chances for men and women,
- As a continuation of the inequality of class positions in the social structure of society,
- As the oppression of men and women by traditional roles (feminization and masculinization) in cyberspace.

Digital gender inequality has two dimensions: at the level of access and ownership of ICT and related electronic means, as well as at the level of using the opportunities provided by ICT (temporal, cognitive, behavioral, psychological and other features).

In the first approximation, digital gender inequality can be described as a discrepancy between the status positions of genders in various spheres of society's life, as well as their representation in cyberspace, due to the gender factor (gender socialization, gender roles, gender stereotypes, discriminatory practices, etc.), and features of access and mastery of digital technology.

In this understanding of the phenomenon under consideration, the socio-economic conditions for the development of society will be recognized as the main factor influencing its sustainability. In support of this, it can be noted that the World Bank has identified indicators of gender inequality in a separate area of assessing the quality of the institutional structure of the economy [15].

No less significant factor can be considered the efforts of state institutions to build human capital, in particular, the activities of public authorities to remove barriers in the field of education and maintain women's health, remove obstacles to full and stable employment, and support women with children.

3 From Gender Inequality to Digital Gender Inequality: A Literature Review

3.1 Gender Asymmetry and Segregation in the Labor Market in a Digital Economy

In the Russian Federation, the number of women exceeds the number of men—for example, according to the Federal State Statistics Service for 2019, 1154 women per 1000 men. In the long-term forecast of Rosstat, this ratio will be 100–1128 by the year 2036 [16].

One of the mechanisms for assessing gender asymmetry in the countries of the world is the World Bank study. The analysis is carried out according to legal documents that allow assessing the opportunities and rights of women in the areas of remuneration, employment, owning a business, managing assets owned by women, pension provision, freedom of movement, as well as having a family and children. According to a study for 2019, Russia received 73.12 points out of 100 [17]. The experts called the most problematic areas the remuneration, employment of women, and the right of women to enter into marriage and terminate it.

Since 2006, the World Economic Forum has been evaluating gender equality in the world according to its own Gender Gap Index. The index takes into account data on four main areas of manifestation of gender inequality: economy (wages, employment), education (accessibility), health and life expectancy, politics (representation in the highest authorities).

In a report of the World Economic Forum in December 2018, Russia ranked 71st out of 149 countries in terms of gender gap [18]. There is significant gender-based discrimination in pay, but the political situation is especially bad—an equality indicator is indicated in 8.5% out of 100% possible.

Indeed, women are represented unevenly in the legislature. So, in the Federal Assembly of the Russian Federation, out of 168 members, only 29 are women, out of 450 deputies of the State Duma of the 7th convocation—66 women (changes may occur due to political appointments or natural causes). Moreover, the number of women deputies of the State Duma of the Russian Federation is represented as much as possible from the political party "United Russia" and those elected in single-member districts. Large gender imbalances are observed in the presence of women deputies from the political parties "LDPR" (1 deputy out of 34), "Communist Party" (3 deputies out of 35) and "Fair Russia" (1 deputy out of 16). Among the 48 deputies of the Legislative Assembly of the Sverdlovsk region there are 3 women, although the proportions in the Assembly apparatus are different—9 men and 7 women.

In March 2019, Deputy Prime Minister O. Golodets at the Forum "The Role of Women in the Development of Industrial Regions" announced the existence and preservation of gender imbalances in wages: "The average wage of women in Russia is 70% of men's wages" [19].

For analysis, we turn to the results of sample studies of the Federal State Statistics Service of the workforce in the Russian Federation (see Table 1).

As can be seen from the data in Table 1, Russia is one of the countries where there is a high level of women's employment. So, if the overall level of employment in the country as a whole in 2017 was 66.5%, then female—60.1% (for comparison—on a global scale, the proportion of working women is 49%).

A high proportion of working women aged 20–49 years, in 2017 it amounted to 77%. And this is the age when the family is "growing", children appear, parents are forced to pay them a lot of attention, educate and socialize them. It can be confidently

Table 1 Differences in labor force by sex at the end of 2017, in absolute terms and % of total[a]

Indicators	Men, thousand and share	Women, thousand and share
Employment	39210 (71.5%)	36899 (60.1%)
Urban area	29457 (73.4%)	28874 (62.2%)
Countryside	9753 (66.1%)	8025 (53.5%)
Informal employment	7963 (21.5%)	6290 (18%)
Only in it	7437	5862
The number of employees aged 15–72 years Executives Unskilled workers Highly qualified specialists	2877 3118 6449	2028 2860 11104
Married and have two additional work	462 (2.5%)	674 (2%)
Widowers/widows have two additional jobs	9 (2.4%)	48 (2.7%)
Divorced have two additional work	62 (2.5%)	152 (2.7%)
Employment of people aged 15–72 years in household production	741	770
Unemployment rate for women with 3 or more children		9.8%
Urban area		8.2%
Countryside		11.8%
Unemployment rate for women without children under 18		5.9%
Employment rate for women with children under 18		77.8%
Employment rate of women without children under 18		78.6%
Number of unemployed with higher education	2102 (16.9%)	1865 (24.8%)

[a]Labor force, employment and unemployment in Russia (based on the results of sample labor force surveys). 2018: Stat.sb./Rosstat. M., 2018. 142c

stated that children are born to working mothers and even whiter than fathers, this is confirmed by the employment structure, 68.8% of working people are married, and the largest working group is the group of ages from 30 to 39 years. At the same time, not only homework, but also equal employment with men, fall on women's shoulders. So in 2017, 84.6% of women worked on a full-time week (31–40 h a week), the difference with men was not significant, they were full-time workers in 85.7% of cases.

It turns out that women's employment is not much inferior to men's, but more serious differences are present depending on the type of settlement: in rural areas, women's employment is much lower. In the structure of the informal economy, the gap between male and female employment is practically small—3.5%, that is, women, along with men, have to look for various employment opportunities that reduce the quality of their human potential.

Women, along with men, have to have more than one job to maintain the socio-economic stability of the family and in absolute terms, the number of women with two or more additional sources of income to the main one is even greater than the number of men.

Moreover, women who are divorced or have lost husbands, more often than men in such situations, have to find an additional two or more sources of income.

Differences are also present in household production, where women's employment is higher than men's.

The presence of children and their number also affect differences in female employment: the larger the number of children under 18 years of age with a woman, the higher the unemployment rate, which in rural areas is almost 12%. However, at the same time, the employment rate of women with children and women without children differs only in 0.8%. And the most vulnerable categories of women are those who have children of preschool age.

It can also be noted that women are almost on a par with men in the category of "unskilled labor", while the representation in the category of "highly qualified specialists" is much higher among women and among the category of "managers" it is much lower.

To clarify issues related to the representation of women among senior management, we turn to the results of a study conducted by Kontakt InterSearch Russia in January 2019 among 613 women who can be classified as senior management in Russian large companies or their own business organizations [20].

38% of the women surveyed had two or more specialized education, the main motivating factor for the occupation of the position, most women indicated "an interesting project", "intellectual challenge" and "company reputation". Women's answers to the question about the desire to develop further and the barriers to this development were compared with the answers of top men to this question.

If 81% of male leaders believe that nothing prevents them from developing, then among female leaders less than half gave the same optimistic answer—only 48%. That is, more than half of women in top positions feel some barriers. The main barriers to further development 22% of women consider uncertainty in the next step and fear

of change, 17%—gender, age and other discrimination, 12%—lack of knowledge of prospects, 11%—lack of experience and knowledge.

Among Russian employers who use the services of electronic personnel platforms, the marital status and the presence of children among candidates were considered insignificant for women applicants by representatives of 59% of companies, and for male applicants—71% of companies. Thus, indeed, for every tenth employer, this item is one of the decisive factors when hiring a woman.

About 8% of companies take into account the gender of the applicant in each of their vacancies. A little more than half of the recruiters said that the gender of the future employee is important to them only in some cases. The gender of the candidate is not important for 38% of respondents.

In order to mitigate the main differences in the working and employment conditions of men and women, in 2017 in Russia, the National Strategy of Action for Women for 2017–2022 was adopted, which formulated the main goals of gender policy in the country. This strategy provides a clear outline of gender policy and outlines measures for its implementation. Priorities include:

- Reducing the gender pay gap;
- Encouraging female entrepreneurship;
- Reduction of female occupational segregation and improvement of labor protection;
- Ensuring a better balance of work and family life;
- Increased employment and increased competitiveness of women.

Within the framework of the state program "Promoting Employment", an event is being implemented to promote the employment of women raising children, aimed at creating opportunities for women to take vocational training in the direction of employment services and return to work at their previous workplace (updating professional knowledge and skills), or after leaving the leave to care for a child under the age of three years, get a job at a new place of work that is most suitable for combining with responsibilities for raising a child. In 2018, 15.5 thousand government-provided career guidance services were provided to women, 15.9 thousand women on maternity leave until they reached the age of three years, started vocational training and additional vocational education for women, completed vocational training of 13 thousand women [21].

In the Russian Federation, there are legislative restrictions on female employment in certain types of jobs—this list includes 456 specialties (among them, for example, a driver with more than 14 seats, a driver of electric trains, steam locomotives, diesel locomotives, diesel trains, a bulldozer driver, a tractor, a carpenter, fisherman, etc.). In real practice, women still work in these professions, but informally, or with significant support from trade unions or even international organizations. Particular problems arise here in monoregions and cities, where most of the available highly paid professions are prohibited for women. From January 1, 2021, the list of prohibited professions will be reduced to 98.

The share of women employed in the technological sector, engineering, is significantly lower than the share of men—this trend is recorded both in the West and

in the East (in the global IT industry, the share of women is on average 15%, in the management of the IT industry—up to 10% of women) According to a study conducted by Booking.com in 2018 to assess the status of women in the field of technology, 32% of respondents are hindered by gender stereotypes even at the stage of selection for a position [22].

According to a survey conducted by IRI in 2017, 34% of respondents confirmed that women make up 30–50% of the total number of employees of their companies [23]. Mostly women occupy the positions of project managers (27%) or sales managers (21%). So, in Sberbank Technology, the number of women in 2017 was 26%, in Cognitive Technologies the proportion of women varies depending on the project and can be up to 35% in complex projects with high-level programming. In the management team of Alfa-Bank's IT unit, the number of women over the past 2–3 years has grown by an average of 20%. More than a third of women surveyed by Iran believe that there are no specific difficulties in IT. However, about half note a lack of career growth and a lower salary than that of male colleagues.

The same imbalances are present at the level of "entry" into the profession—educational. Graduates of technical universities in Russia are still several times less than graduates. Statistics confirm that women are less represented in STEM disciplines (for example, 26% of women graduate students and 74% of men study in technical fields; the situation is similar in physical and mathematical sciences) [24]. For example, at the Faculty of Computational Mathematics and Cybernetics at Moscow State University—about 25%, at MSTU. Bauman—20%, and at MIPT—only 12% [23, 25]. So, at the beginning of the school year in 2019–2020, 449 boys and 90 girls were accepted at the Ural Federal University in IRIT-RTF, which makes a difference of almost five times. Here we are dealing with historically established practice, as well as stereotypes and prejudices that appeared in the profession for various reasons. These reasons have nothing to do with the abilities, potential or level of professionalism of women.

Moreover, researchers note that such asymmetry is the result of the cross-cutting nature of the formation of gender inequality in the choice of high-tech professions, passing through the entire socialization of a person in secondary and higher education and his first steps in the labor market [25].

It should also be noted that among the so-called freelancers, the proportion of women is gradually increasing: if in 2009 there were 33%, then in 2019 there were already 46% [23]. A freelance is a form of self-employment, employment for the duration of a task or project, which, on the one hand, allows women to feel more free to use their time, but on the other hand, it does not guarantee them a stable income.

3.2 Inequality in Access and Use of Digital Technology

It seems logical that in the social space of the Internet, the principles of gender equality should be maximally implemented by themselves. But in fact, it was on the network that the practices of gender inequality were radicalized and resulted in the

Table 2 Gender representation of users on social networks, 2018[a]

Social network	Number of authors	Men, %	Women, %
Vkontakte.ru	569,000,000	48.2	51.8
Instagram.com	1,000,000,000	23.4	76.6
Facebook.com	2,270,000,000	40.7	59.3
Youtube.com	1,958,000,000	54.8	45.2
Odnoklassniki.ru	330,000,000	39	61

[a]As of 1 November 2018

formation of exclusively "male" and "female" accounts, groups and public pages on social networks, YouTube channels, websites, etc.

In assessing the degree of population involvement in media consumption and the use of digital technologies, we turn to the Deloitte report for 2018 [26]. The smartphone usage index in 2018 amounted to 87%, the share of smartphone users who connect to the Internet often and rose to 57% for a long period of time, instant messengers became the most popular application on a smartphone, 75% of smartphone users make purchases on the Internet.

Men, on average, are more active than women using different media channels (54% versus 51%), and respondents who are not alone are more active in media consumption. Men and women differently consume information on a channel such as radio (the difference is more than 10 pp.). Men are significantly more likely to play video games than women, although overall the proportion of women playing is 45%. When making online purchases, women are more likely to show themselves in such categories as cosmetics and perfumes, as well as clothes.

As can be seen from the data in Table 2, on Facebook, Odnoklassniki and, especially, Instagram, female authors prevail, in the latter the share of girls is more than 76%. Among the 20 most popular Instagram accounts, 10 belong to women, while 5 belong to corporate accounts. Among the 20 most popular authors on Facebook, only 6 are female.

Moreover, among the most popular 20 content authors on Vkontakte, only 6 are female. However, in general, among the 25.7 million users who publish content, there are more women, the most active audience aged 25–34 years.

YouTube is the largest video hosting service on the Internet and the second most popular search engine. There are more women registered in the hosting, but in the 18–24 category, the audience is mostly male. Among the top 20 channels of the Russian segment, 9 can be identified as the channel of the male author, 2 as the channels of female bloggers, the rest belong to parents developing the channel with the presentation of their children, toys and more. We can conclude that women's blogging is a less pronounced and popular phenomenon than the male version. The only exception is the social network Instagram, which really has the maximum number of female bloggers, however, their content is mainly associated with the stereotypically "female" content. Male bloggers make content for different target audiences, their content is more universal.

A separate area of research is the study of the features of gender representation and gender stereotypes in virtual social networks. In Russia, the number of users of both sexes is almost the same [26]. However, among women, there are more users of Instagram, while among men—users of YouTube. There is a shift to visual communication, but it manifests itself in different ways.

For example, a Microsoft study showed that women in Russia show a higher level of culture of communication on the Internet than men. "For example, they show respect and dignity in relation to other users in 79% of cases, and men – only in 65% [27]. In addition, Russians tend to respect the opinions of their interlocutors in the virtual space in 68% of situations, while Russians—only in 53%" [28].

A study conducted in 2017 (a mass questionnaire of residents of the Sverdlovsk region on a representative sample, 934 respondents aged 16–75 years) showed that the gender sign is significant in assessing consumption in the information society. So, if among women the need for information according to the degree of significance is as follows: entertaining, political, social-spiritual, domestic; men prefer information of a political nature, further—entertaining, sports and economic [29]. Men more often than women use the Internet in a mobile phone or smartphone in order to follow the news (31%), play (12%) and download software. Women, in turn, often need it to use social networks. Men can also be assigned to the group of persons most interested in new products of technical devices.

However, the online sphere continues to be an environment that reproduces gender stereotypes, and an environment that consolidates the existing patriarchal mechanisms in offline space" [30].

4 Conclusion

Gender asymmetry, pronounced in patriarchal societies and associated with the agrarian and industrial type of economy, began to level out in the 20th century. However, traditional social inequality in the digital economy and the information society is exacerbated, and gender inequality takes a new form—digital.

In modern science, the authors remain interested in the topic of gender inequality, however, there are few theoretical and generalizing works. To a greater extent, research and publications are devoted to one or another aspect of the manifestation of digital gender inequality (in the field of education, employment, media consumption).

In the first approximation, digital gender inequality can be described as a discrepancy between the status positions of genders in various spheres of society's life, as well as their representation in cyberspace, due to the gender factor (gender socialization, gender roles, gender stereotypes, discriminatory practices, etc.), and features of access and mastery of digital technology.

In the digital economy, the main forms of gender inequality are digital gap in the labor market (women's representation in STEM professions, media professions, etc., lag in wages), provided that women are actively involved in labor relations and remote employment; digital gender inequality of access and use of information technologies

(differences in the choice of social networks as channels of communication and earnings, digital literacy when using ICT technologies, etc.); inequality in educational opportunities, opportunities for organizing leisure and choosing a profession and so on.

The factors of sustainability of the phenomenon of digital gender inequality are the gender-role nature of general and vocational education, gender segregation in the labor market, and cultural barriers surrounding girls and women.

Gender inequality is reproducing in the field of digital technologies, where a contradictory situation has developed: on the one hand, modern technologies open up new opportunities for female employment, on the other hand, the uneven development of ICT infrastructure and gender inequality reinforce gender asymmetry and discrimination of women in this industry.

A woman, being only a user of a personal computer, is lagging behind in the development of modern technologies, being squeezed out of this sphere by highly qualified men, which widens the gender gap in the labor market and gender inequality in society. This is largely due to the information and communication practice of broadcasting stereotypes: "non-female profession", "non-female business" through the main social institutions (family, school, media).

The improvement of socio-economic conditions, as well as the activities of public authorities to remove barriers in the field of education and maintain women's health, can influence the policy of equalizing gender asymmetries.

Thus, the popularity of remote employment and freelancing provides great opportunities for the self-realization of women, since it is often possible to hide sex in global freelance markets, focusing the employer only on the qualitative characteristics of a professional. To implement women's projects of self-employment and entrepreneurship, you can use STEM-sphere.

Involvement of girls in the STEM sphere must begin at the level of their reproduction of gender-role games—at preschool age, and then—in a cross-cutting format—at the school and university levels. However, at the first stages of implementing a gender-balanced STEM education, we consider it useful to introduce a gender quota for girls among students of technological universities (at least 30%).

It is necessary to actively involve women scientists, women doctors, women teachers, women managers in the implementation of specialized areas of the State Program "Digital Economy", since it is precisely in these areas that the largest share of employees is women, but in the centers of competencies and other management structures, with decision-making—gender asymmetry.

In the scientific understanding of the phenomenon of digital gender inequality, it seems relevant to study the national-state features of its formation and dissemination, to establish correlations and interdependencies with the socio-demographic characteristics of social groups, indicators of the development of the digital economy and innovative activity, the influence of trends in family individualization, personal autonomy and "erosion" boundaries of gender into forms of digital gender inequality.

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The Influence of Cross-Functional Teams on the Development of the Companies' Absorption Ability in the Conditions of Work 4.0

Elena Kalabina and Olga Belyak

Abstract The purpose of the article was to increase understanding of the features of the activity of cross-functional teams of concurrent engineering and their role in the formation of the absorption ability of the company. In the course of this study, organizational, activity and functional approaches were used, as well as basic scientific methods—analysis, deduction and generalization. The article is devoted to concurrent engineering in cross-functional teams as an alternative to the traditional approach to the development of innovative products. The article analyses the essence and features of concurrent engineering in the context of cross-functional teams. The necessity of considering cross-functional teams from the point of view of the community determining identity, common interests in a team, its relative integrity is established. The importance of cross-functional teams in the development and development of the absorption ability of the company is shown. The article discusses the various coordination mechanisms operating in CFT. An analysis of the features of cross-functional teams allows us to determine that cross-functional teams are built on the principles of adhocracy. They have a significant impact on the develop the absorption ability of companies. However, they require a special management approach. The article presents directions for the further development of research, involving an empirical analysis of the influence of various coordination mechanisms on the knowledge sharing in an cross-functional team and the development of the company's absorption ability. The results of the study will contribute to further studies of cross-functional teams and effective knowledge sharing.

Keywords Work 4.0 · Cross-functional teams · Concurrent engineering · Absorption ability · Knowledge sharing

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1 Introduction

Progressive achievements of modern world inevitably lead to labour relations changes in the background, forms and nature, essence of labour activity and its quality [1]. Work 4.0 as a new paradigm of labour relations was named by analogy with Industry 4.0, a new economic structure based on industrial equipment and information systems combination in a unified information space for interaction between themselves and with the external environment without human participation [2]. Work 4.0 deals with the digital age future including the use of robots, automated mechanisms and production processes digitalization, with the aim of developing and implementing resource-efficient, more environmentally friendly, socially acceptable innovative solutions [3].

Traditionally, organizations lined up on a vertical hierarchical structure with a clear division of functionality between company divisions. That is, when developing innovative products, the project went through each of the stages sequentially, entering certain structural units that have a clear functional orientation: the R&D group, production, testing, marketing, etc. These structural units are consistently implementing an innovative product development project and are largely isolated from each other. An alternative approach to the development of innovative products is concurrent engineering in the context of cross-functional teams, when the development of various aspects of the future product is carried out simultaneously and covers the entire product life cycle.

One of the first references to cross-functional teams in Western sources is related to an internal study of the importance of using computers by the Northwestern Mutual Life insurance company in the 1950s. However, the cross-functional concurrent engineering approach has gained worldwide popularity thanks to the Japanese Kaizen philosophy. Kaizen's philosophy is based on the use of cross-functional project teams and is aimed at continuous improvement of standardized actions and processes, from development, production and ending with management [4]. Thanks to the cross-functional Kaizen philosophy, Japanese automakers such as Toyota and Honda have been able to achieve tremendous global success since World War II. Further, the experience of project management based on cross-functional teams used by Japanese companies was introduced into the project management of individual US companies (for example, Hewlett-Packard, Ford, etc.) and also demonstrated its advantages in comparison with the traditional approach to innovative product development [5].

As the experience of world companies shows, the union of specialists representing different functional areas in one team is appropriate and effective, since representatives of these functions have different responsibilities in accordance with their functional affiliation [6]. On the other hand, the existing functional differentiation within one project team creates certain difficulties in integrating these functions. This combination of different functions in one team should be supported by organizational policy and culture [6, 7].

The development of innovative products and services is the creation of new knowledge and the company's task is to contribute to its creation, use and dissemination,

i.e. develop your absorption ability. Despite the different functional areas combined over a single project development, a highly functional knowledge exchange should be carried out in a cross-functional team, ensuring the creation of new knowledge. This means that the management, the company as a whole and the organizational culture in particular are faced with the task of creating an environment and conditions conducive to the knowledge sharing. Hence the relevance of the study of the impact of cross-functional teams on the development of the absorption ability of a company. Thus, the main question posed before this study is the following: "What are the features of cross-functional teams of concurrent engineering that contribute to the development of the absorption ability of the company?".

Based on the research question posed, **the aim** of the work is to increase understanding of the features of the activity of cross-functional teams of concurrent engineering and their role in the formation of the absorption ability of the company.

The issues analysed in this study include:

- What is the essence of cross-functional concurrent engineering teams?
- What are the features of knowledge sharing and barriers to knowledge sharing in cross-functional interaction?
- How do different coordination mechanisms affect the effectiveness of knowledge sharing of cross-functional teams?

The article has the following structure. The first part describes the essence of cross-functional teams, the features of their creation and functioning in the company. The second part is devoted to the knowledge sharing in cross-functional teams, their impact on the absorption ability of the company and the existing barriers to knowledge sharing. The third part describes coordination mechanisms and their impact on activities, and the knowledge sharing in cross-functional teams. In conclusion, the conclusions of the study and the result of the work done are summarized.

2 Essence and Features of Cross-Functional Concurrent Engineering Teams

2.1 The Concept Work 4.0 and Cross-Functional Teams

The push for the term "Work 4.0" spread was the release of the Green Book on Work 4.0 (2015) and the White Paper on Work 4.0 (2017) by the German Federal Ministry of Labour and Social Affairs (BMAS). BMAS raised important questions about the use Work 4.0 mechanisms, labour relations features and possible difficulties related to the total implementation of digital technologies [8].

It is considered that digitalization will significantly change the working processes and ways, focusing the further transformations on a human [9].

As Work 4.0 considers the digitalization of the work field, this concept is based on such elements as work flexibility, freedom, voluntary participation, management

instead of leadership, dynamism and short-term, focus on people, not on machines [10].

These elements were fully reflected in Agile Manifesto (2001), Agile's software development flexible culture. The Agile method considers minimization of external dependencies, leading to flexibility, creativity and productivity, where each participant has equal responsibility for the result of the work [11].

In an organizational context, cross-functional teams of simultaneous and concurrent engineering meet the requirements of Work 4.0, because they have a number of features that are beneficial for Work 4.0 conditions, differentiating them from other types of teams. Concurrent engineering differs from traditional sequential design by the simultaneous aspects process of an innovative product or all aspects of an innovative service. The cross-functional approach, which appears to be a basis of concurrent engineering, provide the functional barriers overcoming, which can exist with the standard project management approach. The temporary nature of cross-functional teams, the limitation by one project or by a common problem, provides dynamism and short-term work, the possibility to show the potential of each participant, which appears as the main idea of Work 4.0.

2.2 What Do We Mean by Cross-Functional Teams?

Compared with the traditional approach, concurrent engineering in the context of cross-functional teams is designed to optimize the development of innovative products and services. In the traditional "sequential" approach, a mistake, especially one made in the early stages of development, leads to the need to "return" to the already completed stage and make adjustments, which may determine the subsequent stages, which generally leads to a general increase in the time and cost of product development or services. This approach works especially hard in modern conditions of a constantly changing external environment and fierce competition, in which modern companies operate, when a product or service developed by a company may lose relevance already in the development process.

In scientific sources, the appearance of concurrent engineering is considered as a response to the challenge of a new reality, where the main characteristics of the environment are uncertainty, instability, ambiguity and fierce competition (for example, [5, 12, 13]).

Modern concurrent engineering goes beyond the development of product design for production and helps to achieve the main goal of coordinating decisions between various engineering functions, such as reliability, maintainability, manufacturability, etc. [14]. Also at the present stage of development, concurrent engineering integrates design solutions with customer needs and marketing strategies, solves larger issues of environmental and social costs [13]. Spanning the entire product life cycle, concurrent engineering is characterized by success indicators such as time, cost, quality, and customer satisfaction [7].

The main principle of concurrent engineering is the parallelism of development [7, 15]. The principle of parallelism, which forms the basis of the innovation development approach under consideration, is implemented through the use of cross-functional teams.

Cross-functional teams are formed from specialists from different professional areas in such a way that the combined functionality of the team overlaps the problem field of the project. Such an organization of project work allows working on all aspects of an innovative product at the same time, sharing control and responsibility between team members [16].

At the moment, in the scientific community there is no generally accepted definition of cross-functional teams. Analysing the scientific literature that defines cross-functional teams (hereinafter, CFT), we can identify the main criteria characterizing this type of team:

- CFT's activity is limited by a common goal, often consisting of developing an innovative product or service [16–23];
- Participants have complementary competencies [17–19, 21–24];
- Have a high level of interdependence among participants [17–20, 22];
- Team members share responsibility for achieving the final results [18, 19, 21, 23];
- The presence of a synergistic effect from teamwork [18, 19];
- The temporary nature of existence [17, 18, 23, 24].

Thus, the talent, experience and skills of team members are necessary conditions for effective innovation, but the culture of teamwork helps to unite the creativity of all team members to achieve a common goal [25].

Also in the scientific literature, the need for voluntary participation and co-location of all team members is noted, which makes it possible for personal communication and building relationships within the team [23].

The most important factors for the efficiency and effectiveness of cross-functional teams are participation in one project, sharing by all participants of one common goal set for the team, and the presence of a senior management representative in the form of a team curator [23, 26].

Due to the fact that the cross-functional team is composed of specialists from different professional fields, they have different professional identities and professional cultures, which introduces an element of disunity and confrontation between representatives of different functional areas [22, 27, 28]. On the other hand, as noted above, when forming a team, it is necessary to achieve cohesion and separation of the common goal, which ultimately allows you to achieve a synergistic effect from teamwork. The existing dualism inherent in cross-functional teams is not reflected in the analysed CFT definitions; however, it puts forward additional requirements for team members and the CFT formation process.

In our opinion, when defining cross-functional teams, it is rational to characterize CFTs not just as a team, and even less as a group of people, but from a position of community showing identity, common interests in the team, relative integrity. Thus, our definition of cross-functional teams has the following form:

A ***cross-functional team*** is a community of people with a high degree of interdependence, possessing complementary professional skills, in aggregate covering the problem field of the project, and assembled for the sole purpose of developing innovation.

Achieving community in a cross-functional team should be considered as the main goal in creating and forming a team, as this will allow to overcome communication barriers, and therefore, provide a complete exchange of information and knowledge to create new knowledge. Best communication practice in a cross-functional team enriches the culture of teamwork and promotes effective innovation in the team [17]. In general, this leads to changes in the field of project control and management, paying special attention to human resource management, knowledge and process management, and the development of absorption ability based on cross-functional teams. In management practice, a cross-functional team should be considered as a complex, adaptive, dynamic system built into the organization and contexts, performing assigned tasks limited by time resources.

3 The Role of Cross-Functional Teams in the Formation of the Company's Absorption Ability

3.1 Absorption Ability of the Company

The absorption ability attracts interest because it directly affects the level of innovation, helps to optimize business processes, and also determines the company growth rate and its profitability.

According to management theory, the absorption ability, or the organization ability to find and process the most valuable information and then use it for commercial purposes appeared to be a relatively little studied phenomenon. It is often defined as a function of existing knowledge, including basic competencies, knowledge and skills of employees, as well as knowledge of the latest scientific and technological developments in the subject area.

Recently, the concept of absorption ability has been studied at various levels, including state, interorganizational and organizational levels. Researches focusing on the organizational level have proven that investments in R&D (Research and Development) determine the ability of a company to absorb and use new knowledge appeared during cross-functional teams work, noticing the importance of employees cohesion and entering the company on a «bottom-up» basis.

3.2 *The Importance of Cross-Functional Teams for the Development of the Absorption Ability of the Company*

Knowledge is considered as an input or resource element of organizational processes—the "knowledge potential of the enterprise" [29], and are the basis of the company's competitive advantage [30].

The model proposed by I. Nonaka and H. Takeuchi opens a perspective for understanding development of the absorption ability of a company and the formation of organizational knowledge of an innovative firm. The model is developed on the basis of the idea of informal (implicit) knowledge, which, according to the authors, is the source of the company's competitiveness and is "personal (knowledge) and dependent and therefore difficult to formalize and disseminate" [31]. Innovation in the presentation of Nonaka I. and H. Takeuchi is not a function of one separate team, but an integral function of the whole company, which involves all levels and divisions.

The model of I. Nonaka and H. Takeuchi is based on a multidimensional approach and considers the knowledge of the firm in time expression and forms of representation (see Fig. 1).

According to Nonaka I., Takeuchi H., the model for creating organizational knowledge should be considered as an endless circle, implemented using cross-functional teams. The first stage is the expansion of the knowledge of individuals in order to further exchange this knowledge with other participants. In the future, there is an exchange of informal (implicit) knowledge through social interaction—the participants of the cross-functional team create new knowledge through discussion—this is the stage of "socialization". Further, knowledge created under conditions of cross-functional teams is distributed through externalization in various departments of the team. At the combination stage, the acquired knowledge is checked for their usefulness to the company and, in the future, already substantiated knowledge is built into the general knowledge of the company.

There are some conditions that contribute to this process, namely creative chaos, redundancy, and necessary diversity.

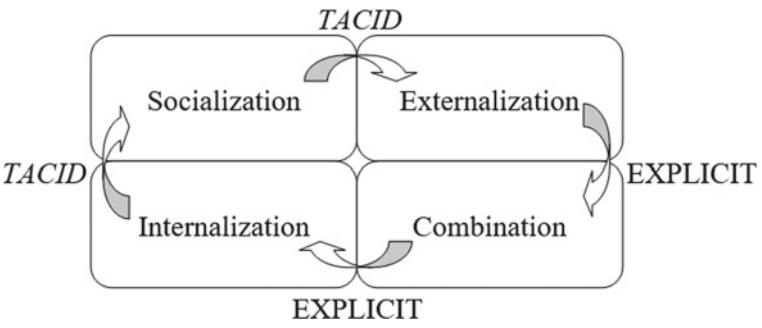

Fig. 1 Model transformations knowledge of Nonaka-Takeuchi

Creative chaos is a situation when an organization is faced with a crisis or when a sense of urgency arises. This is positive, as it makes people focus on solving problems.

Redundancy of information is a situation when overlapping information is found to have a positive effect, since it accelerates the process of creating new knowledge, and the management hierarchy can be reduced due to redundant information.

Required diversity: the team creates diversity within itself to match the diversity that needs to be handled.

As we can see from the presented model, cross-functional teams occupy an important place in the process of creating and developing the absorptive capacity of a company engaged in innovative developments.

The basis of the considered model for creating organizational knowledge is an effective knowledge sharing. It is believed that the intensive knowledge sharing both within cross-functional teams and with various functional departments of a company contributes to innovation and the success of new innovative products (for example, [17, 32, 33]).

When analysing the process of knowledge exchange, it is necessary to take into account the existing diversity of knowledge in cross-functional teams, as well as the various boundaries of knowledge that must be crossed when exchanging them.

Carlile P. R. (Carlisle P. P.) defined three levels of the boundaries of knowledge in an organization formed by the localized, embedded, and embedded properties of knowledge [34]. Depending on how localized, embedded or embedded knowledge can be, people face various problems associated with their transfer, translation or transformation (Table 1).

The three boundaries of knowledge range from subtle (the transition from syntactic to semantic knowledge) to thick (the transition to pragmatic knowledge). They influence the complexity of integration and, in the process of team building, require, on the one hand, the use of special management decisions to overcome these boundaries, and on the other, a high level of motivation for participants to overcome these barriers.

Table 1 Boundaries of knowledge

The boundary of knowledge	Description	Overcoming
Syntactic	Differences in language usage	Development of common vocabulary for information processing across borders
Semantic	Differences in interpretation and interpretation systems that create barriers of understanding for people involved in cross-functional team	The development of common knowledge through mutual engagement around joint problems
Pragmatic	Different and potentially competing interests of people involved in new product development	Development of common interests through negotiations

3.3 *Factors Affecting the Knowledge Sharing for Cross-Functional Teams*

The behavior of participants in a cross-functional team in the knowledge sharing and overcoming the existing boundaries of knowledge is determined by factors of different levels. To identify the levels of factors and the relationship between these factors, it is appropriate to consider the concept of the "knowledge management approach" proposed by N. Foss (hereinafter, N. Foss) [35].

The study identified factors related to the micro and macro levels. The macro level N. Foss refers to the management practices used by management to control organizational processes, for example, such as a reward system, etc. The micro level of factors includes the individual characteristics of team members. The macro factors existing in the company influence the microfactors and, as a result of this interaction, a certain behavior pattern of the team member is formed. These processes are graphically presented in a diagram based on the diagram of J. Coleman (J. Coleman) (see Fig. 2).

Solid arrows show the mechanism underlying the relationship of the organizational environment and performance (dashed arrow).

The presented model shows that both managerial practices and personal attitudes affect the effectiveness of knowledge sharing among members of a cross-functional team.

Management practices used by management can be directed to:

- The formation of motivation for the knowledge sharing in a cross-functional team (tangible and intangible incentives);

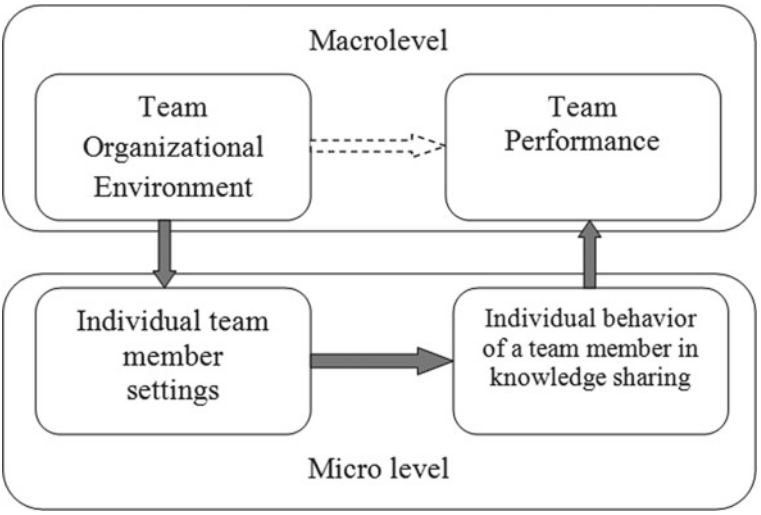

Fig. 2 The concept of an approach to knowledge management for a cross-functional team

- Providing opportunities for the knowledge sharing in a cross-functional team;
- Developing the ability to share knowledge among members of a cross-functional team.

Regarding the individual attitudes of the participants of the cross-functional team, it is appropriate to pay attention to the theory of social exchange proposed by Peter Michael Blau (P. M. Blau). The theory of P. M. Blau establishes the laws of exchange between participants in social relations [36]. According to P. M. Blau, if the exchange of values between people is mutually beneficial, then the relations between the parties are strengthened, otherwise the relations are weakened. With regard to group activities, the theory of social exchange establishes that the attractiveness of participation in a group for a person is determined by the degree of reward that he can receive. Accordingly, the more rewards individuals exchanged with each other, the greater the likelihood of subsequent acts of exchange, including due to the establishment of mutual obligations.

3.4 Barriers to Knowledge Sharing in a Cross-Functional Team

Barriers of different nature and hierarchical levels may arise on the path to the transfer and acceptance of knowledge within cross-functional teams of concurrent engineering. Currently, a large amount of scientific research has been accumulated in the field of barriers to the knowledge sharing, including in project teams. Analysing existing sources that classify barriers to knowledge sharing, we present a summary table of classifications of groups of barriers to knowledge sharing (Table 2), compiled on the basis of [37–44].

As you can see, in the process of developing the company's absorption ability and sharing knowledge in a cross-functional team, barriers of different nature, character and level may arise. Overcoming the barriers that have arisen requires proper analysis, timely identification and management decisions, including the use of coordination mechanisms that facilitate effective interaction between CFT participants and, as a result, the effective knowledge sharing and the development of the absorption ability of the company as a whole.

4 Mechanisms of Coordination and Their Influence on the Knowledge Sharing in a Cross-Functional Team

Central to enterprise management functions is coordination. Structurally, coordination can be defined as ensuring the coherence of the work of all parts of the control system, i.e. coordination ensures the integrity and sustainability of the organization.

Table 2 Summary table of classifications of groups of barriers to knowledge sharing

Classification sign	Barrier groups	Description of the barrier group
Hierarchical	Interorganizational	Associated with company interactions
	Organizational	Relate to the features of the organizational structure of the company, including the absorption ability of the company
	Team	The factors that determine the team within which knowledge is exchanged are combined: the level of trust, the strength of team identity, the nature of established communication
	Personal	Associated with intrapersonal beliefs, relationships between people, their culture
By nature of the barrier-forming factor	Information technology	Associated with the characteristics of information and technology infrastructure supporting the knowledge sharing in an organization
	Organizational and management	Associated with the management practices used in the organization, which are used to coordinate organizational processes and are in the control and influence of managers
	Corporate	Combine the barriers associated with the organizational features of the company, relatively independent of management, including age, company size, etc.s
	Economic	Associated with the value of knowledge as an economic resource and a source of economic benefit
	Personal	Associated with psychological traits of knowledge sharing participants
By the source of the barrier	Knowledge donation barriers	Associated with bringing knowledge to the knowledge-sharing medium
	Recipient barriers	Associated with the collection of knowledge among colleagues

Depending on the nature of coordination, it is customary to distinguish between preventive (preventive) and permanent (on-line), the characteristics of each are given in Table 3, compiled on the basis of the analysis [45–48].

Preventive coordination is based on the formation of constraints through standardization and regulation, or, in other words, formalization. Formalization can include standardization of jobs, standardization of graduation, standardization of knowledge,

Table 3 Classification of coordination of coordination mechanisms

Type of coordination	Coordination function	Coordination mechanisms
Preventive	Performs a warning function	Formalization
Permanent	Performs real-time eliminating, regulating and stimulating functions	Direct control
		Mutual agreement
		Group coordination

skills of an employee, all that implies "programmed impersonal coordination". This type of coordination includes all kinds of instructions that prescribe the decision procedures in a particular situation, job descriptions, and rules. Formalization allows you to narrow the set of known or permissible relationships, thereby speeding up the process of overcoming the problem situation.

The type of coordination "direct control" or individual coordination implies the presence of a coordinating leader. The role of the coordinator in presenting the goals and objectives facing the employees, team, group, unit, that is, its purpose is to inform and directly monitor the implementation. In a cross-functional team, the coordinator is the project manager, team leader or senior management representative who coordinates the team. This type of coordination involves building vertical links, that is, a clear hierarchical structure.

"Informal non-programmed coordination" or mutual coordination is carried out voluntarily, informally, without prior planning. In this case, control over the work is carried out by the employees themselves. The conditions for this type of coordination are an understanding of their tasks and tasks and the team, the employee feels part of the team and considers the tasks facing the team his own. The basis of the "mutual coordination" mechanism is informal communication between team members.

The type of coordination "direct control" and "mutual coordination" are based on communication and ensure the movement of information inside hierarchical levels, thereby expanding the set of well-known connections at the horizontal level, creating horizontal relationships.

Group coordination involves discussion and decision-making on coordination issues at special regular meetings and commissions. It brings together the leaders of different departments, providing a knowledge sharing, decisions are made regarding different teams, departments and units. This type of coordination strengthens horizontal relationships within the company at different hierarchical levels. This type of coordination allows you to create and strengthen a common vision of the situation and strategic goals of the company among the heads of CFT and structural units, as well as the role of each team and unit in achieving these goals. In the future, an understanding of the goals of the company and a common vision is transmitted by managers in their teams and divisions.

The main coordination mechanism of a cross-functional team is individual coordination. Individual coordination is carried out by the activities of the team leader—the project manager. He is the link between the team and senior management of the company, and also participates in the internal processes of the team, coordinating the

development of an innovative product. Individual coordination can also be implemented with the help of a senior management representative who oversees a specific project and is sometimes called the project supervisor. In addition to coordinating the work of the team, he performs an important function of "protecting" his team at the level of senior managers, creating a sense of security among team members.

At the same time, informal non-programmable coordination in the form of mutual coordination operates within the cross-functional team.

Informal coordination is based on the understanding that exists between team members and common attitudes. Starting to participate in a cross-functional team, a person shares the goals of the team, understands his tasks and the tasks of the team, feels himself part of the team, i.e. goes through the stage of forming a common vision.

As noted above, informal relationships are an ideal platform for interaction within a cross-functional team. Informal relationships include interpersonal relationships with other team members and colleagues that are not regulated by instructions, regulations, and rules, but only by ethical standards.

Solving the problem of creating and strengthening informal ties in a cross-functional team, the project manager focuses on the formation of rational ties between participants, i.e. based on understanding and acceptance of common attitudes, life experience, values.

Analyzing the possibility of using formalization as a mechanism for coordinating cross-functional teams, we note that the specifics of this type of coordination are not consistent with the very idea of concurrent engineering. In fact, formalization can be limitedly applied at the stage of formation of cross-functional teams as a standardization of skills and knowledge (qualifications) of prospective team members, as well as, in accordance with the above model of creating organizational knowledge, I. Nonaka and H. Takeuchi, at the stage of disseminating new knowledge and his transition from CFT to the level of organization.

Also, an important place in the activities of cross-functional teams is occupied by horizontal relations with other departments and teams operating within the organization. Undoubtedly, a cross-functional team, working on a specific project, remains within the company and lateral relations between team members and other company employees can be useful in the process of exchange, accumulation and dissemination of knowledge.

Various coordination mechanisms operate throughout the functioning of the team and affect the emerging states, both individual and team, on the interaction between team members, as well as on the results of the team. Conceptually, the impact of coordination mechanisms on cross-functional interaction can be represented in the form of a model (Fig. 3). The proposed model uses the input-intermediary-output-input (IMOI) structure proposed by [49], which depicts teams as complex adaptive systems. This model represents cross-functional interaction as a dynamic system, taking into account the constantly changing state of both participants and the team as a whole.

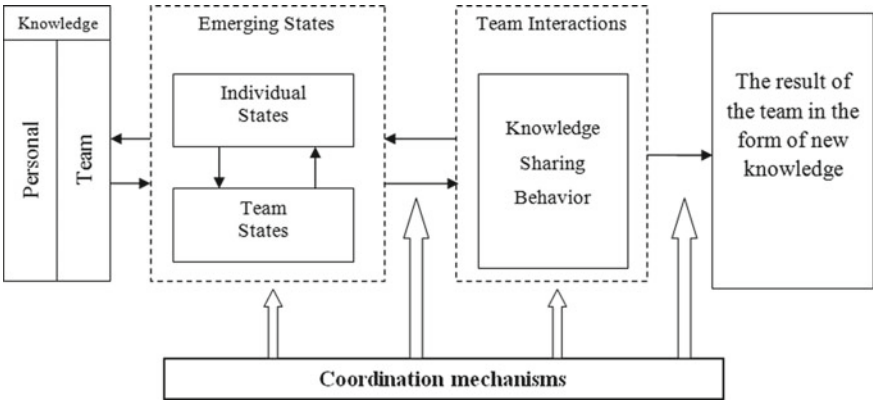

Fig. 3 Model of cross-functional interaction

Personal or individual condition includes the psychological state of the participant, formed as a result of participation in a cross-functional team. For example, a sense of belonging, an understanding of their role in the team.

Team condition involves the formation of a common mental model of the team, a common vision. For example, the clear goals of the team, as well as the norms and procedures in place in the team to ensure the achievement of the goal. Individual and team states continuously interact, influencing each other. Coming to the team, each new member has his own experience in the profession and relationships in the team. Interaction with other team members and reflection on progress are examples of actions that can help clarify roles, create a sense of belonging, while at the same time, this interaction helps to achieve clarity regarding the goals, norms and procedures of the team. In this case, the emerging states (personal and team) form interaction within the team, namely the behavior of team members in the knowledge sharing and overcoming the boundaries of knowledge discussed above. Accordingly, the interaction within the team affects the emerging states (individual and team). As a result, the behavior of team members in the process of knowledge sharing allows you to get the result in the form of new knowledge.

All processes occurring in a cross-functional team are coordinated by various mechanisms: formalization, direct control, mutual agreement and group coordination. Each type of coordination brings its own specifics to the work of a cross-functional team, acting on the emerging conditions of the participants, the team as a whole, the behavior of participants in the process of knowledge exchange and the formation of the result of the team's work—new knowledge, and therefore the development of the company's absorbing ability. For further study, it is interesting to annotate the effect of each coordination mechanism on knowledge sharing—on the individual intensity and activity of knowledge sharing, as well as on the development of absorption ability.

5 Conclusion

The use of cross-functional teams in the development of innovative products and services has a potential that can be revealed precisely in the context of digitalization and the establishment of Work 4.0, thereby ensuring companies achieve a sustainable competitive advantage in the market.

The purpose of the article was to increase understanding of the features of the activity of cross-functional teams of concurrent engineering and their role in shaping the absorption ability of the company. The results of the theoretical study allow us to determine that cross-functional teams are built on the principles of adhocracy and have the following features:

1. The goal of cross-functional teams are innovative developments.
2. Cross-functional teams are limited in time by the horizon of project planning, i.e. they are temporary.
3. Cross-functional teams operate in a complex, dynamic environment.
4. Professionals with special education and skills that are the basis for further development and creation of new knowledge are involved in the teams.

Of course, due to the fact that the object of activity of cross-functional teams is new knowledge, which will later be transformed into an innovative product, the type of teams under consideration can be called the basis for the development of the company's absorbing ability. The creation of new knowledge is based on an effective knowledge sharing. Therefore, the identified features impose certain requirements on the methods of managing interfunctional teams, especially in terms of coordination, in order to form an effective knowledge sharing in a team and build effective horizontal relationships.

It is proposed to determine the degree of influence of various coordination mechanisms on the knowledge sharing in cross-functional teams as a promising area for further research. It is proposed that this will enable the development of effective knowledge management strategies for companies using cross-functional concurrent engineering teams to develop innovative products.

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Adaptation or Protest: Evaluation of the Employees Sentiments Under Labour Market Transformation

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Abstract The possible behaviour patterns of employees in various professional spheres in the situation of proposed changes in labour relations connected with robotics and the digital economy are analyzed in the issue. Employee behaviour is considered as the determining factor in the performance of the "lagged effect" due to which a reduction in labour demand does not automatically lead to a reduction in employment. Authors' conclusions are based on the results of a sociological poll of 3000 respondents from various sectors of employment in the industrial region of Russia—the Sverdlovsk Region.The results of the research show that uncertainty and protest sentiments prevail among the community of professionals; paternalistic sentiments are strong enough; adaptation strategies—readiness for retraining and re-skilling—are among the outsiders. The sentiments of uncertainty are mostly represented among employees in the industry, social sector and government. Protest sentiments are mostly expressed among the business community. Students—potential participants of the labour market—feel more prepared for adaptation and retraining. The adaptational potential manifested itself slightly higher among the employed population—employees of medium and large business structures and authorities. Migration sentiments are poorly expressed, except for students and private entrepreneurs. The results show a weak level of awareness among the community of professionals about upcoming changes in the content of

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the digital employee labour. The authors emphasize the need to popularize the adaptation strategy in society as the adequate response of employees to the upcoming transformation of the labour market.

Keywords Labour market transformation · Digital economy · Employee behaviour patterns · Protest sentiments · Readiness for development · New career model

1 Introduction

"The second century of machines"; "digital era" [1], "fourth industrial revolution" ("industry 4.0") should be noted as being the main trends in the development of modern society [2]. A variety of technological and technical changes, automation, and robotics, the implementation of artificial intelligence soon will radically change human life, have a significant impact on employment processes, regulation of the labour market, and lead to a significant reduction in demand for labour.

Scholars point out that the "labour market", in contrast to the "product market", responds accurately to changes in supply and demand. The so-called "lagged effect" operates here, when the reduction in demand for labour force does not automatically lead to a reduction in personnel. The unions that protect the right of an employee to work; the policy of a state interested in maintaining social stability; commitments of an employer to its employees (social contract, "collective employment agreement"); finally, the adaptational potential of an employee will be able to play the role of the damper (constraining factor).

Can we predict today the behaviour strategies of wage earners in a situation of the inevitable transformation of employment? How can one measure the adaptational potential of a modern employee, his readiness for change and development, or vice versa, his protest potential [3], and "counterproductive behaviour" in relation to activities [4]? To what extent do employees today realize the prospect of change, understand the need to adjust their path of professional growth in order to maintain a place in the labour market?

Research hypothesis: the economically active population of the industrial region of Russia (the Sverdlovsk region) is poorly aware of the threat to lose their jobs in the situation of informatization and robotization, believing that these modernization processes in Russia are a matter of the distant future; paternalistic sentiments of employees are preserved, a wait-and-see attitude dominates, the awareness of the need to adjust their labor skills in the context of the upcoming transformation of the labour market is weak.

The purpose of the article is to analyze the adaptational potential (readiness for change) and the level of protest sentiments among employees in various areas of economic activity of a vast industrial region of Russia—the Sverdlovsk Region in a situation of threatening changes in employment under the conditions of economy digitalization.

Research objectives: to find out the extent to which representatives of various professional groups—current and potential participants in the labour market—are informed about upcoming changes in the employment structure in their organization; to identify the range of sentiments, to predict behaviour patterns of various professional groups in a situation of threat of employment loss and changes in the socio-economic situation in their municipality.

2 Literature Review

Analysts predict scenarios of labour market transformation when artificial intelligence and new technologies become part of our everyday life [5–7]: up to a third of jobs can be replaced by robots. In our opinion, those forecasts that consider the "lagged effect" when analyzing the transformation of the labour market in the context of digitalization are of the most significant interest today. McKinsey experts note in their report "Jobs Lost, Jobs Gained: Workforce Transitions in a Time of Automation": "About half of all types of activities worldwide have the potential for automation, but the proportion of actually reduced jobs by 2030 is likely will be lowered due to technical, economic and social factors" [8]. Countries with developed economies are more under the influence of automation than developing countries etc. By 2030 between 75 and 375 million employees (from 3 to 14 percent of the global labor force) will be constrained to retrain.

Upcoming changes will require an employee to be ready for changes, to acquire new skills [9]. Scholars note that the traditional career model, in which people have been studying for the first 20 years of their lives and have been working for the remaining 40–50 years, will change due to robotization [10]. They will have to learn new skills throughout their professional activities [11]. Nature [12], the structure [13], the organization and content of labour [14, 15], labour requirements [16] will change significantly.

The processes of adaptation of an employee to organizational changes are investigated in the framework of behavioural sociology. Various aspects of employee behavioural strategies are considered: problems of informing employees about occupational safety hazards, employee behavioural reactions to information received [17], the problem of conflicting expectations of various participants in labour relations, the risks of self-deception in public relations [18]; the need for a theoretical and empirical analysis of the behavior of not only an employee but also an employer in a recruiting situation is pointed out [19]; the influence of mentality on human behavioural reactions in society [20]; stereotypes of behaviour of a Russian employee and a low level of occupational mobility [21], the relationship between job insecurity and counterproductive behaviour of an employee is considered [22].

However, theoretical gaps are observed in literature: there is almost no analysis of the adaptational potential of employees, forecasting the behavioural strategies of employees in a situation of the threat of losing their usual jobs in a digital economy. The results of an empirical study of the sentiments and expectations of employees in the industrial region of Russia presented in this research are intended to contribute to solving this problem.

3 Research Methodology

The empirical background of the article is the results of the sociological poll "Behavioural strategies of the population of the Sverdlovsk Region in the context of changes in the labour market", conducted with the participation of the authoring team in the Ural Institute of Management—Branch of the Russian Presidential Academy of National Economy and Public Administration in May 2018.

The total number of respondents is 3000. The questionnaire-based survey was conducted personally by interviewers in various types of cities of the Sverdlovsk region. The sampling is represented by different kinds of cities in the Sverdlovsk region: a million city (population over 1 million people); a large city (population from 250 to 500 thousand people); a city (population from 10 to 250 thousand people); a small city (from 50 to 100 thousand people); a large town (population up to 50 thousand people). The sample is as follows: in a million city, in Ekaterinburg—1100 respondents; in a large city, in Nizhny Tagil—400 respondents; in a city, in Kamensk-Uralsky—360 respondents; in small cities, in Serov—300, Berezovsky—180, Verkhnyaya Pyshma—200 respondents; in large towns, in Irbit and Irbitsky district—180, Aramil—80, Kachkanar—140, Kirovograd—60 respondents (see Table 1).

The questionnaire-based survey was conducted among representatives of various professional spheres (see Table 2) personally by interviewers at respondents' place of work or study.

40.5% are factory workers. The opinion poll was held at enterprises included in the list of innovative enterprises of the Sverdlovsk Region: Uralvagonzavod, Ural Mining and Metallurgical Company, Uralelectromed (an enterprise of the UMMC holding), as well as at Mashprom, Serov Mechanical Plant, Kachkanarsky Mining and Processing Plant, Kamensk-Uralsky Metallurgical Plant, Irbitsky Dairy Plant, Monetary Crushed Stone Plant.

20.2%—employees of social sector (education, healthcare, job centers, etc.): employment agencies—employment department in the Oktyabrsky district of SPI Ekaterinburg Employment Office, employment department in the Verkh-Isetsky district of SPI Ekaterinburg Employment Office, employment centers of Nizhny Tagil, Serov, Irbit, Berezovsky, Kachkanar; healthcare organizations of Ekaterinburg, Serov, Verkhnyaya Pyshma, Kamensk-Uralsky, Irbit, Berezovsky; employees of educational institutions—schools in Ekaterinburg, Kachkanar, Aramil, child (teenage) center Edelweiss in Serov, professors, and employees of higher education

Table 1 Characteristics of the research geography

Types of the Sverdlovsk region cities	Cities of the Sverdlovsk region	Number of respondents (people)	Percentage of the total number of respondents
A million city	Ekaterinburg	1100	36.7
A large city	Nizhny Tagil	400	13.2
A city	Kamensk-Uralsky	360	12.0
Small cities	Serov	300	10.0
	Berezovsky	180	6.0
	Verkhnyaya Pyshma	200	6.7
Large towns	Irbit	180	6.0
	Aramil	80	2.7
	Kachkanar	140	4.7
	Kirovograd	60	2.0
Total		3000	100%

Table 2 Professional occupation of the respondents

Professional sphere of the respondents	Number of respondents	Percentage of the total number of respondents
Enterprises	1215	40.5
Social sector (education, healthcare, job centers, etc.)	606	20.2
Public agencies	480	16
Small businesses	129	4.3
Large and medium businesses	279	9.3
Students (future participants of labor relations)	285	9.5
Total	3000	100

institutions—the Ural Federal University, the Ural Institute of Management—Branch of the Russian Presidential Academy of National Economy and Public Administration, the Ural State Mining University, the Ural State Vocational Pedagogical University.

16%—public servants and municipal employees: the Sverdlovsk Region Government, the Department of Labour and Employment of the Sverdlovsk Region, the Ministry of Education and Youth of the Sverdlovsk Region, the municipal administrations of the urban districts of Irbit, Serov, the Departments of Youth Policy of Serov and Berezovsky.

Representatives of small businesses—4.5%, medium, and large businesses—9.3% (at the request of the respondents, the organization names are specified).

Students (as future participants of labour relations) made up 9.5% of the respondents (students of the Ural Federal University, the Ural Institute of Management—Branch of the Russian Presidential Academy of National Economy and Public Administration, the Ural State Mining University, the Ural State Vocational and Pedagogical University and the Ural State University of Railway Transport).

The presented characteristics of the respondents allow us to single out the range of opinions of various social and professional groups of the economically active population of the region.

4 Results and Discussion

It should be emphasized that in the context of the upcoming transformation of employment, a job becomes a privilege. To what extent do employees realize today the prospect of change, understand the need to modify their path of career growth in order to maintain a place in the labour market?

What is the degree of openness in communication between management and employees? Is it customary to inform the personnel about upcoming organizational changes? We got the following results having grouped the answers of the respondents to the question: "Do you know what changes your organization will encounter in the context of digitalization?" in terms of being kept informed (see Table 3).

The presented data indicate a closed management policy relating to staff awareness of upcoming organizational changes. Only about a quarter of employees (27%) are

Table 3 The degree to which employees are aware of the changes that the organization will encounter in the context of digitalization (percentage of the respondents)

Answer options	Percentage of the respondents	Level of awareness distribution
Informed		
Management often talks about it	12.8	27
I am informed of all the difficulties that the organization encounters	14.2	
Not informed		
No, they do not tell me about it	19.3	73
It does not interest me, and these are the problems of senior management	6	
I only know what I deal within the line of duty	28.5	
Neither agree nor disagree	10	
No answer	9.2	

aware of possible problems in the organization to some extent: 14.2% "are informed of all the difficulties that the organization encounters", another 12.8% heard about trends, because "management often talks about it".

Most employees do not yet suspect how the upcoming digitalization can affect their professional activities. More than half of the respondents are not at all aware of any problems facing their organization: 19.3% said that "they are not informed about it", 28.6% were engaged in current job duties, without thinking of what was happening in the professional occupation ("I only know what I encounter in the course of my official duties"); 6% are not at all interested in the organization's problems, believing that this will not affect their employment ("I do not care, these are the problems of senior management"). We add here two groups of the respondents who either refused to answer (9.2%) or found it difficult to answer (10%), and the total number of the respondents uninformed about upcoming changes will be 73%.

Thus, it is possible to conclude a low degree of personnel involvement in the threatening problems of labour relations restructuring in the context of digitalization.

Which occupational groups are more adjusted to a situation of a threatening transformation of the labour market? A comparative analysis of the answers of respondents from various sectors of employment to the question, "Do you know what changes your organization will encounter in the context of digitalization?" is shown in Table 4.

The most informed today are representatives of small businesses (the total number in the informed group was 37.2%), social sector employees (34.2%), medium and large businesses (31.7%). Incredible as it may seem, public servants and municipal employees (28%), along with the dominant sphere in the region—industrial employees (27.5%) are less concerned about the proposed upcoming changes in the structure of employment. The future participants of labour relations—students—turned out to be the most "careless" group, who are least informed of the problems of labour market transformation.

However, the upcoming changes in labour relations under the conditions of digitalization will inevitably lead to a reduction of staff, a transfer to job flexibility, and, therefore, to a worse state of some employees' finances. What actions are employees ready to take in order not to fall into the number of "rogue" employment, victims of staff reductions?

To consider the readiness of labour market entities for various forms of adaptation or social protest, the respondents were asked to answer the question: "What actions are you ready to take, if the social and economic situation in your organization suddenly changes, your financial situation takes a turn for the worse?" (see Table 5).

Only 14% of employees today are ready to take responsibility for their fate and career, express their willingness to change professional skills, to search for a new job—an adaptation strategy.

A group of respondents inclined to protest (27%) was singled out. Of these, one in ten is ready to participate in authorized rallies. A more radical group is ready to take part in strikes in the event of a sharp deterioration of their financial situation—8%, and another 9% will limit themselves to criticism on social media.

Table 4 The degree to which employees are aware of the changes that the organization will encounter in the context of digitalization (percentage of the respondents)

	Industry	Social sector	Authorities	Small businesses	Medium and large businesses	Students
Informed						
Management often talks about it	15.8	14.4	9	19.7	9.2	5.2
I am informed of all the difficulties that the organization encounters	11.7	19.8	19	17.5	22.5	8.6
Total number in the "informed" group	27.5	34.2	28	37.2	31.7	13.8
Not informed						
No, they do not tell me about it	17	21.2	19.7	8	16.9	28.8
It does not interest me, and these are the problems of senior management	5	6.4	4	8.8	9.2	6.4
I only know what I deal within the line of duty	32.3	30	34	27	33.5	11.6
Neither agree nor disagree	13	3.5	7.5	6.5	5.5	12.4
No answer	5.2	4.7	6.8	12.5	3.2	27
Total number in the "uninformed" group	72.5	65.8	72	62.8	68.3	86.2

If the social and economic situation in the country changes, 8% declare their intentions to leave the country—migration sentiments.

Every fifth respondent (19%) does not intend to take any active actions, relies on the situation, demonstrating paternalistic expectations that are customary to Russians—"the authorities know better, the state will not leave in danger"—a demonstration of passivity.

Table 5 Forecasting of respondents' behaviour in the situation of upcoming employment changes (percentage of the respondents)

Actions	Percentage of the respondents	Analysis of the sentiments
I shall not perform any self-activities, everything will be regulated by the senior management	19	Passivity
I shall look for another job, change my occupation	14	Adaptation
I shall participate in authorized protest rallies	10	Readiness to protest 27
I shall criticize authorities on social networking websites	9	
I shall take part in strikes	8	
I shall leave the country	8	Migration
Neither agree nor disagree	24	Uncertainty
Your option	8	Your option

Every fourth respondent was undecided—a demonstration of uncertainty.

Among the respondents who chose "their answer option" in the event of a worsening financial situation, we can single out:

– strategies that specify options for social and occupational mobility: "I shall set up my own business", "I shall seek a higher-paying job";
– the Soviet model of the population "survival": "I shall focus on agriculture, livestock business", "cultivating food products in the garden", "I shall pick mushrooms, berries";
– behavioural patterns that are not related to labour activity: "to go to church more often and pray at home, at work, everywhere" or just cut costs "I shall spend less".

Thus, a critical attitude towards upcoming changes in employment prevails among employees, but the protest attitude is expressed, first, in readiness to participate in rallies or criticism on social media. Paternalistic sentiments, the hope for "wisdom of executive staff" that will solve all the problems are strong enough. Only a small part of the respondents demonstrates their readiness for retraining and re-skilling.

What behavioural patterns prevail in different occupational groups? A comparative analysis of the answers by the respondents of various occupational groups to the question "What actions are you ready to take, if the social and economic situation in your organization suddenly changes, your financial situation takes a turn for the worse?" was carried out (see Table 6).

The ranking of priority behaviours in various occupational groups is as follows (see Table 6).

Protest sentiments are most clearly expressed among the business community (40% of private entrepreneurs and 36% of medium and large business employees versus a quarter in other groups and a fifth of students).

Table 6 The attitude of the respondents from various occupational groups to upcoming changes in employment (percentage of the respondents)

	Industry	Social sector	Authorities	Small businesses	Medium and large businesses	Students
Passivity	19	20	17	14	21	23
Adaptation	12	12	16	10	15	21
Readiness to protest	24	23	24	40	36	20
Migration sentiments	5	3	3	14	8	17
Uncertainty	31	32	30	14	14	10
Your option Other	9	10	10	8	6	9
Total (%)	100	100	100	100	100	100

Effective adaptation strategies are demonstrated, first, by potential participants of the labour market—students (21%), while their migration sentiments are the strongest (17%). The adaptation potential manifested itself slightly higher among the employed population—employees of medium and large business structures (15%) and authorities (16%).

Migration sentiments among current participants in the labour process are poorly expressed: apart from the students noted above, the position of private entrepreneurs stands out—14% of them intend to apply their entrepreneurial abilities outside Russia.

5 Conclusion

The presented results of the survey made it possible to confirm the hypothesis of the research as a whole: current and potential participants in labour relations demonstrate poor readiness for imminent changes in the employment structure. Most employees do not really think about how the upcoming digitalization can affect their professional activities. The least informed were the potential participants in labour relations—the student community, the more informed—business representatives and employees of social sector. The researchers were unpleasantly impressed by the lack of awareness of employees of central and local public authorities in a situation when the Government of the Russian Federation enacted the national program "Digital Economy of the Russian Federation" and "Interindustry strategy for the development of labour market conditions and employment of the population of the Sverdlovsk Region for the period until 2035".

Not surprisingly, in this situation the willingness to use an adaptation strategy, expressed in the ability to social and professional mobility and the acquirement of new

skills is weakly expressed. The exception was made by potential participants in the labour market—students and small business, but their adaptation is mostly associated with the manifestation of migration sentiments. Adaptational potential slightly above average found expression among employees of medium and large business structures and public authorities. Representatives of these areas of the employed population are more prepared for changes in their labour behaviour than others.

There are strong hopes for a "good will of the state" among the employed population of Russia, which will not offend the working people. The protest sentiment is limited mainly by the willingness to participate in rallies or criticism on social networks. While the protest sentiment is demonstrated, first, by the business community and students.

Obviously, the implementation of the strategic goals related to the digital economy requires focusing effort to popularize the threatening transformation of the labour market in the society, create a sentiment for readiness to change, constant retraining and re-skilling. It is the flexible behavioural strategy of the employee that can become an essential factor in the smooth transition of the society to the new realities of employment in a digital economy.

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The Role of Digitalization in the Solution of Problems of Employment of Labor and Student Migration

Elena Gasparovich and Elizaveta Kotova

Abstract The current stage of development of society is characterized by the need for digitalization of the political, economic and social life, as one of the essential conditions for this development. Informatization of society is not enough to ensure the necessary pace of development. In this regard, society estimated the need for digitalization of development processes. The topic of digitalization concerns all spheres of human life, and its influence can especially be traced in the spheres affected by globalization, among which the labor sphere and the sphere of education which interest us. One of the indicators of globalization in these areas is labor and student migration. At the present time in Russia there is a trend of increasing numbers of foreign migrants. Globalization and digitalization are necessary, and are also able to accelerate the pace of socio-economic development of Russia. Due to the fact that the quantitative and qualitative needs of the labor market often remain unsatisfied, the flow of migrants is able to partially satisfy these needs. However, in the process of employment, migrants face various kinds of problems. The article reveals the content and essence of the basic concepts. In addition, the article discusses the problems and difficulties in finding employment in this field that are encountered by both labor and student migrants. The article contains the results of studies. The article describes the negative outcomes and consequences that lead to difficulties in finding jobs for migrants in Russia, as well as possible solutions of these problems through digitalization.

Keywords Digitalization · Labor migration · Student migration · Professional mobility · Foreign citizen · Employment

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1 Introduction

The relevance of research in the study of the problems of migrant employment is dictated by modern socio-political and socio-economic trends that have developed in the world during the historical period of the first half of the twenty-first century. The problem of employment of student and labor migrants is significant for the Russian Federation. Improving the quality of the population by using the digitalization potential of the socio-cultural and economic spheres of its life and its inclusion in strategies and programs of socio-economic development is one of the promising areas of research in the Russian economy and human resource management. Migration processes took place in all periods of Russia's history, and they still occur today. However, according to Rosstat, Russia has seen a steady increase in the number of immigrants since 2004. In recent years, due to the political, economic and social situation in the world, the number of migrants has increased significantly. According to the UN, there are 258 million international migrants in the world in 2018. Since Russia for many reasons has always been of interest to migrants entering for different purposes, including student and labor, the problem of employment of student and labor migrants remains relevant for a long time. Currently, in Russia, due to the complex demographic situation that negatively affects the economy of the state, special attention is paid to the issue of employment of student and labor migrants. The legal framework is being developed, for example, the draft Federal law No. 831695–7 "on amendments to the Federal law "on the legal status of foreign citizens in the Russian Federation" (in order to simplify the procedure for employment in the Russian Federation of students in Russian professional educational organizations and educational institutions of higher education of foreign citizens and stateless persons)" (as amended by the State Duma of the Federal Assembly of the Russian Federation on 07.11.2019). According to the proposed changes, the situation with the employment of student migrants will change in the near future. The changes may affect students who study full-time at Universities that have state accreditation, and who work in their free time. This way, it will become easier for the employer to employ foreign students, namely, to do so without obtaining a work permit.

The purpose of this study is to identify the role of digitalization in solving the problems of employment of student and labor migrants in Russia. The hypothesis is that digitalization and the process of employment of students and labor migrants are interconnected with each other, and digitalization is an effective tool in solving the problems of employment of student and labor migrants.

Research methods are: theoretical (analysis, generalization of scientific and legal literature on the research problem); practical: survey, interviewing.

The structure of the article includes: Introduction with an indication of relevance, theoretical validity and legal security of the article. Materials and Methods with a description of the main directions of research and statistical data on the research problem. Results of research and Discussion on the problems of foreign citizens in employment in the Russian Federation. Conclusion based on the study.

The degree of theoretical and practical elaboration of the problem. The research is based on the study of world legal norms that include the fundamental conventions: Migration for Employment Convention (Revised) 1949 (No. 97), Migrant Workers (Supplementary Provisions) Convention, 1975 (No. 143), Domestic Workers Convention, 2011 (No. 189). Other relevant documents include The Multilateral Framework on Labour migration (2006), and General principles and operational guidelines for fair recruitment and definition of recruitment fees and related costs (2016).

The search for Russian original ways to solve the problems of employment of student and labor migrants takes place in the conditions of digitalization of the Russian economy. Based on world experience, Russian scientists find a number of interesting answers. Nevraeva N. Yu. et al. considers the economic effect of student and labor migration (migrants with qualification and social parameters support the development of the country). Writing E. E. et al. conducting sociological research, notes the socio-economic effect (the inability of legal employment of student migrants damages the quality of education received, as well as generates risks of losses of the University associated with illegal labor activities of foreign students). Mitin D. N. et al. from the point of view of science emphasizes the correct migration policy can lead to economic progress and social prosperity (social-labor effect: depopulation destabilizie the situation on the labour market, which will lead to a decrease in the number of qualified personnel; economic impact: without the involvement of skilled migrants will slow the pace of economic growth and improved welfare of the population of Russia).

The novelty of the research is revealed in the study of the role of digitalization as a modern phenomenon in the Russian economy and its impact on solving actual problems of employment of student and labor migrants.

"Currently, the term "digitalization" is used in a narrow and broad meanings. The first one refers to the transformation of information into digital form, which in most cases leads to lower costs, new opportunities, and so on. Digitalization in the broad sense means modern global trend in the development of the economy and society, which is based on the conversion of information into digital form and leads to an increase in the efficiency of the economy and an improvement in the quality of life" [1].

"Digitalization has replaced informatization and computerization, when it was mainly about the use of computer technology, computers and information technology to solve specific economic problems" [1].

"The fundamental documents of the digital transformation of Russian society and the economy are the "Strategy for the Development of the Information Society in the Russian Federation for 2017–2030", approved by Decree of the President of the Russian Federation dated May 9, 2017 No. 2032, and the program "Digital Economy of the Russian Federation", adopted by order of the Government Of the Russian Federation dated July 28, 2017 No. 1632-p" [1].

The expanding possibilities of digitalization of the economy and society make it possible to actualize the problem of studying the role of digitalization in solving the problems of employment of student and labor migrants in the Russian Federation.

2 Materials and Methods

"Current trends in the field of migration in the Russian Federation are mainly determined by economic and social factors. A stable socio-economic situation, the preservation of historical and cultural ties between the peoples of the Commonwealth of Independent States, mutual visa-free travel, the establishment of the Eurasian Economic Union are powerful factors of the migration attractiveness of the Russian Federation" [2].

Statistics on the number of international migrants in the world according to the United Nations, UNHCR, ILO, UNESCO read out of 258 million international migrants, including: 150.3 million labor migrants, 4.8 million international students, 102.9 million children and the elderly. According to Rosstat data, 8.6 million citizens from other countries, mainly from the CIS countries, arrived in Russia in the first half of 2019. Thus, presently, Russia is of interest to immigrants crossing the border for various purposes. However, the most interesting for us are immigrants who enter for the purpose of study [3] and work. It should be noted that the largest part of migrants are labor migrants. Their share of the total number of those who crossed the Russian border is 51% [4]. This is due to the desire of world states to constantly accelerate the development of the economy which is inextricably linked with the exchange of labor resources. To this end, world states agree on a joint economic space, simplification or abolition of the visa regime, which involves the free exchange of labor resources. Russia is also included in this process. As an example, one can recall Russia's membership in the Eurasian Economic Union, one of the goals of which is to create a single labor market [5]. Studying the legal and regulatory framework in order to identify problems, search for employment solutions for student and labor migrants, we note that Russian legislation is based on international legal experience in these matters.

In theory and practice, the definition of "migration" (from the French. Migration, German. Migration) means resettlement, relocation (for example, of a population within a country or from one country to another) [6].

It is also necessary to give an example of a legal definition of "migration". "Migration" is a socio-legal phenomenon associated with the territorial movement of people across the borders of a country or its territorial-administrative units for various reasons, with the following change of their permanent place of residence or temporary stay, characterized by a combination of legal relations, usually involving acquisition, change or termination the legal status of a migrant" [7].

In Russia, there is a number of legislative acts regulating migration processes in the state, the main of which are the following:

1. Decree of the President of the Russian Federation of October 31, 2018 "On the Concept of the State Migration Policy of the Russian Federation for 2019–2025";
2. The Federal Law "On the Legal Status of Foreign Citizens in the Russian Federation" of 07.25.2002 [8];

3. The Federal Law "On Migration Registration of Foreign Citizens and Stateless Persons in the Russian Federation" dated July 18, 2006 [9];
4. The Federal Law "On the Procedure for Departure from the Russian Federation and Entry into the Russian Federation" of 08.15.1996 [10];
5. The Decree of the Government of the Russian Federation of January 15, 2007 "On the Procedure for the Migration Registration of Foreign Citizens and Stateless Persons in the Russian Federation" [11] and others.

In addition to labor migrants, the category we are interested in is student migrants.

"The serious attitude of the international community to student migration is evidenced by the fact that the WTO classifies education as a list of services that are regulated by the provisions of the General Agreement Trading Service: freedom of transnational movement of students and teachers, educational programs, educational institutions nationally and internationally, etc." [12].

According to statistical data provided by the Ministry of Internal Affairs of Russia in the period from January to June 2019 234,143 people indicated the purpose of their entry Russia to study, which is about 4% of the total number of people entering.

Training immigrants are recognized as the most desirable category of migrants. In addition, the concequences of the "demographic pit" of the 90s are still affecting Russian sociaty. The number of graduates of higher educational institutions does not satisfy the quantitative needs of the labor market.

In accordance with the statistics of the Ministry of Internal Affairs of Russia [4], Table 1 shows the numbers of labor and student migrants in various regions of Russia between January and June 2018 and 2019.

After analyzing the table, one can conclude that during the indicated period of time in all regions except the North Caucasus and Ural federal districts there is an increase in the number of labor migrants and in absolutely all regions of Russia there is an increase in the number of student migrants. It should be noted that, in general,

Table 1 Indicators of the number of labor and student migrants in various regions of Russia during the period January–June 2018 and 2019 [4]

Region	January–June 2019, people		January–June 2018, people		Growth, %	
	Work	Study	Work	Study	Work	Study
Total	2,895,117	234,143	2,676,500	187,232	8.16	25.05
Central Federal District	1,325,886	82,939	1,268,603	53,680	4.51	54.50
Northwestern Federal District	619,244	43,342	512,481	37,566	20.83	15.37
Southern Federal District	159,244	18,639	153,286	18,180	3.88	2.52
North Caucasus Federal District	35,777	4402	38,970	2961	−8.19	48.66
Volga Federal District	230,701	32,109	223,988	26,756	2.99	20.00
Ural Federal district	195,971	11,936	196,210	10,691	−0.12	11.64
Siberian Federal District	190,319	30,555	188,650	30,470	0.88	0.27
Far Eastern Federal District	137,975	10,221	94,312	6928	46.29	47.53

the increase in the number of student migrants in Russia is almost 17% higher than the increase in the number of labor migrants.

Due to the fact that most of the students receiving higher education in Russia plan to stay here after receiving a diploma for the purpose of employment, and some foreign citizens already working in Russia are graduates of Russian higher education institutions, the topics of labor and student migration are very closely interconnected.

Defining the role of digitalization in solving the problems of employment of student and labor migrants in the territory of the Russian Federation, two areas of research must be defined. The first direction is the potential of digitalization in solving the problems of migrant workers in the field of vocational education. The second direction is the role of digitalization in solving the problems of employment of student and labor migrants.

The first area of research. "Today we can say that digital technology is a unique mechanism for the diversified development of a modern higher educational institution. Due to digital technologies, we can confidently talk about the globalization of the scientific world and the active development of academic mobility.

A promising area of integration of higher education institutions in the international educational space is to attract foreign experts and students, open international campuses, and strengthen academic mobility programs for scientists and students" [13].

Thus, digitalization in education is becoming a kind of trend leading to its internationalization, which is inextricably linked with the processes of migration.

The second area of research. Digitalization in the labor world is also directly related to the processes of globalization. "Globalization is reflected in a number of economic and socio-political processes that determine global changes in the economic and political life of states. These changes also significantly affect the international labor market (ILM) [14].

"The background reasons for digitalization at the state level in Russia include: globalization of the economy; the functioning and the creation of new economic zones and a single economic space; active development of Internet technologies; the wide spread of mobile devices; deep integration into the life of social networks; the emergence of digital startups, with which the "traditional" and often conservative enterprises have to compete; understanding the need for digital transformation as a condition for survival in the digital space of global economies" [1]. It should be noted here that Russia is included in international standards, pursuing as its goal the implementation of a program to digitalize the economy. All these processes are inextricably linked with the labor migration flow, which includes both immigration and emigration.

Speaking specifically about the digitalization of work, it should be noted that "the direction and range of its influence covers the forms and processes of employment, all the characteristics of the labor market, the underlying bases of social and labor relations, organization of work" [15].

In addition, it is necessary to determine that at the intersection of student and labor migration there is the aim of obtaining a higher education with subsequent employment.

The study of the role of digitalization in addressing employment issues for student and labor migrants leads to the coverage of certain problems facing foreign citizens in employment in Russia.

The study was conducted in the territory of the Sverdlovsk region. The aim of the study was to determine the presence and nature of problems with the employment of migrants in Russia. The study was conducted in the form of a survey consisting of 12 questions (open and closed), one of which was a proposal to write one's comments regarding the employment of migrants in Russia. The survey method made it possible to identify the personal point of view of student migrants on the problem under study, and served to achieve the goal of the study, namely, to identify the role of digitalization in solving the problems of student migrants in Russia. Participants were asked to indicate the level of their education, the direction of training and the name of the university, answer the question about the difficulties associated with completing internships while studying in Russia, answer the question about the desire and attempts to find a job in Russia after graduation, the difficulties that accompanied the employment process, as well as indicate how realistic, in their opinion, is employment in Russia after graduation. The survey involved 144 people. All of the respondents graduated from undergraduate and graduate programs at various universities in Russia in various areas of training.

To the question "Have you encountered any problems completing studying practice as a part of the internships in Russia?" 43% of respondents answered "Yes", 57% answered "No", no one indicated "I didn't go through practice" as their answer.

To the question "Does digitalization help/make it difficult to solve the problems of student migrants in Russia?" 61.4% of respondents answered "Favours", 38.6% answered "Hinders".

To the question "What problems did you encounter during your practice?" a multiple answer option, 60% of respondents indicated that they faced such problems as the difficulty of finding a place for practice, and the same percentage of respondents indicated that they faced reluctance of employers to accept foreign students.

To the question "Do you want/did you want to find a job after graduation in Russia?" 71.4% of respondents answered "Yes", 28.6% answered "No". The question "Have you tried to find a job in Russia after receiving a diploma?" has the same percentage of answers.

To the question "How possible, in your opinion, is it to find a job in Russia after receiving a diploma?" 14.3% of respondents answered "Impossible", 28.6% of respondents answered "Very difficult (almost impossible)", 42.9% answered "Possible, if you make an effort".

To the question "In your opinion, are there any difficulties in hiring foreign citizens in Russia?" 85.7% of the respondents chose "Yes".

To the question "What difficulties did you encounter when finding employment in Russia after graduation?" with a multiple answer option, 83.3% of the espondents chose "Unwillingness of employers to hire a foreign citizen" as one of the answer options, 33.3%—lack of work experience, 16.7% also indicated such an answer option as "Difficulties with obtaining a work permit".

To the question "Did you manage to find a job in Russia? How easy is it?" 57.1% indicated "Failed" as their answer, 28.6% indicated "Success, but very hard".

Since respondents were also asked to leave their comments on the topic of the problems in free form, we received next comments. Respondents indicated that, after graduating from a university in Russia, the state does not give a work permit and does not extend a visa, which is necessary to gain work experience and conduct research in Russia. Respondents gave an example that after graduation, some countries give foreign citizens a residence permit for 3 or 5 years. In addition, the respondents who indicated the direction of preparation for "Industrial and civil construction" left a comment stating that after graduating from a university, finding jobs in Russian companies is simply impossible.

Since construction companies most often receive permission to attract foreign workers in Russia, we conducted an interview with the head of one of the Russian construction companies, LLC IRISTROY-Moscow. The company staff is 284 people. The share of foreign workers is about 90%. The head was asked questions about problems in the employment of foreign workers. The interviewing method made it possible to identify the personal point of view of the Manager on the problem under study, and served to achieve the goal of the study, namely, to identify the role of digitalization in solving the problems of employment of labor migrants in Russia. The main problems, the manager calls the largest, are time and financial costs of obtaining permits for staff. Personnel who require a visa to enter Russia and obtain a work permit expect to receive documents for one and a half to two months; personnel who do not need a visa, but need to obtain a patent for a job, are waiting for paperwork for 1–2 months; Citizens of the Eurasian Economic Union Member States expect documents for about 2 weeks. For this reason, the head says, especially in the absence of time, very often they have to sacrifice qualified foreign specialists in favor of specialists who are ready to get down to work right away though having an insufficient level of qualification.

3 Results and Discussion

The study of the role of digitalization in solving the problems of employment of student and labor migrants allowed to conduct a discussion, highlight a problem field in the issues of employment of student and labor migrants, to identify the role and possibilities of digitalization in solving these problems.

3.1 Problems of Foreign Citizens Employment in Russia

The first problem faced by migrants arriving in Russia is obtaining permits, which greatly complicates the process of employment. Foreign citizens cannot start working

without obtaining a work permit or patent. An exception is made for the citizens of member states of the Eurasian Economic Union.

The second problem concerns both foreign citizens wishing to find a job and employers themselves. These are large time expenses for paperwork, as well as bureaucratic red tape. For employers, this is fraught with financial costs associated in some cases with the payment of the cost of living and meals of their future employees, as well as with lost profits, and for the employees themselves—a decrease in motivation for employment.

It is necessary to specifically highlight the problem associated with the large financial paperwork costs for the employer. Here it is worth mentioning the need for additional medical examinations, translation of documents and their notarization, nostrification and more.

Another problem is that not all organizations have the right to hire foreign citizens, since the legislation of the Russian Federation implies that the employers, who want to hire foreigners of their own, must receive the permission to attract foreign labor, as well as the use of quotas to attract foreign labor. These requirements are put forward in order to protect the national labor market.

The process of employing foreign citizens in Russia is quite problematic. "As the results of sociological studies have shown, when answering questions about adaptation problems in Russia, foreign students put the impossibility of legal employment (23%) on the first place, the high cost of living in cities (14%) on the second, and poor living conditions on the third in hostels of universities or the absence of acceptable conditions in general (11%), on the fourth—the impossibility of frequent trips home, on the fifth—poor quality of medical care (7%) and on the sixth—the high cost of medical insurance (about 4%)" [16]. The quantitative data are shown (see Fig. 1).

The above-mentioned problems are characteristic of both labor migrants, since their initial purpose of entry is employment, and student migrants, since many of

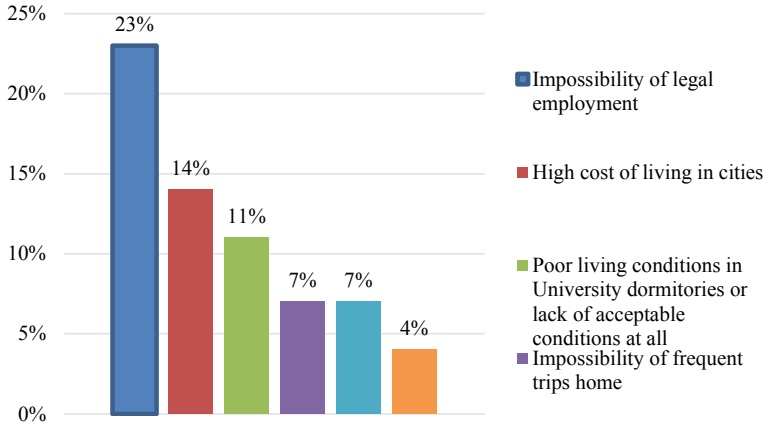

Fig. 1 Problems of adaptation in Russia

them, after graduation, have a desire to find work in Russia. However, during the training itself, student migrants also encounter problems specific to them.

3.2 Problems of Employment of Foreign Students in Russia

The first problem that is worth mentioning is the restriction provided by Russian law regarding the work of foreign students. They are given the opportunity to engage in labor activities without obtaining a work permit or patent only at a specific time, free from studies, which is also limited. In addition, foreign students have the right to find a job without a work permit or patent only in the institution of higher education in which they are studying. In other cases, they must receive permits for employment.

"At present, in the Russian Federation there is no special legal regulation that allows attracting foreign citizens studying in Russian educational institutions in the simplified procedure to carry out labor activities. There are no preferential conditions for foreign citizens—graduates who have graduated from higher education institutions in Russia, as well as those studying or completing postgraduate and doctoral studies. As a general rule, they are obliged to leave the territory of the Russian Federation after graduation" [17].

Foreign students in this context find themselves in a difficult situation: on the one hand, they have the desire to work and the need for their own income since the lack of scholarships, because "those categories of foreigners who need additional income to ensure a comfortable stay and study come to study" [14], and on the other hand, there is the lack of the possibility of legal employment.

Obviously, for this reason, according to the survey, 43% of foreign students want to work, but do not have the opportunity to work, and 29% do not work because they do not need to. However, "about 28% of foreign students have full-time jobs or work part-time. Obviously, this is due to the low level of scholarships, limited training opportunities on a budgetary basis, and high costs for food. Most international students work without formal work permits. Enterprises and organizations that lack specialists and are ready to accept them cannot register labor relations with foreign students through an employment contract. Many foreign students are forced to work by oral agreement, which significantly reduces the degree of their social protection" [18]. The quantitative data are shown (see Fig. 2).

"Limitations in additional earnings are fraught with the fact that the student cannot carry out practical activities, cannot take part in real business, scientific and research work. All these limitations do not provide an opportunity to improve the professional level and improve the quality of training. The simplification of the legislative system leads to the creation of special centers and laboratories, which in the end still offer students the opportunity to "part-time" " [18].

Another problem that student migrants face is the difficulty of completing internships during their studies. This is due to the fact that many employers are not willing or afraid to accept foreign students for internships. However, this is due to ignorance

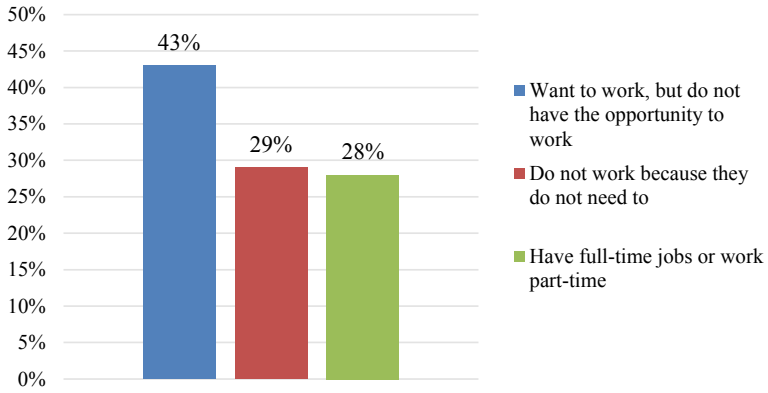

Fig. 2 Ratio of working and non-working foreign students

of the intricacies of Russian legislation, as well as for the reason that employers accept the practice for carrying out labor activities.

"In senior courses, many of the foreign students are forced to independently seek out practical training places that could later become their permanent place of work. Enterprises and organizations are ready to accept senior students at the time of practice *for paid work*, but this possibility is not provided by the Russian law. In general, many students say that the lack of obtaining Russian citizenship is a serious obstacle to finding a job in Russia. Many deliberately compromise between part-time employment and relatively low wages in order to combine work with study" [19].

The above problems lead to another. Due to the fact that during the training foreign students are not able to undergo practical training, as well as to find a job while receiving education, as Russian students can do, they are faced with a complete lack of work experience at the end of training. This significantly reduces the level of their competitiveness and leads to additional difficulties in subsequent employment in Russia.

4 Conclusion

The results of the study of the problems of employment of student and labor migrants in Russia and the emphasis on the role of digitalization in their solution allows us to draw the following conclusions.

1. The role of digitalization in solving the problems of employment of student and labor migrants is relevant for the world economic practice in General, and for Russia in particular. At the moment, the developed theoretical framework and legal support partially allow us to solve both problems, but work in this direction should be actively continued in the current dynamic socio-economic situation in Russia.

2. The research materials obtained based on the use of theoretical (analysis, generalization of scientific and legal literature on the problem of follow-up) and practical (survey, interviewing) methods allowed us to reveal some negative and positive aspects in solving the studied question.
3. *When summarizing the study of the problems of employment of student and labor migrants in Russia, the following negative aspects are highlighted.*
The most serious negative outcome in the described situation is the leak of qualified personnel. Employers also face this problem, and this confirms the study. The problem of the diversion of qualified personnel is more relevant than ever, because the modern economy is striving to increase the pace of development, which becomes impossible without the development of research potential, which involves attracting highly qualified personnel. Another important problem in the case of student migrants is the loss of workers capable of quicker and easier adaptation. This is due to the fact that foreign students who have completed their studies in Russia have the experience of self-adaptation both at the university and in the student community, and in another country. It should also be mentioned here that migrants entering Russia decide on employment or study in Russia independently, they are result-oriented and aimed at achieving their goals, they are highly motivated. Employment problems for student and labor migrants lead to the loss of motivated personnel. The next problem is related to such a category of personnel as workers. "The specificity of the reality of Russia lies in the fact that in the country there is both a huge shortage of specialists of the highest category and a shortage of low-skilled workers in industries that are regarded by local residents as non-prestigious: with difficult working conditions, low salaries, and seasonality" [19]. Here again, it is necessary to recall such a modern phenomenon in Russia as the "qualification pit", which implies the presence of personnel with excessive qualifications for occupying certain posts, as well as with insufficient ones.
4. *When summarizing the study of the problems of employment of student and labor migrants in Russia, positive aspects are highlighted.* However, in spite of the fact that when employing foreign citizens-workers, the employer incurs high costs for obtaining the necessary permits, hiring migrant workers remains profitable for employers, since in Russia the demand for cheap labor is very high. But the local population is either not aimed at occupying these jobs, or does not provide the necessary level of quality and labor productivity. Despite the presence and negative impact of immigration, for various reasons, the state still needs external migration, both labor and student. The study of the effect of the number of migrants (people who arrived in the Russian Federation) on the unemployment rate has opposite results. In this case, the study is not objective and appropriate because of the low interconnection of the analyzed factors. However, taking into account the impact of unemployment on GDP, which has a direct and strong impact, the absence of a correlation between the unemployment rate and the number of citizens moving in indicates a rather large amount of illegal labor migration and the shadow economy" [20].

5. So obviously, as we can see, despite the fact that the employment of migrants is accompanied by various difficulties and problems and is quite complex, labor and student migrants play a rather important role both for the Russian labor market and, in general, for the state. In this case, all the advanced resources of state, economic, social, technical support are connected, and it is *digitalization that has the potential to solve the above problems with student and labor migration.*
6. The role of digitalization in solving the problems of employment of student and labor migrants is difficult to overestimate. Answering this question, measures should be divided into two levels—the level of an enterprise and the level of the state. As for the level of an enterprise, it is necessary to organize additional professional training, advanced training of staff workers with the aim of their additional training in the field of labor and migration legislation of the Russian Federation. To organize consultations on the labor and migration legislation of the Russian Federation both for students themselves and for employers, enterprises organizing training/production practices for students. The means to achieve these goals will be the digitalization of the processes in the enterprise. The digitalization of processes in the enterprise has the greatest potential in the field of personnel training. Distance education could become the most attractive for employees, since it does not imply the availability of time and space. Organizations need to strive to automate and simplify the procedure for employing foreign citizens.

As for the level of the state, it should be noted that the legal framework for training foreign students is quite complex, but still certain levers of simplification of this issue have begun to be implemented.

One of the measures to formulate the principles of migration management is the creation of a single digital platform that will allow you to quickly and easily draw up the necessary permits (patent, work permit, etc.), as well as accumulate information about the demand for certain workers in certain regions. The hypothesis of the study that digitalization and the process of employment of student and labor migrants are interconnected with each other, digitalization is an effective tool in solving the problems of employment of student and labor migrants was fully confirmed. "Digitalization of services will lead to a simplification of the migration process, its greater manageability, including through tools of maximum accessibility for the user to information about relocation, convenient services for submitting initial documents and getting the opportunity to choose vacancies and employment" [16].

It should be noted here that the digitalization process in migration registration is already planned. The purpose of which will be the introduction of a "unified mechanism for monitoring migratory flows and operational reliable accounting of labor migrants", which will undoubtedly lead to the solution of the main problems of employment of student and labor migrants in Russia.

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Russian Labour Market and Economy Digitalization: Opportunities and Risks

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Abstract The article presents the results of a factor analysis of the current state and development prospects of the Russian labour market in the context of active processes of the economy digitalization. The purpose of this article is to identify the most important factors that ensure or limit the formation of effective relationships in the labour market that meet the requirements of digitalization at all levels of management. The research is based on an analysis of the works of foreign and domestic authors on the problems of digitalization of the labour market and the use of such methods as statistical, factorial, and logical analysis, monographic description, synthesis, comparison, and graphical representation of information. The analysis is carried out according to indicators both in Russia as a whole and in its particular regions. It is noted that, in the sphere of the labour market, problems arise in the formation of a flexible mechanism for building relations between employers, workers and the state, taking into account the interests of each subject of social and labour relations. The analysis showed that in spite of the opportunities of the digital economy, the Russian labour market is not actually ready for digitalization on a number of built-in organizational and socio-economic barriers caused by systemic imbalances of social and labour relations. Conclusions contain the main directions for adapting the labour market to digital platforms.

Keywords Digitalization · Labor market · Risks

1 Introduction

For most countries, digitalization is a strategic priority, global and dynamic process. By 2030 almost 15% of the world workforce will need professional retraining and change their profession, because of the introduction of digital technologies in the

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economy and social sphere. The more economically developed country is, the higher is the value of this indicator (from 9% in India to 18 and 26% in Russia and Japan, respectively) [1]. Understanding the importance of this task, flexible policy is implemented in many countries. It includes large-scale work on professional retraining of the population. Nevertheless, there are many problems in resolving social and economic issues related to the digitalization of labour market in various countries, including Russia.

According to the expert and analytical report of the Centre for Strategic Research (Moscow), in the near future the labour market should expect:

- a change in the structure of the labour market towards production robotization, which will have consequences for employment in the segment of manual professions. According to prognosis estimates, by 2035, robotics will replace 25–30% of the work performed by people;
- by 2025, up to 30% of corporate audits will be conducted on the basis of artificial intelligence technologies. Experts suggest that in certain sectors of banking, legal services, and accounting full robotization is possible;
- quick change of qualification requirements for employees and rejection of lifelong hiring systems, which will lead to a change in attitude to professional career and choice of occupations;
- the growing need for new professions related to the use of advanced production technologies, intellectualization, production robotics, and etc. [2].

Thus, in the process of digitalization of the economy in the labour market, new opportunities for development and new risks and threats arise that can equally affect both workers and employers. Based on this, according to the Digital Economy of the Russian Federation Program (hereinafter referred to as the Program), approved by the order of the Government of the Russian Federation of July 28, 2017 №1632-r, the main directions in the field of employment and the labour market are:

- creating key conditions for training the digital economy personnel;
- improving the education system that provides the digital economy with competent personnel;
- orientate the labour market to the requirements of the digital economy;
- creation of a motivation system for the development of the necessary competencies and the participation of personnel in the development of the digital economy of Russia [3].

The directions formulated in the Program indicate that digitalization is primarily a change in the managerial paradigm at all levels of the national economy. A fundamentally new management system, formed jointly by all subjects of economic relations, which are business, the state, and the population, should become the basis for a qualitative update of social and labour relations in the context of the rapid introduction of digital technologies.

In this regard, studies of processes caused by ongoing changes in the requirements for human capital in the context of digitalization and studies of factors that form certain opportunities and barriers to satisfy these requirements are becoming urgent.

2 Studies of Labour Market Digitalization

Among foreign studies of the labour market digitalization process, it is necessary to highlight the following areas:

- formation of a social protection system for employees of digital platforms based on the search for the optimal ratio of tax benefits and social insurance [4];
- study of the problems of polarization of the labour market, the emergence of new employment forms under the influence of digital technologies and their analysis from the perspective of workers' risks and opportunities for adaptation to new conditions [5]. Researchers see the solution of problems mainly in increasing the flexibility of the system of social guarantees for hiring and dismissing workers;
- identification and classification of basic skills and knowledge related to digital literacy of the population that necessary for a successful job search [6];
- development of methodological support for assessing changes in various parameters of the labor market (wages, for example) under the influence of digital technologies [7]. In the context of our study, an interesting conclusion is that the effects of digitalization are overlaid on existing imbalances in the labour market, only enhancing their effect.
- study of the digital technologies impact degree on employment in various types of economic activity. The research results indicate that digital technologies used in production will have the greatest impact on development and the labour market in industries such as automotive industry, logistics industry, engineering industry, aerospace industry, and chemical industry [8];
- gender and territorial aspects of economy digitalization, related to the ability to adapt to the conditions of digitalization, which is characterized by a certain set of properties associated with the employees' level of digital skills and with their minds about the likelihood of finding a new job in the near future [9, 10].

Among Russian works analysing the evolution of the labour market in the context of digitalization, the main emphasis is on finding a solution to the problem of the proportional ratio between three components of the labour market that ensure the competitiveness of this market: "knowledge", "ability" and "skills". The main problem of the Russian labour market is the lack of a connection between wages and skill levels, which ultimately leads to a small proportion of workers with digital competencies [11].

In the article "Digitalization and Adaptation risks for Regional Labour Markets in Russia", the authors assess the possibilities of the Russian regions to reduce risks and adapt to digital transformation and conclude that in regions with a high concentration of human capital, the IT sector is developing at a faster pace—on average 0.85–0.9% higher than in regions with lower concentration of human capital [12]. The main result is selection of 4 groups of regions of the Russian Federation depending on the level of adaptive potential of the population and the risks associated with the introduction of high technology. Similar studies confirm that territorial socio-economic imbalances only underline the complexity of the transition to a digital society.

The results of the analysis of foreign and domestic literature indicate that the digitalization processes are causing an active restructuring of the social labor division system at the regional, national and international levels. The contradiction of these processes is expressed in their "double effect", when, along with positive changes, arises a real threat of social and economic upheavals. Under the conditions of modern social structure, when digital technologies are introduced into the sphere of social and labor relations, this contradiction means that the potential opportunities for reducing working time and labor intensity will be implemented, first of all, not in the form of increasing free time of the employed population, but in the form of increasing unemployment and social tension. This is a major concern for many researchers. A purely technocratic approach ignores the social components of the economy digitalization, which ultimately can lead to strategic miscalculations when choosing directions of socio-economic growth.

Thus, from an analysis of the works of Russian and foreign authors, we can conclude that one of the most important factors for achieving success in the development of the digital economy is the restructuring of social and labor relations to a qualitatively new state.

3 Research Methods

The research information base was made up of open information resources of the Federal State Statistics Service of Russia (Rosstat). The time range of the study covers the period 2001–2017.

To conduct the study were used methods of economic and statistical research of data, and logical analysis, synthesis, comparison, and graphical representation of information.

In the article analysis used the main indicators that characterize the functional state and dynamics of the labour market and the sphere of employment of the population in Russia as a whole and in particular regions. Various possibilities for adapting labour markets to digitalization conditions were determined on the basis of an integral assessment of the employment quality, calculated for different regions of Russia.

Integral assessment of the employment quality is carried out according to the following formula:

$$Cqe = 1 - \frac{N_{awc} + N_{ie} + N_u}{N_{eap}} \quad (1)$$

Cqe is the employment quality coefficient, N_{awc} is the number of people employed in adverse working conditions, N_{ie} is the number of informally employed people, N_u is the number of unemployed according to the ILO methodology, N_{eap} is the number of economically active population.

From the above formula it follows that the indicator varies from 0 to 1.

4 The Digitalization Problems of the Labour Market in Russia

Analysis of the current state of the social and labour sphere in the Russian Federation indicates the presence of many deformations in the development of its structural elements, one way or another affecting the character of social and labour relations in the context of the economy digitalization.

Among the wide range of problems that occur on the Russian labour market, we will try to focus on several aspects, which, according to the authors of this article, play a key role in assessing the relationship between digital technologies and the labour market, namely:

1. Quantitative and qualitative provision of the economy with labour.
2. The state of digital literacy of workers and organizations.
3. Level of informal employment.
4. Technological multistructural economy.
5. Regional imbalances in labour markets.

Since 2000, the employment level in Russia has steadily increased, amounting to 65.6% by 2018 [13].

High employment level currently provides fairly low unemployment rates. In general, from 2000 to 2017, the overall unemployment rate was in the range of 10.6–5.2% (Fig. 1).

At first glance, it may seem that the labour market in Russia is stable, the unemployment rate tends to decrease, which must indicate an improvement of in the labour market. However, this is not quite that. Experts agree that a stable level of employment is ensured by low wages, which distinguishes the Russian labour market from most developed countries [14].

Fig. 1 Dynamics of unemployment in the Russian Federation for the period 2000–2017 [13, 15]

Certain risks of digitalization are due to the quantitative provision of the economy with labour, which is associated with a reduction in the working-age population, while at the same time, the aging tendency is increasing. The economic activity of the population aged 60 and over was only 5.9% in 2017 with a share of about 30% of this age category in the total population of the country. In a qualitative aspect, the competitiveness of employees will increasingly be determined by the level of their interaction with information and access to information resources, which requires certain skills: digital literacy, attention management, information hygiene, the ability to work in a multicultural environment.

In this regard, as a positive point, it should be noted that the digital literacy of Russians is increasing every year. Almost 70% of the country's population use the Internet every day. If in 2010 the proportion of the population regularly using the.

Internet was 26%, in 8 years it has increased by more than 2.5 times. Moreover, not only the growth of digital consumption is noted, but also the growth of digital competencies of the population. Almost 75% of Russian citizens use the Internet to receive state and municipal services, 76.6% of households are connected to the Internet, which indicates the strong introduction of digital technologies in the everyday life of Russians [16].

The level of digital skills knowledge creates the basis for subsequent employment of a person and for its career prospects. As can be seen from Table 1, the vast majority of Russians aged 15–24 are the most "advanced group", both in terms of the simple use of digital technology, and in terms of creating new software products.

In each of the subsequent age groups, digital competencies are declining. This fact confirms the high demand of the economy for the availability of not only vocational education and certain qualifications for employees, but also for their digital technology skills. In addition, the high digital literacy of young people can make significant competition in the labour market in relation to middle-aged and older people. For the population this entails the need to adapt to finding ways for improving of digital literacy. That is, it creates the prerequisites for mass training/retraining of employees, increasing their digital competencies. However, to date, the scale of giving the education to adult population is extremely small.

Table 1 Digital skills of the Russian Federation population in 2018 [16]

Digital skills	Total	In age group						
		15–24	25–34	35–44	45–54	55–64	65–74	75+
Work with text editors	41.1	69.0	54.0	50.3	43.1	28.0	12.3	2.4
Email sending	36.8	51.3	52.7	47.7	39.5	24.7	9.6	1.6
Work with spread sheets	20.8	41.3	28.3	25.8	21.2	11.3	2.5	0.4
Connection and installation of new devices	9.8	18.1	16.3	12.0	8.4	4.4	1.3	0.4
Changing of configuration settings	2.7	5.0	5.2	3.1	2.1	0.8	0.3	0.1
Writing of software	1.1	2.4	2.1	1.2	0.7	0.3	0.1	0.02

A clear indicator of the digital technology introduction is the proportion of organizations using cloud technology. If in 2015 such organizations in the business sector made up only 18.4%, then their share increased to 22.6% just two years later. The use of cloud services by organizations in the social sphere manifested even strongly. In 2015, the share of such organizations was 20% and 2 years later it increased to 24.4% [16].

A serious problem of the Russian labour market that impedes digitalization in the field of social and labour relations is the high level of informal employment. In 2017, the level of informal employment amounted to 19.8% of the employed population in Russia, i.e. almost every fifth employee was in an informal labour relationship with the employer.

Professionals identify three key components in informal employment [14, 17]:

1. Informal employment. This group usually represents workers with a low level of education. The prevalence of this type of labour is noted in trade, household services, and construction;
2. Irregular or casual employment. This group of employees is the most vulnerable, and the range of remuneration of such a group is very wide from minimum wages to rather high;
3. Self-employment. This is precisely the category that, with the intensification of digitalization, can have every chance of increasing and tightening its hold on the informal labour market. Today, self-employment in Russia is low and is at the levels of 5–6%. As a rule, workers in this category have a secondary or higher education.

A high level of informal labour relations indicates the existence of a secondary labour market with low wages, an almost complete absence of any social guarantees, and unsatisfactory working conditions.

From 2001 to 2017, the number of informally employed people aged 50–72 years tripled (from 1296 to 3368 thousand people), and the proportion increased from 16 to 23.6% in the total number of this category of the employed population (Fig. 2).

The highest proportion is young people aged 25–29. During the period under review, the number doubled from 1023 to 2108 thousand people, and the proportion changed from 12.5 to 14.8%. A strong increase is also observed in the age group of 30–34 years. Over these years, their number has increased from 1107 to 2077 thousand people, and their share—from 13.6 to 14.6% in the overall structure of informal employment.

The level of education of informally employed is lower than in the economy in general. The share of people with higher education in this sector amounted to 18.1% in 2017, in the economy in general this share was 34.2%. At the same time, the share of people without vocational education in the informal sector reaches 35.1%, against 20.9% in the economy in general.

The proportion of employees with specialized secondary vocational education and primary vocational education in the informal sector and in the economy as a whole is comparable and amounts to 46.7% and 44%, respectively.

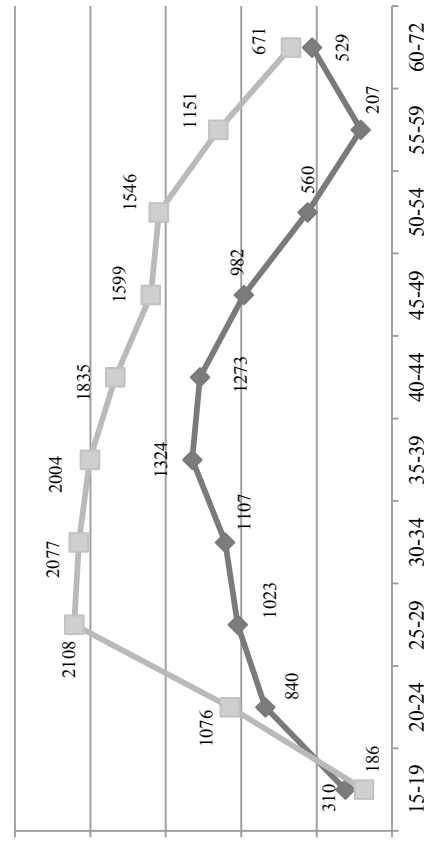

Fig. 2 The structure of informal employment in the Russian Federation by age group, thousand people [13]

Today, the largest share of informal employment is noted in such economic activities as wholesale and retail trade and vehicle repair services. The share of informally employed in this sector is consistently almost one third of the total number of employed in these economy sectors. In second place in the spread of informal labour relations are the sectors of agriculture and forestry. In 2017, the proportion of informally employed in this sector of the economy amounted to 16.8%.

The next serious problem facing the labour market in the context of digitalization is due to the technological multistructure of the Russian economy. According to the general theory [18–20], six technological segments are distinguished, and the latter is still only developing. In the Russian Federation, the share of the fifth segment accounts for only 10% of production, mainly related to the military-industrial and aerospace complexes. More than half of current technologies are in the fourth segment, and about one third of current technologies are in the third segment [21].

Statistical information can serve as definite confirmation of the technological multiculturalism of Russian economy, as it shows the degree of consumption of fixed capital, which currently stands at 47.4% [22]. This means that almost half of the basic production funds need to be replaced, repaired or updated. The extreme degree of depreciation is observed in the information sphere (60.5%), which, against the background of the state's desire to develop a digital economy, looks rather paradoxical. A high percentage of it shows the degree of consumption of fixed capital (more than 50%) is noted in the sphere of healthcare, transportation, and mining. The current situation hinders the introduction of digital technologies and increases the need for low-skilled workers.

In order to create effective employment policies during the transition to a digital society, one cannot ignore the aspect of regional differentiation of labour markets. Due to its vast territory, the availability of various natural resources, various socio-demographic parameters and historically established conditions for the formation of industries, regional labour markets have differences in processes of adapting to the conditions of economy digitalization. This can be seen by analysing the integral indicator of the employment quality that includes indicators characterizing the factors of influence on the social and labour sphere, which we described above.

The higher the value of the indicator, the higher the quality of employment, due to the influence on the labour market and on the region's employment sphere of several key factors: employment opportunities, social protection of workers, working conditions. These factors largely depend on the state of basic production assets and technologies used. Figure 3 shows the results of calculations for those regions that differ significantly from the average Russian value of this indicator.

According to the data presented in Fig. 3, the Russian regions vary quite significantly in terms of the quality of employment.

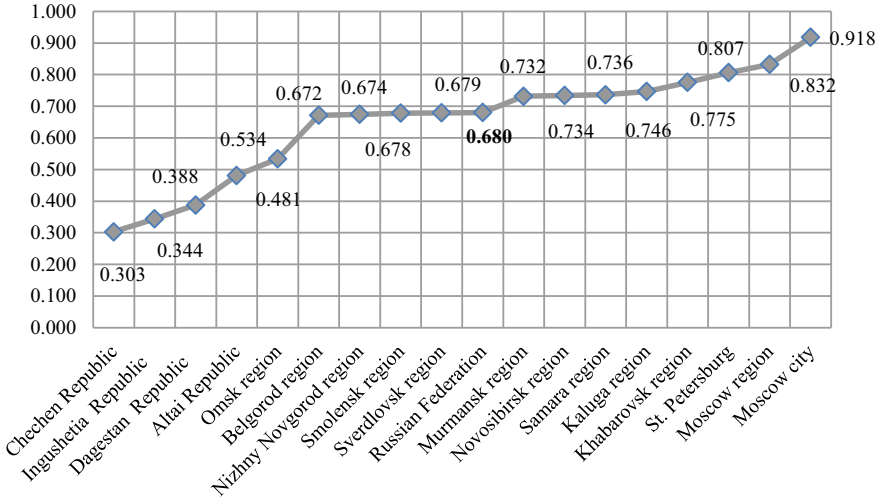

Fig. 3 The integral coefficient of the employment quality in some Russian regions in 2017

An especially alarming situation has developed in some North Caucasian and Siberian regions. Above the average Russian value, but far from the ideal state of this indicator, many other regions of Siberia, the Far East, the Urals. The best value in Moscow.

5 Conclusions

This analysis of the labour market and of the Russian population employment sector indicates both the opportunities and risks for the sphere of labour in the transition to a digital economy. First of all, the measure for risk minimization is seen in the development of educational technologies aimed at improving the digital competencies of the population, especially of middle and older age groups, and also in a differentiated approach to the development of digitalization programs for the individual economies of the Russian regions based on the characteristics of their socio-economic development and place in the current regional division of labour.

The importance and need for a scientific understanding of the economy digitalization is due to the multidimensional nature of this socio-economic phenomenon, to the complexity of the system of interconnections of processes that determine the transformation of social and labour relations, and to its results and consequences.

The noted trends in the state of the social and labour sphere actualize the scientific task of further developing of existing methodological and methodological apparatus for studying and assessing the impact of digitalization on the labour market and employment, which will serve as the scientific basis for the development and imple-

mentation of effective management decisions to improve the quality of life of the Russian regions population and to the transition of the national economy to digital technology.

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Employee Job Satisfaction Under Digitalization: A Gender Aspect

Olga Ponomareva and Denis Shkurin

Abstract The main goal of the article is to study gender differences in employee job satisfaction in context of production processes digitalization. The article provides review of modern approaches to factors of job satisfaction, including gender. Particular attention is paid to studying the experience of personnel job satisfaction management of Russian large enterprises and to the results of a personnel survey taking into account gender differences in context of digitalization of a particular enterprise. The survey methodology can provide relevant information for making point-based management decisions in digitalization conditions. Based on the synthesis of theory and practice, the authors have developed a number of practical recommendations aimed at improving the staff job satisfaction management in a gender aspect with respect to digitalization. It is shown that the effectiveness of the job satisfaction management depends, in particular, on timely decision-making based on monitoring results and targeted approach to staff. The main problems in this regard are the blurring of gender differences, the underestimation by the company government of the job satisfaction level and neglect to the potential of the digital working conditions and the digital environment.

1 Introduction

The preservation and growth of human resource in the face of changing gender structure of company personnel and the free movement of highly qualified employees in the labour market due to their unmet needs, require a revision of approaches to personnel, revision of motivational mechanisms for personnel management and differentiation of approaches to increasing work satisfaction. It is necessary to take into account the influence of gender differences, emphasizing the role of not the

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biological, but the social sex, associated with socio-culturally determined differences between men and women. At the same time, there are a large number of studies on the problems of women's job satisfaction and their rights [1–5], while in terms of gender differences this problem is not well understood.

In the context of the economy digitalization and in all spheres of life the interest to this problem is growing, which is important for increasing the labour potential of women combining work and household. The analysis shows that the economy digitalization significantly changes the nature of the employment relationship between the employee and the employer. Not only the appropriate labour operations are automated, but a significant part of the labour relations and entire segments of employment goes into the virtual environment, and enterprises show an increase in demand for non-algorithmized work and creativity [6].

Moreover, digitalization allows you to open new opportunities for employee participation in improving the quality of their working lives, drastically changing the information and communication infrastructure of the enterprise and the feedback technology from the head to the employee based on the results of employee's work. At the same time, due attention is not being paid to the study of tools for monitoring job satisfaction in a gender perspective in the context of digitalization.

The complexity and multidimensionality of the problem of job satisfaction determines the multiplicity of approaches to understanding its essence, nature, structure as well as to methods of studying it.

The early and most frequently cited definition of job satisfaction in the works of foreign researchers refers to the definition given by Locke [7]. The author defines job satisfaction as a pleasant or positive emotional state arising from an assessment of work. Researchers of a later period added a new understanding, expanding the concept of job satisfaction to all attributes of the workplace. Thus, Argyll [8] defines job satisfaction as an integrated indicator of the employee's emotional-evaluative attitude to working conditions, to the team and to the organization as a whole.

Other studies have shown that the following job characteristics affect job satisfaction in various fields of activity in different countries: opportunities for training and development, good relationships with a manager [4], recognition and reward [9], relationships with colleagues [10], the complexity of the work [11]. Turabaeva and Baksheev [12] consider satisfaction as a factor of staff stability, retention and reduction of staff costs. In the context of large business enterprises, according to Misyurina [13], it is necessary to have a comprehensive approach to study of job satisfaction, combining factors into groups: social, intraorganizational and personal.

Thus, we believe that job satisfaction is a state of balance between the requirements (requests) made by the employee for the work content, work nature, work conditions and a personal assessment of these requests. A high level of job satisfaction is characterized by a predominance of a positive attitude towards work and a desire for high performance. Whereas job dissatisfaction is manifested in low labour results, high staff turnover, its instability and a decrease in labour activity.

It should be noted that job satisfaction has been studied extensively in different contexts, but gender aspects have not been sufficiently studied until recently. More

often in studies, there is an understanding of gender as a policy of violating the equal rights of men and women, especially in terms of wages [14–16].

Research by Pradhan et al. [17], Menon and Gena [5] revealed that gender differences lead to a deep and permanent impact on the working women perception of changes in their psychological capital. Clark [18] studies on gender differences in the UK show that women have a higher level of satisfaction despite the fact that they work in jobs with lower wages and less career opportunities.

A study of job satisfaction and gender identity of female managers and non-managers among representatives of trade corporations aged 24–50, was presented by Polish researchers Lipinska-Grobenly and Wasiak [19]. The impact of the relationship of gender role orientation and job satisfaction of women with work is revealed. In particular, it was found that women leaders, representing the masculine and androgynous types, differ from women non-managers, representing the androgynous and feminine types, in only two indices: the cognitive and emotional aspects of job satisfaction. The authors conclude that masculine orientation is more associated with the psychological well-being of women, and that a managerial and non-managerial position does not affect the relationship between job satisfaction and gender identity. Schuttenberg et al. [20] studied job satisfaction of school principals, counselors and teachers (both women and men) and found that androgynous respondents tend to have a higher level of job satisfaction. Eagly and Carli, in their research on gender differences in leadership, found that differences between men and women were small and that the overlap was significant [21].

2 Research Methods

The purpose of this study is to exam the gender differences in employee job satisfaction with on context of digitalization of Russian large business in the field of energy supply and rail transportation.

The following working hypotheses were formulated:

1. Job satisfaction has gender differences.
2. Level of job satisfaction affects the manifestation of gender differences.
3. The degree of production processes digitalization as a factor of job satisfaction is estimated differently depending on gender types.

The study was conducted at two large Russian enterprises: (1) Sverdlovsk Railway (SvZhD) is a branch of Russian Railways, (2) Kurgan department of Energosbyt branch in a large energy company «ESC «Vostok» JSC» (Table 1).

For the study of gender differences was used gender role questionnaire by Bema [22]. It allows diagnosing the masculinity and femininity of objects. The IS index is defined as IS = (F−M) * 2.322. Based on the data obtained, four gender role types were distinguished: first is masculine—high masculinity and low femininity (IS < −1); second is feminine—high femininity and low femininity (IS > 1); third is androgynous (IS in the range from −1 to 1).

Table 1 Characteristics of the respondent sample, 2019

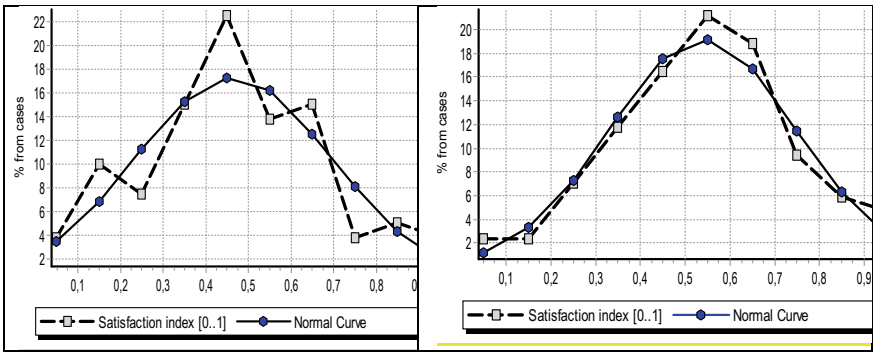
Criterion	Sverdlovsk Railway (Transport company)			
Age	28–40			
	80			
Sex	Male		Female	
	40		40	
Service	Train dispatchers	Dispatchers of transportation control center	Train dispatchers	Dispatchers of transportation control center
	20	20	20	20
Staff category	Specialists	Specialists	Specialists	Specialists
	20	20	20	20
Criterion	*«ESC «Vostok» JSC» (Energy company)*			
Age	21–30	31–40	41–50	51–60
	25	33	28	14
Sex	Male		Female	
	12		88	
Service	Heat and water supply	Energy supply to the public	Electricity supply	
	45	29	26	
Staff category	Managers	Specialists	Manual workers	
	12	83	5	

For the purpose of studying the labour satisfaction factors, the authors developed a questionnaire, where these factors had specific characteristics depending on the enterprise. The questionnaire consisted of two blocks: the first block included questions of a socio-demographic nature. The second block of the questionnaire was aimed at assessing respondents' satisfaction factors (total 14), including the factor of degree of production processes digitalization.

To process the obtained data at the 1st and 2nd stages of the study, the methods of mathematical statistics were used: assessment of the normality of the distribution of indicators for the selection of calculation criteria (Kolmogorov-Smirnov criterion), non-parametric Kruskal-Wallis criterion, correlation analysis (according to the calculation criterion—Pearson or Spearman coefficients) using SPSS for Windows v. 21.0 and Vortex 10.

3 Results: Job Satisfaction Measurement

The Satisfaction index was calculated as the sum of all satisfaction indicators (14 indicators) normalized from 0 to 1. As it shown in Fig. 1, this index has an almost normal distribution (does not significantly differ from normal) at both enterprises,



a (transport company) b (energy company)

Fig. 1 Distribution of job satisfaction index, %

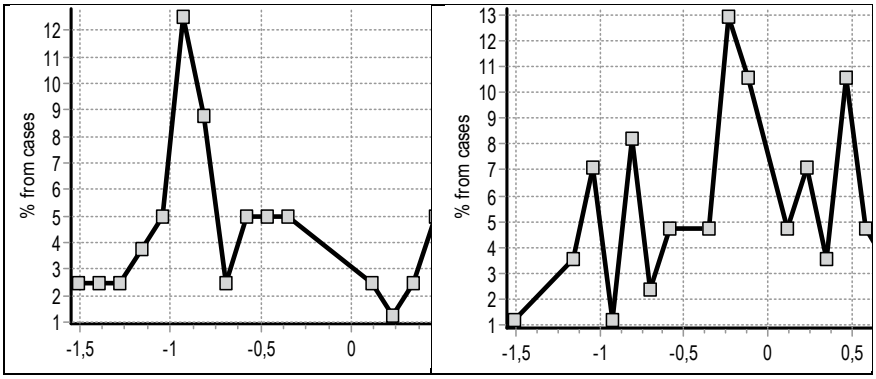
which allows us to use the average value of the satisfaction index and parametric correlation coefficients (Eta, R Pearson).

Table 2 shows the job satisfaction index data for different sexes and genders at both enterprises. It is noteworthy that, for the second enterprise (in the field of energy supply) sex differences between men and women are not statistically significant (significance 0.250), but the gender differences are (significance 0.001). The reason for this phenomenon can be understood from the explanation to Fig. 3.

Thus, the first hypothesis was confirmed—job satisfaction has gender differences: at the first enterprise (in the field of transportation), the most satisfied are masculine and androgynous and the least satisfied are feminine. At the second enterprise (in the field of energy supply), the most satisfied are the expressed gender roles (masculine and feminine) and the least satisfied are the androgynous.

Table 2 Average values of the satisfaction index for different groups of personnel of both enterprises

Enterprise	Criterion	Group	Sample	Mean satisfaction index	Standard Deviance	Significance
1. (Transport company)	All employees		80	0.4645	0.2304	
	Gender	Maskulins	13	0.4980	0.253	0.004
		Androgynous	56	0.4803	0.2309	
		Feminines	11	0.3445	0.1751	
2. (Energy company)	All employees		85	0.5391	0.2078	
	Gender	Maskulins	10	0.5750	0.1057	0.041
		Androgynous	72	0.5317	0.2099	
		Feminines	3	0.5952	0.4306	



a (transport company) b (energy company)

Fig. 2 IS distribution (%)

3.1 The Study of the Relationship of Gender Differences with Indicators of Job Satisfaction

To study the relationship between the gender differences index (IS) and other indicators, the results of the IS + in both samples were checked for normal distribution (Fig. 2).

The analysis shows that the distribution form of the gender differences index (IS) in both arrays does not correspond to the normal distribution. In the array of Enterprise 1 (Fig. 2a), the IS value is measured from −1.509 to 1.3932 and has several pronounced modes of the androgynous index: one with androgynous index −0.2 and another androgynous index 0.5. In the array in (Fig. 2b), the IS index takes values from −1.509 to 1.1610, has two pronounced modes: one with androgynous index 0.9 (almost at the junction of the androgynous and masculine types) and another with femininity index 1.1. In this connection, in further analysis of the IS index, we used the Kruskal-Wallis nonparametric rank criterion and the Spearman rank correlation coefficient. At the same time, the bimodality of distribution in the array of the transportation enterprise (Fig. 2a) has a clearly expressed gender nature. We see that the distribution is abnormal throughout the sample, but since the IS parameter is strongly influenced by sex, within each gender the distribution becomes normal.

3.2 The Relationship of Gender Differences and Job Satisfaction Subscripts

To study the effect of gender differences on job satisfaction subscripts we used a correlation analysis—Spearman rank correlation coefficient (Table 3). The reasons for choosing this nonparametric coefficient is due to the fact that the job satisfaction

Table 3 The results of the correlation analysis of the relationship of gender differences and employee satisfaction at the enterprise 1 (in the field of rail transportation)

Job satisfaction	RS Spearmen value	Significance	Sample
Training and professional development	−0.505	0.000*	80
The degree of production processes digitalization	0.455	0.000*	80
Wage level	−0.450	0.000*	80
Objectivity in evaluation of performance	−0.439	0.000*	80
Relationships with management	0.399	0.000*	80
Relationships in team	0.316	0.004*	80
Organization of work at the enterprise	−0.276	0.013*	80
Providing stuff necessary for work	−0.264	0.018*	80
Career development prospect	−0.230	0.040*	80
Bonus system	−0.165	0.143	80
Solutions to social issues	−0.125	0.268	80
Administration attitude to employee requests	−0.101	0.374	80
Awareness of the company and its development prospects	−0.049	0.668	80
Work content	0.037	0.746	80

*Significant correlation coefficients (≤ 0.05). If the significance level (error margin) is less than 0.05, it means that the margin of error is too small, thus the relationship is significant, otherwise, if the significance level is higher than 0.05, it shows that the margin of error is large, therefore, the relationship between given variable and gender is irrelevant

subscripts had an ordinal measurement scale from 1 (completely unsatisfied) to 5 (completely satisfied).

An analysis of the calculation of correlation coefficients revealed the presence of significant direct and reverse relationships between gender differences and employee job satisfaction in the rail transport company: the higher the index of gender differences (femininity pole is greater than or equal to 1), the higher the satisfaction with factors in which a direct relationship between the indices was revealed; the higher the femininity, the stronger employees dissatisfaction with factors in which an inverse relationship between indices was revealed. That is, employees with a feminine consciousness are more satisfied with factors such as "The degree of production processes digitalization"; "Relationships with superiors", "Relationships in team". It can also be said that the higher the femininity, the stronger employees dissatisfaction with such factors as "Training and professional development", "Wage level", "Objectivity in evaluation of performance", "Organization of work at the enterprise", "Providing stuff necessary for work" and "Career development prospect". Whereas employees with masculine consciousness who have exactly the opposite index values will be more satisfied with precisely these factors.

The data obtained tells us that only in one of the enterprises, namely in the field of rail transportation, the analysis of calculation of correlation coefficients revealed a

Table 4 The results of the comparative analysis of the job satisfaction level of employees of two enterprises (by coefficient Eta*)

Enterprise	Satisfaction		
	Sample	Mean	Standard Deviance
In the field of energy supply	85	0.5393	0.2077
In the field of rail transportation	80	0.4645	0.2295
In total	165	0.5030	0.2211

*(Eta coefficient (value 0.17, significance 0.03))

connection between the gender differences and job satisfaction, including connection between gender differences and the degree of production digitalization processes.

Further analysis showed that in terms of the job satisfaction level statistically significant differences between enterprises were revealed: the level was higher among employees in the field of energy sales (Table 4).

Thus, it has been experimentally established that the level of job satisfaction affects the manifestation of gender differences. With a high level of job satisfaction, gender differences disappear. With a low or mixed level of job satisfaction, gender differences are more pronounced.

3.3 Relations of Gender Differences and Satisfaction Factor with the Level of Production Processes Digitalization

According to the analysis of the Table 3 employees with feminine consciousness are more satisfied with factors such as "The degree of production processes digitalization". This is about employees aged 28–40, who are dispatchers of the Train Dispatcher Services and the Transportation Control Center Dispatcher Services. We also found that in this case, the femininity and sex indicators are very much interconnected (the Kruskal-Wallis test showed significance indistinguishable from 0). The analysis of the overall index of women's satisfaction at this enterprise (Table 2) revealed its low value (0.3447), significantly different from the general index of men's job satisfaction (0.5842). The feminine type (0.3445) also shows a low level of overall satisfaction index. At the same time, if we turn to such a factor as the level of production processes digitalization (Table 3), we will find a high level of satisfaction index (approximately 4 out of 5 points or 0.79 on a scale from 0 to 1) for both women and employees with a feminine type of consciousness.

The conditions for production processes digitalization at the dispatcher's automated workstation are ambivalent. On the one hand, the work of the railway transportation dispatcher is highly automated and digitalized: special software and hardware systems (such as the Neva Dispatch Center, DC Luch, DC Setun, etc.) are used for railway automation, telemechanics and communication devices, designed

for centralized dispatch control of arrows, signals and other objects of the dispatch circle and all the employees we interviewed, regardless of sex or gender, work in approximately the same conditions and on one software. On the other hand, the digitalization process does not cover all routine operations of the railway dispatcher, which causes certain reasons for the masculine gender carriers to be dissatisfied with this fact. First of all, we are talking about such factors of dissatisfaction with the production processes digitalization that fit well into traditional stereotypes of gender differences:

The work of the railway dispatcher involves:

- A lot of negotiations, direct interpersonal communication between participants in rail transportation. Feminine gender representatives are more flexible in the communication process. It is more difficult for dispatchers of masculine gender to make concessions, coordinate the transportation process with a large number of participants, they prefer this process to be formalized and automated.
- Multitasking—it is necessary to simultaneously coordinate more traffic. Feminine gender dispatchers find it easier to work in such conditions, while masculine gender dispatchers prefer the task switching process to be automated.
- Shift work. When agreeing the schedule, masculine gender employees often agree to night shifts, which contradicts their biological clocks and leads to a loss of attention and concentration necessary in conditions of multitasking and constant communication. In this situation, digitalization of this communication is more necessary.

All three of these factors form a high level of stress, which is easier for female employees to deal with. In addition, employees with masculine consciousness react more tensely to stressful situations of negotiations disruption or transportation schedule disturbance.

If we take into account the fact that there is a significant positive correlation of two other factors of job satisfaction (team relations and relationships with management, see Table 3), then for employees with a feminine gender type this fact may be related to satisfied need of communication and "Person-person" support, because the whole day they have to work with a "machine" heaped up with digitalization.

Next, we made an attempt to differentiate the data on the level of job satisfaction depending on gender differences in the sample of employees of the enterprise in the field of transportation (Fig. 3). An analysis of the data shows that for a given age category, the higher the value of the IS index (approaching femininity), the lower the job satisfaction index, which confirms the above-established regularities of the relationship of these indicators. It can also be said that the lower the value of the IS index (approaching masculinity), the higher the index of job satisfaction. This relationship is statistically significant (Pearson linear correlation coefficient $R = -0.339$ at $r \leq 0.004$).

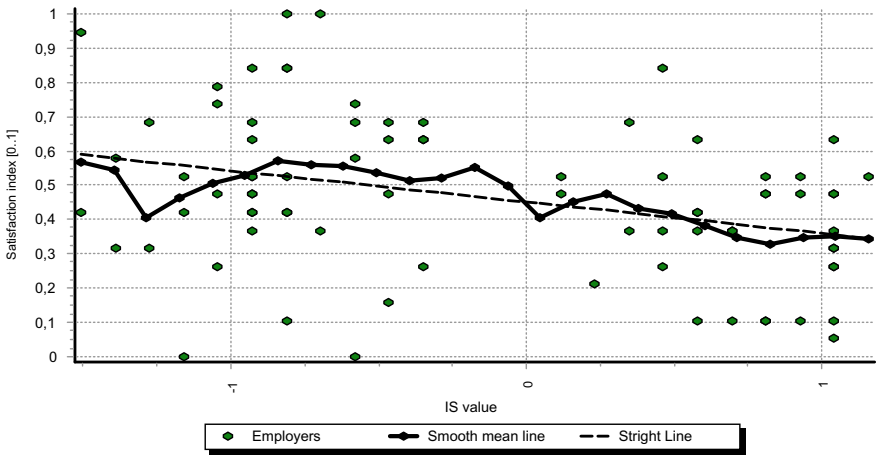


Fig. 3 Influence of IS value on the Satisfaction index with work of the personnel in the railway transport company

3.4 Discussion

Thus, in our study, all formulated hypotheses were fully or partially confirmed.

First hypothesis. Job satisfaction has gender differences. It has been experimentally confirmed that women and men, representatives of the feminine and androgynous gender, have a higher level of satisfaction with factors that improve their psychological well-being in the company, in particular with factors of relationships with management, relationships in team, which matches with the findings of many studies concerning women only [5, 17, 18, 23]. Also of a particular importance is the new data linking the level of satisfaction with the factors of the production process digitalization in the field of rail transportation. Digital technologies of the future determine how we make predictions, work, think. And it is the feminine type that reacts more sharply to these changes.

Second hypothesis. Level of job satisfaction affects gender differences manifestation. It has been experimentally established that at an enterprise in the field of energy sales, with a high level of job satisfaction, gender differences are erased. With a low or mixed level of job satisfaction, gender differences are more pronounced.

These data can be attributed to previously unknown and discussed from the point of view of managing the motivational mechanism of the personnel. First of all, the value of the research results lies in the targeting of management at the importance of dealing with real people. To maintain a high level of job satisfaction one need to conduct periodic monitoring of indicators, to have high-quality tools, including, in addition to indicators of job satisfaction, tools for diagnostics of the gender role orientation, which has a tendency to change, and to evaluate the existing incentive system and the need-motivation sphere. This will create an opportunity to formulate

a targeted approach to personnel and to perfect a system of personnel retention and the human capital preservation and growth at the enterprise level.

Third hypothesis. The degree of production processes digitalization, as a factor of job satisfaction, is estimated differently by gender types. It was found that the higher the level of IS (femininity is more pronounced), the more employees are satisfied with the degree of production processes digitalization. In other words, employees with masculine consciousness are more dissatisfied with the degree of digitalization and would like to increase it, while employees with feminine consciousness, on the contrary, are satisfied with the current state of affairs. Perhaps this is due to the interest in the effects of digitalization: the strengthening of the control function, obtaining operational feedback, communication with other people, the desire to go beyond the limits of interaction in the "man—technology" continuum to the "man—man" dyad. It is also important that at this enterprise the sample of respondents is characterized by an age range from 28 to 40 years. This age category is more used to interact with digital tools, so they make up the bulk of the staff in this position.

4 Conclusions

In the context of digital technologies and digitalization of the production process, the responsibility and risk level of employees and enterprise managers for performance. These responsibility and risks increase many times in the case of providing services to the public, problems which can lead to industrial and social disasters. The effectiveness of such enterprises in the field of energy supply and rail transportation depends on the quality and professionalism of employees, on their job satisfaction and their desire to do the job as best as possible. The results of the study in this article emphasize the importance that should be given to gender differences in the study of job satisfaction. The experimentally revealed effect of the employee's gender type on his level of satisfaction is not limited only to significance for the employee himself, but has a direct impact on the effectiveness of the organization [5]. If the organization adheres to a supportive approach in gender terms to improve the level of job satisfaction, employees will feel their value and significance for the company, which will allow them to be a source of increasing the company's human capital.

The results of the study can serve as an information occasion and scientific basis for managerial decisions and recommendations for improving personnel management in the context of digitalization, among which we consider:

- Development and updating of personnel management policies for enterprises taking into account gender roles (types), and not just traditional male and female roles (biological sex). This will allow tracking changes in the development of personnel, in revealing of its potential and in behaviour and performance;
- The use of the methodology of the study of job satisfaction, focused on the study of a set of personnel indicators and relationship of these indicators to obtain reliable

conclusions. Such indicators as level of satisfaction, position, length of work, sex, gender type, motives and needs of employees, assessment of incentives;
- Monitoring the level of job satisfaction and gender type of key and core personnel in order to build an effective system for managing job satisfaction, updating it annually and applying monitoring data to make point-based management decisions;
- Targeted approach to the development of social motivation programs to maintain the level of job satisfaction for feminine-type employees and participatory management and career promotion programs for androgynous and masculine types in order to maximize the employee's potential;
- Professional diagnostics of satisfaction with the digitalization production processes and with the digital environment of the company in general. The use of data for the development and improvement of digital conditions and technologies, as well as the planning of training programs for personnel on their effective use.

Thus, personnel data on the gender type in the company significantly change the perception of real processes in the management of job satisfaction.

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Entrepreneurship Education and Digital Literacy as Element of Innovative Learning

Zuzana Dvorakova and Ilona Polents

Abstract Entrepreneurship education is considered one of the prerequisites for shaping young entrepreneurs who can generate economic growth and create new jobs. The education system at all levels contributes to the formation of entrepreneurial competences. A special status attributes to universities whose curricula contribute to the motivation to set up a business and do business. Teaching methods e-designed to provide students with knowledge of entrepreneurship and develop entrepreneurial thinking and behavior that employers need in the Industry 4.0. The paper aims to analyze the entrepreneurship education with a focus on Russia and the Czech Republic and to define what digital literacy brings to entrepreneurship education. The methodology uses a bibliometric analysis of the databases of Web of Science and Scopus for the period 1990–2020 about the state-of-the-art in the field of entrepreneurship education at universities. The bibliographic data supplement research findings from secondary sources and five case studies. The later ones utilize data from unstructured interviews held in Russia and the Czech Republic about the job requirements applied to university students and graduates in the context of educational digitization and digital literacy. The challenges for university study programs and lifelong employability remain whether curricula will develop and implement in collaboration with the business, and teaching will use proactive and activating teaching methods.

Keywords Entrepreneurship · Education · Digital literacy

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1 Introduction

The democratic societies recognize that a critical role in ensuring economic growth and the new job creation plays entrepreneurs. They glorify entrepreneurship and entrepreneurial competencies as a fundamental basis for achieving their wealth [1]. The education and life-long learning drive sustainable development and employability, and in this context, educational research focuses on transforming the education system and lifelong learning with the focus to innovate the content and education methods. In recent years, the emphasis has been on digital literacy, because shortly, according to European Commission research, 90% of jobs will require a certain level of digital skills, however, currently 47% of the working population do not have the necessary digital literacy [2]. It requires a conceptual innovation, which means a new approach to education through digital plays, open education for the masses, and the involvement of business in education [3].

Since 2005, the European Commission's Joint Research Center on Education has focused on making better use of information and communication technologies (ICT) in innovations of education and learning [4]. Attention focuses on the development of entrepreneurial competencies, such as leadership, self-esteem, creativity, and motivation, as they hide the ability to learn and the art of learning others.

The aim of the paper is:

- To analyze trends in educational innovations in the EU and Russia and identify what entrepreneurial competencies are beneficial and searching by employers,
- To characterize the innovations in the Russian and Czech tertiary education systems towards the development of entrepreneurial competencies,
- To identify trends at Russian public universities, which are associated with the development of students' entrepreneurial competencies, and illustrate mismatching in the context of the reality of both countries mentioned above,
- To outline what educational methods can develop entrepreneurial competences.

2 Research Methods

Research methods collect data and evaluate efforts focused on selected research areas. They cover quantitative and qualitative methods. Firstly, we apply the bibliometric methods aimed at an analysis of bibliographic data of publications in the Web of Science and Scopus. It identifies trends, monitors the development of knowledge, and searches for new fields for future research. Secondly, five unstructured interviews deal with university education and professional training in the Russian and Czech environments; two interviews are with young people on the threshold of their professional career, one with the university's top manager and two with business representatives. We summarize their findings in five short case studies to characterize the quality of education at universities in two countries in the context of the digitalization of the economy and the globalization of the labor market.

The reason for using these methods is that the topic analysis social phenomena that determine the national culture, economic conditions, and behavior of people whose changes influence a national socio-economic system and ICT. A combination of two groups of research methods provides a rational ground for predictions which areas of future research can expect, and which innovations can become perspective in the field of entrepreneurial education at universities.

3 Theoretical Grounds of Digital Literacy in Entrepreneurship Education

3.1 Analysis of Bibliographic Data

We retrieved 17,349 bibliographic records that matched the query in database search in the period 1990–2020: records from the Web of Science databases count for 7472 and Scopus 9877. The structure of bibliographic records shows Table 1. The enormous amount of literature of various sciences does not allow conducting a complete analysis of all of them. In this paper, the analysis is limited by the most significant works, considering the citation index related to entrepreneurship education and learning, entrepreneurial competencies, and digital literacy. The study outlines the development of promising directions in several areas of educational research, business economics, computer science, social sciences, and engineering.

Entrepreneurship education belongs to the most studied topics in the People Republic of China (700 publications in the Web of Science), USA (265), England (162), Spain (121), Romania (77), Germany and Malaysia (both 74). In Russia, it covers 21 publications and in the CR 18.

In the case of digital literacy, the order of the number of publications characterizes the following: USA (323), Spain (237), England (172), Australia (121), and Canada (87). In the CR, it includes 31 publications and in Russia 28. Studies dealt with

Table. 1 Bibliographic records by the query in web of science and scopus database 1990–2020

Query	Web of Science[a]	Scopus[a]
University entrepreneurship	174	182
Entrepreneurial competencies	189	295
Entrepreneurship education	2285	2599
Entrepreneurship learning	73	103
MOOCs	2889	3911
Digital literacy	1842	2764
MOOCs and digital literacy	20	23
Total	7472	9877

[a]*Source* Authors [accessed in databases 2020/02/13]

Table 2 Bibliographic records by the query in web of science database 2005–2020[a]

Query	Year							
	2005	2010	2015	2016	2017	2018	2019	2020
University entrepreneurship	4	8	22	15	19	25	20	1
Entrepreneurial competencies	0	9	23	27	22	37	30	1
Entrepreneurship education	10	64	270	369	433	340	245	11
Entrepreneurship learning	0	1	10	10	17	15	12	0
MOOCs	0	1	481	563	584	475	360	24
Digital literacy	9	53	212	232	285	270	305	19
MOOCs and Digital literacy	0	0	6	2	5	1	3	0

[a]*Source* Authors [accessed in databases 2020/02/13]

Massive Open Online Courses (MOOCs) mainly published in the USA (574), People Republic of China (412), Spain (392), England (220), Australia (142), and Germany (134). In Russia, the number of publications in the research area includes 55, and in the CR, only 9.

The literature between 2005 and 2019 was used since this period substantially increased the number of publications about the works related to entrepreneurship education, digital literacy, and MOOCs, as shown in Table 2.

3.2 Entrepreneurship Education: An Agenda of the Labour Market

The 'Skills for Jobs Database 2018' published by the OECD states that the most common shortage of knowledge, skills, and competence in the labour market of OECD countries exists in highly skilled occupations [5]. Job positions requiring the highest qualification are the most difficult to recruit. In the Czech Republic, the situation in demand for workers according to the level of competencies can characterize in the way that the most demanded are people with a medium level of qualification (approximately 60% of the demand of employers). That follows the demand for the highest level of qualification (almost 40%), but no job recruitment reports for the unskilled labour force. The demand for competences is moving towards more complex, non-routine tasks as a result of digitization and globalization. On average, behind the OECD and EU countries, ICT skills, i.e., computer hardware and software, programming and applications, represent the most significant shortages, closely followed by the demand for judgment and decision-making skills and verbal skills, such as writing, comprehension and oral expression.

Industry 4.0 is increasing the employers' demand for technical knowledge and skills aimed at generating and exploiting innovations, especially in the fields of science, technology, engineering, and mathematics. Digital literacy acquired at

school of all levels as a part of initial education and developed in continuing vocational education can contribute to enabling people to use new technologies and to switch between different job positions, and sectors of the economy [6]. University education usually involves acquiring cognitive competencies. However, the life-long employability insists on non-cognitive competencies that an individual has from early childhood and schools, such as persistence, purposefulness, and the joy of learning.

Education and training systems should operate according to the International Labour Organization [7]:

- To equip the workforce with digital literacy,
- To use opportunities generated by digital literacy,
- To facilitate dynamic life-long learning.

Vocational higher education and business training must be relevant to practice; for example, employers appreciate possibilities to extent qualification profiles and integrate key work competencies into university study programs. Such an approach increases the potentials for future upgrades of initial qualifications.

Entrepreneurship education is one of the world's fastest-growing fields of education. The systematic literature review shows that it represents one of six streams in the research area covering digital entrepreneurship, together with digital business models, digital entrepreneurship processes, platform strategies, digital ecosystem, and social, digital entrepreneurship [8].

The analysis of university study programs points at that content and teaching methods vary according to the university objectives [9]—from the programs with theoretical courses aimed at increasing awareness of entrepreneurship to the practically oriented programs that should motivate to establish a company and develop entrepreneurial competencies. At the same time, limited attention has been paid to the entrepreneurship of students and graduates, and at the very beginning, research on the entrepreneurial ecosystem in entrepreneurship education at European higher education institutions has been initiated [10]. Universities usually target researchers who set up their businesses or spin-offs using the intellectual property owned by the university [11].

An analysis of entrepreneurship education at universities done by Lackéus [12] shows that the main objective is to develop entrepreneurial competencies to some extent and that universities practice one from the three following approaches:

- To teach about entrepreneurship, i.e., about the content and theoretical approaches to entrepreneurship in order to understand this phenomenon; this approach is typical for higher education,
- To teach for entrepreneurship, i.e., to provide entrepreneurs with the necessary knowledge and skills,
- To teach through entrepreneurship, i.e., a process-based approach, which is often experimental, where students go through a real learning process and simulate entrepreneurship by starting a business.

An illustration of entrepreneurial education and entrepreneurial intentions of university students gives a study about the impact of education and entrepreneurial

self-efficacy on entrepreneurial intentions in the Visegrad countries (the Czech Republic, Hungary, Poland, and Slovakia) [13]. Its findings show that the differences exist across the four nations. However, the direct impact of entrepreneurship education at the high-school level has a positive and significant impact only in Poland. It supports findings achieved in another study that contextual conditions have the importance, i.e., entrepreneurial behaviour generates the domestic environment, language ability as well as education based on cultural-cognitive and normative pillars of institutionalization [14].

Entrepreneurship education transmits knowledge, skills, and attitudes to influence the willingness and ability to fulfil an entrepreneurial role and create new business opportunities. It covers both cognitive and non-cognitive competencies, firstly generally defined for any job position, and secondly highly suitable for entrepreneurial roles. Non-cognitive competencies, such as entrepreneurial alertness, entrepreneurial thinking, self-confidence, entrepreneurial identity, proactive approach to work, uncertainty and uncertainty tolerance, innovativeness, and persistence, seem to be very important for the future.

Entrepreneurial competencies are the breeding ground for entrepreneurial behaviour, yet mere knowledge of entrepreneurship does not lead to entrepreneurial behaviour, and entrepreneurship education does not improve the motivation of university students to become entrepreneurs [15]. Kyndt and Baert [16] believe that perseverance and insight into the market opportunities contribute positively to being and remaining active as an entrepreneur. It is becoming accepted that universities need to develop productive thinking, motivation, interpersonal skills, and leadership [17], as they form the core of entrepreneurial competencies [18] and encourage the development of entrepreneurial thinking [19]. Research has not yet dealt with the relationship between entrepreneurship education and non-cognitive competencies, which provides ideas for applied research with suggestions on how to further develop curricula, teaching, and learning methods.

The MOOCs paradigm begins in 2008 and opens challenges for innovations at all levels of education so that to prepare the economy for requirements connected with Jobs 4.0 and Industry 4.0. Digital technologies are changing job specifications while facilitating access to knowledge and learning opportunities. For example, MOOCs and training videos prove to be a suitable means for updating work competencies regardless of time and place of training [20]. However, opportunities arising from e-learning and access to online courses should link to certification and other forms of education, so-called blending learning [21]. The universities must connect them with business and involve companies in education and learning.

4 Case Studies

Education, entrepreneurial thinking, and the use of digitization at universities are illustrated by five case studies, four from Russia and one from the Czech Republic.

They used information obtained from unstructured interviews in Russia done in December 2019 and the Czech Republic in November 2019.

Case study 1. Alexey is a student of the 1st year of the Moscow Institute of Physics and Technology (MIPT) and Skoltech (Data Science). Together with his team, he won the big competition for the digital analysis of big data. Talking about his journey to Data Science and achieving his first great victory, he advises everyone who wants to succeed in this area. The most important thing is that he/she must communicate as much as possible, participate in joint projects and conferences, take various online and offline courses according to his/her chosen specialization. For example, Alexey highlights the benefits of countless Data Science courses that he considers useful to succeed. At the same time, he emphasizes the importance of primary classical education at MIPT, as it has been instilled in it the flexibility of the mind and the ability to quickly acquire the skills needed to manage in almost every field of human activity. Also, he underlines the importance of having a mentor, as he acquires not only knowledge, skills, and advice, but above all experience with real scientific problems and builds relationships with the scientific team. As a result of such communication, he develops a sense of real tasks, acquires scientific programming skills, and accumulates experience in communicating with other scientific groups and high-tech companies.

Case study 2. Olga is a young researcher at the Laboratory of Chemical Pharmacology at St. Petersburg University. She won the CAS Future Leaders competition, and for the second time in the history of the competition, it was a victory for a scientist from Russia. That achievement helped get an internship in the USA specially organized for the winners of the prestigious international competition. According to Olga, in 2019, she belonged to the thirty most promising young chemists in the world thanks to the digital technologies and skills that emerging scientists must develop today. She learned about the competition on the SciFinder website, which she uses every day at work, giving her access to the most comprehensive and representative source of references in the world of chemistry and related sciences. These are research applications that, in her view, provide support for young scientists, help in professional growth, knowledge gathering, communication with colleagues from around the world, and are among the top of all the latest developments in their scientific field. Olga believes that such opportunities should have students in all educational institutions, and the task of secondary and higher education is to turn a young person into an independent, self-confident person who wants and can actively use all available digital tools.

Case study 3. Vladimir is a leader in a large Russian university with branches in all Russian regions. The university, in addition to tertiary education, specializes in managerial training, employee development of large companies, consulting, development of, and implementing modular training programs, which commissioned by state corporations. The broad scope of the university's activities enables to get an up-to-date and comprehensive overview of modern education requirements and trends in the labour market. The first thing, Vladimir pays attention to in his work is that there is a growing demand for entrepreneurship and digital education in Russia. He perceives that the "digitalization of society and the economy" will have far-reaching

consequences and, therefore, the education system must change substantially. Each university should become a continuing education school—a university for all generations, including adults, people with some professional experience. He believes that in the modern world, no one will be able to say for sure what he will do in ten years, no man, no business, no industry, no region. Besides, he witnesses a rise in demand for professionals who can continually adapt to new challenges, have a high level of digital knowledge and can make independent decisions in non-standard situations. As regards higher education for the younger generation, he believes that it would be ideal for the education process to be built in close collaboration with practice and close communication with all stakeholders so that students can seamlessly move from the university to an employer, into the practice of their profession.

Case study 4. Tatiana is the head of the Human Resources Management Group, which operates in one of the three largest Russian consulting companies. According to her, every major organization in today's Russia is considering the possibilities of business digitization. Industry leaders are already implementing digitization programs to increase productivity, roll out new products, and develop digital channels of interaction with customers and suppliers. With this, requirements for potential jobseekers are increasing, such as extending the content of their work to IT activities and creating new digital competences. Tatiana states that at least 50% of companies report a shortage of highly qualified employees with the required profile and that more than 40% of already hired candidates do not have appropriate qualifications because there are not skilled enough. Young professionals—yesterday's graduates—do not have enough skills to work with products that are relevant to employers and lack the necessary entrepreneurial competencies. Leading digitization companies solve this problem by educating their employees by developing their modular education systems or using modular education programs from their partners. Most often, this practice will resolve the need of the employer to obtain the necessary professionals in the most demanded areas at fair market value. Also, during training with employers, prospective job seekers do not communicate with HR managers, but directly with IT department managers—trainers, who, in turn, have opportunities to assess the skills of potential employees.

Case study 5. Radek is a co-owner of two multinational companies. One is the Internet of Things operator and the other a business management consulting company. Both are local brand entities that operate in the global network and whose organizational structure acts as a network of independent local entities. Both Czech branches are fully autonomous, and their performance depends on the quality of the human capital of their employees. The top manager of the local branch substantially determines the core people's practices, as he actively acts in the essential practices, such as selection, placement of personnel, performance management, promotion, and remuneration. Recruitment for a business analyst position targets students and recent graduates, regardless of a university and a field of study. Prospective employees usually addressed directly, and it is highly appreciated a reference from a current or former employee. In the case of a consulting company, the selection procedure includes solving a real business case study that the company solved for its client, followed by an interview with the owner or the top manager. The decisive criterion

for the candidate success is his/her full knowledge profile (not only from the technical or natural sciences field, but also the social ones), willingness to learn, the ability to find unconventional problem solutions, share experiences and collaborate in a team. Digital literacy and language skills mean a prerequisite for any candidate to have a chance to succeed. Since the probationary period, the new employee becomes a member of the team solving projects for clients. If his/her performance achieves the above-standard level, he/she gets responsibility for increasingly demanding tasks, and their wages are above average compared to local wages for similar job positions. The company expects that employees take care of their permanent self-education, are temporal and spatial mobile, cooperate, share experience, and have fun with work. In the Czech market with highly qualified workers, the demand of employers exceeds the supply, especially in technical and natural sciences. However, the number of graduates of Czech universities in these fields will not meet the demand of companies in the medium or long term.

5 Conclusions

The recent economic crisis has turned the attention of European policymakers towards entrepreneurship as a driving force for the creation of new jobs, regional and national competitiveness, and sustainable growth [20]. Work requirements are increasing worldwide, and education can only provide essential competencies at all stages of the educational system so that life-long employability requires acquiring and developing entrepreneurial competencies. Learning methods that are proactive and interactive have the potential to acquire them. The attractiveness of such training increases when the training provides the company or the university in close collaboration with business. Despite recent efforts to innovative entrepreneurship education, entrepreneurial behaviour and thinking are an expression of personality and skills such as self-management and leadership, creativity and proactivity, and entrepreneurial motivation.

Entrepreneurship education at universities is influenced by several factors, like

- A labour market situation,
- Budgets distributed to educational institutions,
- The position of educators in society and the economy,
- Collaboration educational institutions with practice,
- Values of young people and their attitudes towards learning.

The benefits of changes in the education system can register at least ten years after their implementation. However, education systems in the former Eastern bloc went through reforms in shorter intervals. We argue that the decisive step for transforming universities in Russia and the CR into the digital and entrepreneurial age is to stabilize administrative approaches to education and provide incentives for collaboration between business and entrepreneurship education.

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The Digital Era of Healthcare in Russia: Case Study

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Abstract These days, availability of digital technologies to a wide range of users forms modern interdisciplinary studies influencing the dynamics of society development. The paper substantiates the possibility of the Russian Federation to implement Digital projects. Digital transformations of the society often reveal the processes of social transformation, forcing science to constantly improve both technologies and software applied as electronic services. The phenomenon of digital transformation is specially noted in scientific studies and applied decisions in such area as Digital or Electronic Healthcare, a part of Digital Economy program or Smart City projects. The paper aims to identify the trends of the interdisciplinary research field "Social aspects of Digital Economy: design of telemedicine services" in the context of Russia. The article presents a comparative analysis of the publication dynamics in this field. The publications are part of Russian scientific discourse on the considered subject domains and trends. The research has been conducted based on the information arrays from various digital sources including scientific publications: eLibrary, a collection of Russian scientific publications, and the content of sociopolitical discourse (Integrum) over the past 10 years. A synthetic method, a unique scientific technique specially developed for the automated extraction and explication of contextual knowledge from an array of textual modality resources, is presented. The "Electronic Healthcare", a priority project of St. Petersburg, its development and results are presented as a case study "Electronic service: Telemedicine consultation."

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Keywords Digital economy · Digital technology · e-Health · Contextual knowledge · Knowledge management · Telemedicine consultation · Design of digital services

1 Introduction

Digital Economy of the Russian Federation is a national program affecting traditional and new socio-economic spheres and aspects of social development. This program is a priority in Russia. One of the key social areas is Healthcare. The digitalization of this sphere in recent years has become widespread, with remarkable success in regions. At the same time, the development of digital medicine in the regions has been spontaneous. The heterogeneity of medical services, including telemedicine services, in terms of their level and variety, offered in regions, is a consequence of the current situation. Knowledge management in Digital Healthcare is possible based on scientific approaches that allow to identify and exploit contextual knowledge from information resources with textual modality, as well as to directly analyze the practice of digital service design. Aggregation, analysis, and explication of knowledge in design and implementation of digital medical services is an important task for researchers. The methods and technologies for searching, extracting, and explicating contextual knowledge ensure the effectiveness of this challenging task.

The study aims to complement the information field by knowledge on the e-Health and telemedicine development in Russia in the context of the Digital Economy program. The "Telemedicine consultation", a digital service designed by Saint Petersburg Medical information and analytical center, is a part of the "Electronic Healthcare", a priority project of St. Petersburg, and is considered as an example of Digital Economy program implementation.

The paper is structured as follows. The Russian Federation legislation and e-Health initiatives are overviewed in (Sect. 3.1) followed by the research methodology and terminological landscape of the subject domain (Sect. 3.2). The data, information, and knowledge about the situation in Russia are critically examined and clarified. Furthermore, the dynamics of science and Media publication activity in the "e-Health" subject domain is discussed. By analyzing modern literature, the components of "e-Health", such as Telemedicine and Telemedicine technologies, are highlighted. These components are applied in t business and information process modeling (Sect. 3.3). The paper proceeds with a discussion of implications and limitations of modeling and regional experience (Sect. 3.4). The design of telemedicine consultation service and its operational mechanism to empower social effects are presented in (Sect. 4). The conclusion and the ideas for further research are provided (Sect. 5).

2 Approaches and Methods

A unique automated technique to extract and explicate contextual knowledge (synthetic method) from information resources of textual modality is described [1]. The synthetic method integrates several approaches to solve problems of allocation and explication of scientific content on interdisciplinary research topics.

A comparative analysis is applied to determine whether the development of telemedicine and telemedicine consultations correspond to e-medicine development trends. The same method is used to determine whether the level of telemedicine development in Russia corresponds to global trends.

The design approach and the architectural design method are applied for the medical consultation service.

3 Research Context and Methodology

3.1 International Review

To understand the state of telemedicine as one of the key areas of e-Health, Russian and world practices were compared. Scopus publication arrays as the most authoritative digital databases of scientific publications were initially analyzed (query: "e-Health" or "Digital Healthcare", from 2008 to 2019). The obtained data have shown an increase of research interest to this topic (Fig. 1).

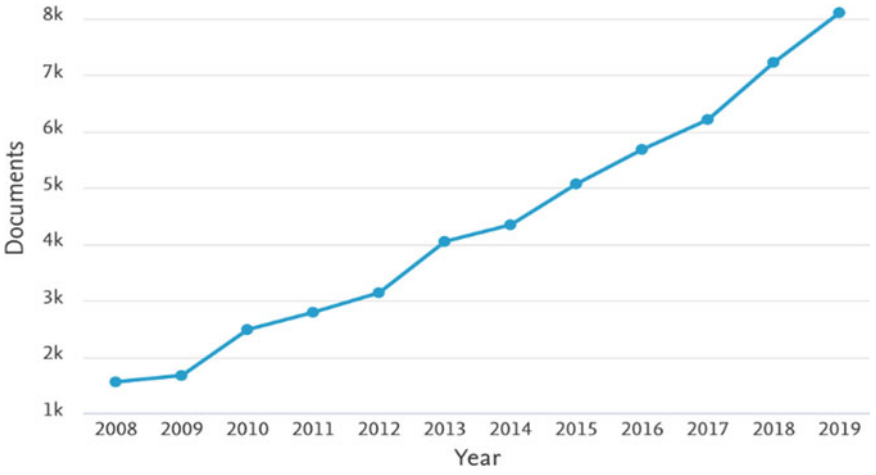


Fig. 1 Scopus, 2008–2019. Dynamics of scientific publications for the query: "e-Health" or "Digital Healthcare." The diagram is built by Scopus portal tools

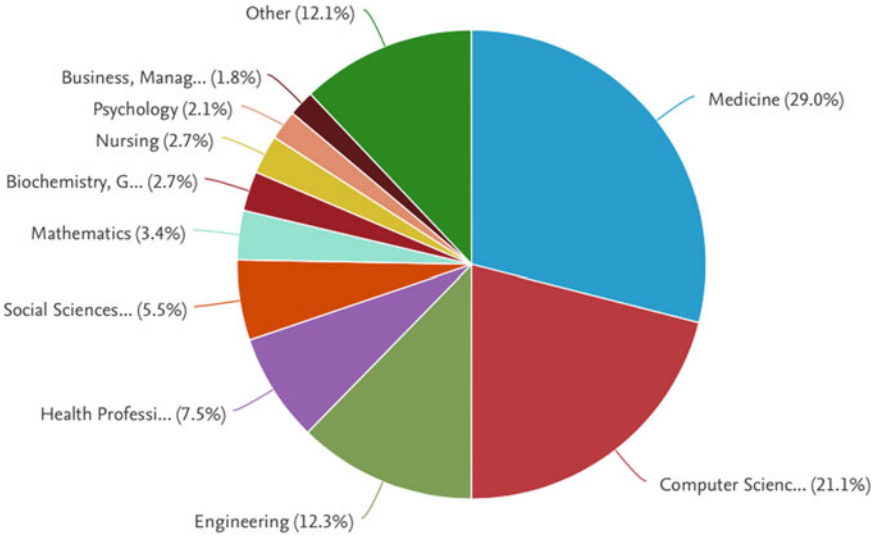


Fig. 2 Scopus, 2008–2019. Dynamics of scientific publications for the query: "e-Health" or "Digital Healthcare." The diagram is built by Scopus tools

The aspects of e-Health development are considered by researchers from various fields, which indicates the interdisciplinary nature of this topic (Fig. 2).

The dynamics of research interest in telemedicine consulting is in the trend of telemedicine research development. However, as areas of telemedicine, telemedicine consultations are of less concern to researchers (Fig. 3).

The total amount of papers in Science Direct corpus is 6600 for search query "Telemedicine" and 2108 for search query "Telemedicine consultations". The number of articles in open access is 877 and 220, correspondingly. The articles distribution in 2013–2019 is shown in Fig. 4.

The review of publications has shown that telemedicine is considered as a means of distant communication between clinics [2] and as a new format for remote patient counseling [3, 4]. The issues of economic feasibility and widespread application of telemedicine technologies and solutions [5, 6], and risk analysis of e-Health system [7] and palliative medicine [8] are reviewed. The shortcomings in Health system organization are identified in [9]. Scientific publications also address the organization of telemedicine consultations and their efficiency [10, 11]. The scientific topics common for the telemedicine field are image recognition and processing [12], design of information systems for rehabilitation [13], technical issues of telecommunications for data collection [14–16] and health effects monitoring [17–20], and development of self-diagnostic systems [21, 22]. The effectiveness of Internet technologies [23] and video conferencing systems for group treatment [24], as well as application of telemedicine systems in pediatrics [25] and in various therapeutic practices [26] are also noted. Some authors associate the increase of digital health effectiveness with an

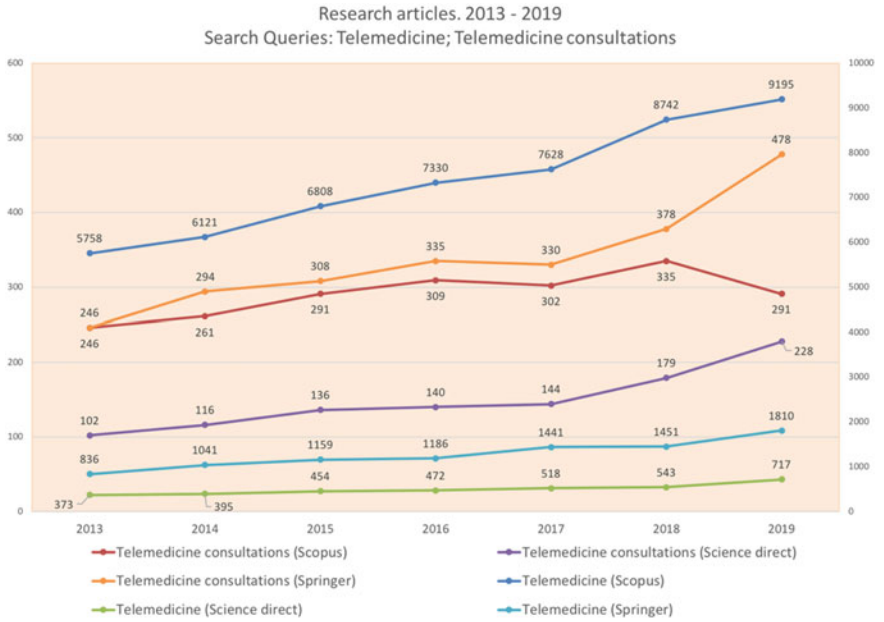


Fig. 3 Dynamics of research interest in telemedicine and telemedicine consultations, requests for "elemedicine" and "Telemedicine consultations" (Scopus, Springer, Science Direct, 2013–2019)

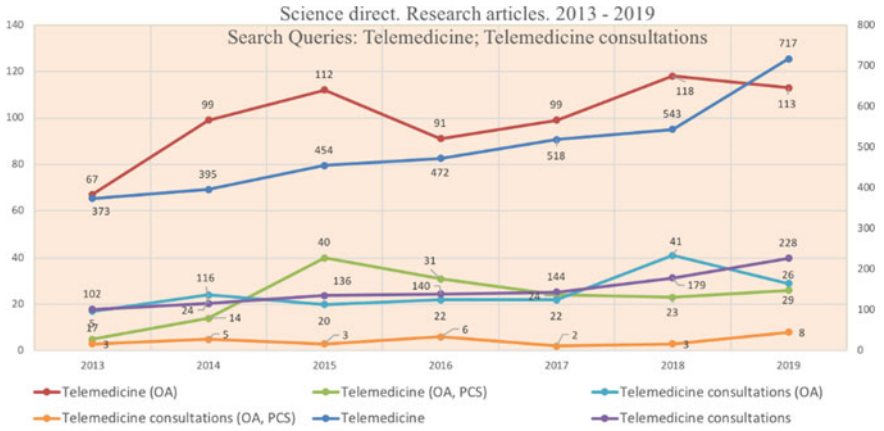


Fig. 4 Science direct (Elsevier). The number of publications and their dynamics (OA—Open Access, PCS—Procedia Computer Science)

electronic health map [27, 28], advent of mobile applications [29–34], artificial intelligence systems [35], and also the Internet of Things (IoT) [36, 37] and blockchain technologies [38]. Various technical aspects to develop telemedicine are discussed and some technological solutions are proposed [39–42].

In Russia, the scientific community also discusses various aspects of e-Health development, primarily organizational and legal issues [43–47].

Refinement and specification of search queries revealed that the number of scientific publications related to Computer Science is noticeably less than the number of publications in medical areas. The total number of scientific publications submitted to Science Direct in open access for the entire period 2008–2019 for the request "Telemedicine Consultations" related to Computer Science is 30. An expert analysis of these 30 articles has shown that only 5 papers are relevant to the case study [48–52]. The results of the analysis demonstrate that the design of telemedicine consultation services and apps is a less popular research field. The existing publicly available solutions, such as video conferencing systems, social networks, and mobile applications, are used for telemedicine service design.

3.2 Russian Federation Laws and Governmental Initiatives in e-Health and Telemedicine

Telemedicine is a form of medical diagnostics, preventive, organizational and managerial processes in healthcare with computer and telecommunication technologies [53]. Telemedicine is a way of providing remote consultative medical care using modern technologies and special equipment. Medical organizations apply telemedicine technologies in the Unified System, the State Healthcare Information system of the Russian Federation, the Medical Information System of a medical organization, and other information systems designed to collect, store, process and provide information regarding the activities of medical organizations and services they provide. Irrefutable evidence of telemedicine has had a significant impact on the Unified System law and funding [54].

The Decree of the Russian Federation Government of December 26, 2017 N 1640 (as amended through November 30, 2019) "On approval of the Russian Federation state program "Healthcare development" [55] has a part "Development and implementation of innovative methods of diagnosis, prevention and treatment, as well as the basics of personalized medicine".

The order of the Ministry of Health and Social Development of the Russian Federation № 364 dated April 28, 2011 "On approval of the Concept for creation of the Unified State Information System in the field of healthcare" in article 9.2. "Improving the implementation of information and telecommunication technologies in healthcare" states: "The status and mechanism for conducting telemedicine consultations and organization of consultations, including application of mobile devices, should be fixed" [56]. At the stage of regulation for the widespread adoption of digital medicine

elements in Russian healthcare practice, the rights, and obligations of participants in telemedicine consultations have been indicated:

(a) Federal Law № 323-FL "On the Fundamentals of Health Protection of the Citizens in the Russian Federation" [57].

This law regulates legal relations in the field of healthcare in the Russian Federation.

(b) Federal Law № 242-FL "Amending Certain Legislative Acts of the Russian Federation on Clarification of Personal Data Processing in Information and Telecommunication Networks" [58]. Article 3 of this law defines "telemedicine technology" and indicates medical care features provided via telemedicine technologies.
(c) Order of the Ministry of Health of the Russian Federation № 965n "On approval of the organization and provision of medical care using telemedicine technologies" [59]. This document indicates the procedure for organizing and providing medical care using telemedicine technologies. The rules of organization, types, conditions and forms, and availability of medical care using telemedicine technologies are established. Consultations in real time and deferred consultations are indicated. The procedure for remote patient's health monitoring and the procedure for documenting and storing medical information during telemedicine consultations are indicated.

The "Electronic Healthcare", a priority project of St. Petersburg, aims to increase medical care efficiency for the citizens of St. Petersburg by creating an integrated electronic health record ("EHR for a citizen of St. Petersburg"). This medical card combines information from various medical organizations. The project also aims to implement at least 45 e-services for patients, doctors, and healthcare managers [60].

The adoption of this series of regulatory documents has significantly increased the interest of medical organizations in providing medical care with telemedicine technologies. These technologies have been reflected in scientific discourse and the media, leading to an increase in the number of publications on this topic.

3.3 The Terminological Core of the Digital Economy Domain

To identify contextual knowledge clusters and to form the terminological core of the interdisciplinary research area "Social aspects of Digital Economy: design of telemedicine services", an analytical review of the Russian Federation programs as well as laws was made.

The preliminary stage of the current research included several steps. First, the terminological core of the Digital Economy domain was selected. The "Digital Economy of the Russian Federation" national program (approved by the Decree of the Russian Federation Government dated July 28, 2017 № 1632 p) was analyzed

Table 1 Digital economy and e-Health: terminological landscape[a]

Tsifrovaia Ekonomika (Digital economy)	Tsifrovizatsiia (Digitalization)
Tsifrovye Tekhnologii (Digital technology)	Informatsionnye tekhnologii (Information technologies)
Tsifrovoe Zdravookhranenie (Digital healthcare)	Tsifrovaia Transformatsiia (Digital transformation)
Elektronnoe Zdravookhranenie (e-Health)	Umnoe Zdravookhranenie (Smart healthcare)
Telemeditsina (Telemedicine)	Telemeditsinskie Sistemy (Telemedicine-health system)
Telemeditsinskie Tekhnologii (Telemedicine technologies)	Meditsinskaia Usluga (Medical service)
Distantsionnoe Konsul'tirovanie (Distant consultations)	Elektronnaia Meditsinskaia Karta (Personal Health Record (PHR))

[a]There are transliterated options of the Russian terms and concepts and their English analogs applied in search process in Table 1. The text in bold features the list of terms and concepts used for search query formation

to initially identify the interdisciplinary text corpus on Digital Economy topic with "Digital Economy" and "digital technology" queries.

The second step included the analysis of the programs and laws in e-Health domain as well as "Electronic Healthcare", a priority project of St. Petersburg. Here, "telemedicine technology" was defined indicating medical care features provided with telemedicine technologies. The documents contain such terms and concepts as "digital health", "telemedicine", "telemedicine technologies", and "telemedicine consultation". The explicated terminological core of the domain with Russian and English collocations is presented in Table 1.

The main terms were identified from various sources:

- Article 3 of Federal Law № 242-FL defines "telemedicine technology", where features of medical care provided using telemedicine technologies are indicated [58, 59];
- Terms "digital health"and "telemedicine" [61];
- Terms "telemedicine" and "telemedicine consultation" [56];
- The main terms are presented in Table 1 [62].

To study the development of the interdisciplinary field "Social aspects of Digital Economy: design of telemedicine services" the relevance of terms and concepts found in Russian full-text digital electronic resources to the terminological core of the "e-Health" domain was assessed. These resources include scientific publications (eLibrary), as well as MEDIA-newspapers and magazines (Integrum). The results obtained with the built-in search tools are presented in Fig. 5.

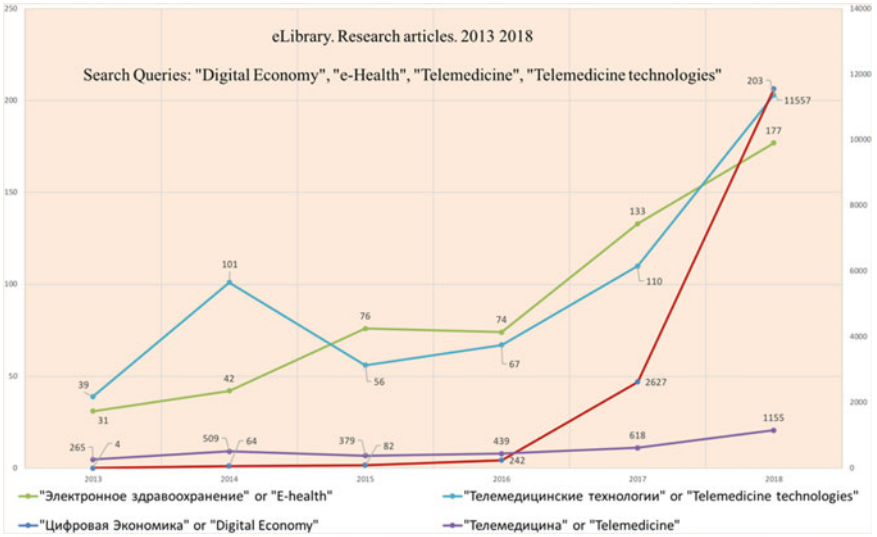


Fig. 5 The dynamics in the number of publications (eLibrary, 2008–2019)

The analysis of these query results from eLibrary indicates that the considered terms and concepts appeared in the early 2000's, that corresponds to the beginning of the information society development in Russia as a sustainable social trend.

To evaluate the number of publications and their dynamics, scientific publications from the Russian information and analytical web portal eLibrary (http://elibrary.ru) were analyzed based on "Digital Economy", "e-Health" and "Telemedicine" terms and concepts. A set of documents was formed by typing the keywords "Digital Economy", "e-Health", "telemedicine" as well as "telemedicine technologies" into the search bar. The advanced search was limited by such sources as journals and conference proceedings, as well as by the dates of publication from 2008 to 2019. Figure 5 presents the most relevant and significant timeline.

The diagram demonstrates a steady growth of interest to the subject domain for every query.

3.4 Telemedicine Development in the e-Health Concept as a Part of Digital Economy Program

To identify key features of the "e-Health" concept development and implementation dynamics, it is proposed to use both scientific digital information resources (eLibrary, http://www.elibrary.ru) and resources accumulating publications from the media that reflect public and political discourse (Integrum, https://integrum.ru).

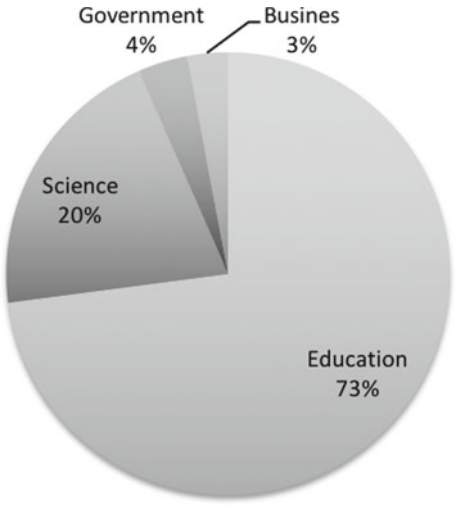


Fig. 6 Distribution of authors' affiliation (eLibrary, 2008–2019)

The extended query in eLibrary was: "cifrovoe zdravoohranenie" or "jelektronnoe zdravoohranenie" or "Digital Healthcare" or "e-Health".

In total, 1246 publications were found for 2008—2019 (Fig. 6).

An analysis of article meta descriptions in the collection of publications revealed authors' affiliation. The majority of organizations belong to the fields of education and science. Business and government in total account for only 7%.

The affiliation distribution by Federal districts of the Russian Federation is presented in Fig. 7.

Most authors of scientific publications represent the Central Federal District. Moscow affiliation makes 80%. The Volga and North-West Federal districts take the second and third places in the rating of publication activity, respectively.

Distribution of affiliations by industry is shown in Fig. 8.

The analysis of scientific publications reveals that their authors equally represent medical institutions (hospitals, medical centers, medical universities and research institutes) and technical universities (Fig. 8). The authors of scientific publications suggest to consider e-Health area in terms of development and implementation of various technological solutions in healthcare. Three groups of researchers: representatives of economic universities, governmental agencies and educational institutions aimed at training specialists for public administration, connect the e-Health area directly with the tasks of the Digital Economy program.

To comparatively assess the dynamics of scientific (eLibrary) and public (Integrum) discourse development, two search queries were performed for the period from 2008 to 2018: "Tsifrovoe zdravookhranenie" or "Elektronnoe zdravookhranenie" or "Digital Healthcare" or "e-Health" or "Telemedicine" (Fig. 9).

The following conclusions are presented based on data analysis:

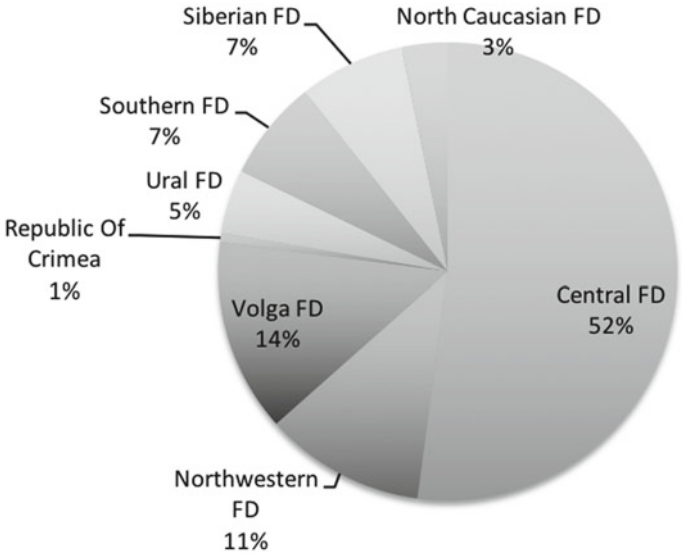
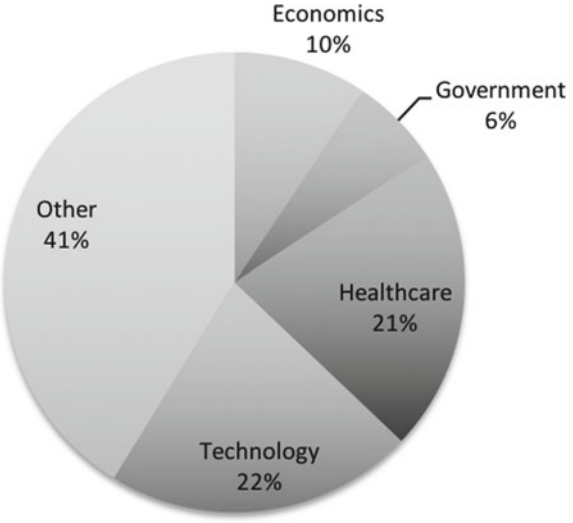


Fig. 7 The affiliation distribution by Federal districts of the Russian Federation (eLibrary, 2008–2019)

Fig. 8 Distribution of affiliations by industry (eLibrary, 2008–2019)



- The e-Health concept includes the "Telemedicine" field. At the same time, "Telemedicine" concept appeared in scientific and public discourse prior to "e-Health" and maintains the upward dynamics of development over the time interval considered.

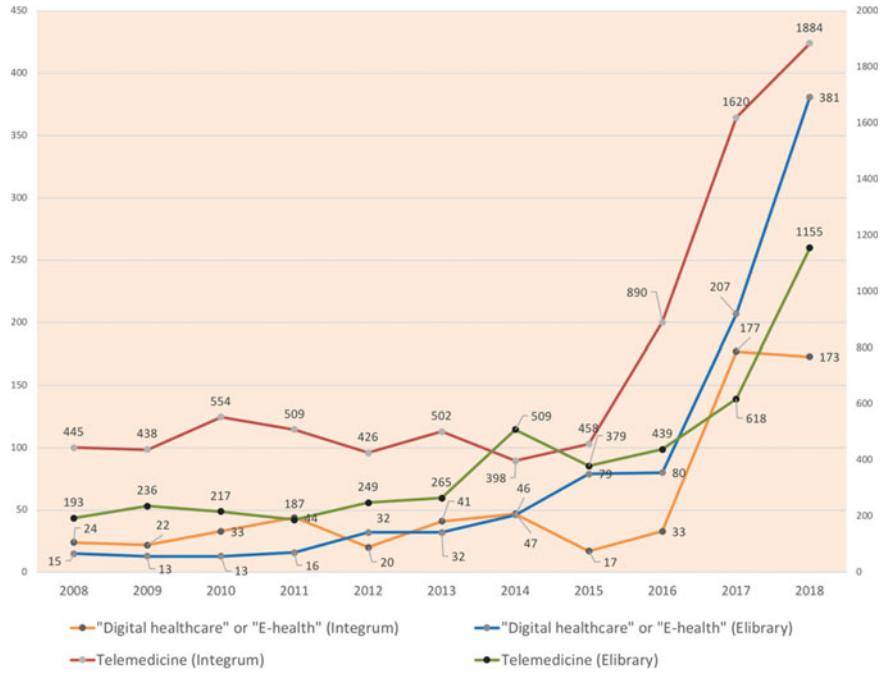


Fig. 9 Russian scientific discourse: dynamics of the publication flow (eLibrary, 2008–2019)

- The issues of e-Health are discussed to a greater extent by scientific community, and telemedicine has a greater response in the media.
- The growth in the number of publications in all the areas presented was noticed in 2017, which is explained by discussion and adoption of several laws and programs in the field of digitalization.

3.5 Development of Telemedicine

The development of telemedicine depends on the evolution of telecommunications and modern technologies, as well as transformation of the healthcare model. Healthcare model transformation results in the availability, quality and timeliness of medical care and the services provided. In Russia, federal and departmental projects appeared in the second half of the 90s: Moscow telemedicine project, the first draft of the federal program "Telemedicine", the project "Moscow—Russian Regions". Since 1997, remote consultations for the regions were organized via videoconferencing and video lecture cycles have started. Since 2001, regional telemedicine systems have been implemented (Table 2) [60]. Attempts are being made to apply telemedicine technologies in the republics of Mordovia, Sakha, Buryatia, Arkhangelsk, Voronezh, Irkutsk, Nizhny Novgorod, Orenburg, Rostov, Samara, Smolensk, Tyumen regions,

Table 2 Federal projects, including telemedicine consultations

27 subjects of the Russian Federation Telemedicine Consultative and Diagnostic Network of the Children of the North Program for distant learning based on the results of cytomorphological, X-ray, and other studies
The Russian Federation telemedicine mobile emergency system based on "HeliosNet" combined access. It provides effective telecommunication exchange of medical data (text, graphics, sound, video) via various satellite channels in real time
Moscow. Telemedicine Center in the Central Clinical Hospital of the Ministry of Railways: real-time telemedicine consultations, lectures and seminars with information displayed both on the monitors of consultants and on demo displays; multipoint transmission and reception of two-stream video and audio conference
Moscow. The technological basis of the project "Moscow—Regions of Russia" is videoconferencing via digital communication channels ISDN (Integrated Services Digital Network): TMK patients are sent for examination or planned operations at leading medical centers in Moscow; consultation of patients after hospital admission; emergency consultation of patients in emergency conditions; distant learning
Moscow telemedicine project aims to create a corporate network combining regional medical institutions with the federal ones to ensure their interaction and remote consultations

Altai and Stavropol territories [63]. Thus, Russia comes to a new stage of the introduction and development of telemedicine technologies.

Table 3 presents the experiments of telemedicine consultations and their implementation in the framework of regional projects.

Commercial electronic telemedicine services are provided in some regions of the Russian Federation (Table 4). They are not well-known among the regional professional community. Moreover, people tend to show mistrust to new services. However, these initiatives are implemented as a sign of progress in healthcare management and as pioneering experiments in the sphere of modern technologies and telemedicine consultations.

Having examined the experience of telemedicine consultations implementation, the following problems that impede the development of telemedicine in the Russian Federation are distinguished:

- Lack of qualified personnel to efficiently interact with telemedicine systems;
- Insufficient equipment in medical institutions, lack of specialized videoconferencing systems and equipped workplaces for medical personnel;
- Problems of compatibility and standardization of devices and technologies used in telemedicine;
- Insufficiently developed legal and regulatory framework that describes the procedure for medical care provision with telemedicine technologies;
- Issues of data protection and confidentiality;
- Patients' resistance for a new type of medical care;
- Low awareness of new services and technologies in Russia;
- Lack of a system mechanism for calculating tariffs for telemedicine services;
- Lack of quality control methods in medical care with telemedicine technologies [62, 64].

Table 3 Regional projects that include telemedicine consultations

Bryansk region The regional diagnostic and treatment center in cooperation with the Hematology Research Center developed and implemented a technology of morphological imaging by a digital camera mounted on a microscope and image storage into a computer. Recommendations and medical reports are delivered by e-mail
Sverdlovsk region The Ural Research Institute of Traumatology and Orthopedics undertook a study to assess the effectiveness of delayed teleconsultations in complex clinical cases when posting depersonalized information on a special server
Kaliningrad region The "OSS Medical Engineering Center" conducts telemedicine consultations with the leading specialists from Moscow, St. Petersburg, and Hanover (Germany). The low bandwidth of information channels does not allow for real-time consultations
Nizhny Novgorod Region In 1998, the Nizhny Novgorod Regional Telemedicine Center started telemedicine consultations in deferred mode. Since 1999 video conferencing has begun. The bulk of medical consultations is performed in federal healthcare institutions with the interregional telemedicine center of the Telemedicine Foundation as a mediator on a contract basis
Arkhangelsk region "Barents Region" Program. A telemedicine center has been created on the basis of the regional hospital and 13 outpatient clinics located at distances from 20 to 700 km from the regional center. The application of telemedicine technology has resulted in a significant reduction in air ambulance services
Altai Territory The developed regional telemedicine system is installed in the telemedicine network of the region. The system includes workstations and the consultations with Moscow research institutes on telepathology and telepediatrics are organized
Voronezh region Telemedicine communication via a digital satellite communication channel is established between the Regional Clinical Hospital and the regional territorial medical associations
Orenburg region The Orenburg Regional Telemedicine Center conducts telemedicine consultations with federal clinical research institutions for both children and adults in videoconferencing mode. The center has created a territorial telemedicine network to help doctors in solving diagnostic and medical issues and provide remote training
Republic of Sakha Since 2015, the AMS Doctor.Net telemedicine information system has been introduced in the republic in district and republican hospitals/early treatment clinics. The system of deferred telemedicine consultations is applied for telemedicine consultations between doctors to clarify the diagnosis, treatment tactics, and for professional teleconferences
Tyumen region Teleconsultations in a "Doctor-patient-doctor" mode are implemented as a pilot phase of telemedicine technologies
St. Petersburg Telemedicine centers have been organized in The Saint Petersburg Research Institute of Emergency Medicine n. a. I. I. Dzhanelidze, and the Saint Petersburg Medical Information and Analytical Center

Table 4 Commercial projects for telemedicine consultations

"Yandex.Zdorov'e" (health.yandex.ru) is a mobile application for 24/7 online consultations with both chat and video conferencing
"Pediatr 24/7" (pediatr247.ru) is a service providing online consultations of pediatricians. A user registers in an application or on a website, receives a patient's personal account and makes an appointment with a doctor
"Online Doktor" (onlinedoctor.ru) is an online family clinic with the functions of the "Pediatr 24/7"
"Doctor Smart" is a blockchain platform for remote consultations with a decision-making support system that accompanies specialists at all stages of work
"DocDoc" (docdoc.ru) is a platform that provides the following services: selection of a doctor in private medical institutions and diagnostic medical centers, doctor home visits, patient visits to a doctor covered by Voluntary Medical Insurance (VMI) policy, telemedicine

In January 2020, a round table meeting on "Development of telemedicine in the Russian Federation: problems of legislative regulation" was held at the Council of the Federation Committee on Social Policy. Following the meeting, recommendations are made to the government of the Russian Federation, the Ministry of Health, regional authorities, members of the Council for the development of Digital Economy in the country.

4 Description of the Smart Service "Doctor-Patient" Telemedicine Consultation

The influence of public opinion on governmental activities is constantly increasing, and the necessity to adopt socially oriented management decisions considering the interests of various social groups is beyond doubt. The "Electronic Healthcare", a priority city project, was reviewed and approved in St. Petersburg in 2018. One of the project objectives is the implementation of 45 electronic services for doctors, patients and healthcare managers, including the "Doctor-patient" telemedicine consultation service [62]. In the framework of the "Doctor-patient" telemedicine consultation, the following forms of interaction are distinguished: Doctor—Patient (or a patient's legal representative); Patient (and/or their legal representatives)—Administrator; Doctor—Administrator. To interact, a patient needs a smartphone, a personal computer or a laptop, and a personal account on the "St. Petersburg Health portal". To get a consultation via video conferencing, a patient needs a camera and a headset. To ensure the possibility of interaction between a patient and a software agent, the latter should include databases with information about patients and medical workers, a videoconferencing module and a chat module.

To ensure information interaction between a doctor and a system administrator (who is also a medical professional), or their communication with a patient, they need a computer connected to a secured network. Access to the telemedicine portal

with a personal account is required. The portal can also be accessed via the Medical Information System operated by a medical organization that provides telemedicine consultation services to patients (provided that the Medical Information System is integrated with the telemedicine consultation service).

The scheme of business interaction in the framework of the "Doctor-patient" telemedicine consultation in real time is shown in Fig. 10.

During face-to-face consultations with a patient a doctor makes a decision about the necessity for further telemedicine consultations. A doctor appoints a telemedicine consultation for a certain time in an electronic form and also leaves a comment with a "Memo to a patient" (if required). The memo contains information on the documents a patient should have, as well as recommendations on how to prepare for the consultation. A patient receives a notification from the personal account about the consultation appointment in accordance with Federal Law № 323-FL "On the fundamentals of protection of the public health" [57], gets acquainted with the voluntary consent to receive medical advice in the form of a telemedicine consultation and accepts its conditions, and confirms their willingness to receive a telemedicine consultation offered by a doctor (or may change the consultation time). Before the consultation, a doctor and a patient receive a notification (by e-mail and in their personal accounts) about the upcoming consultation. Both a patient and a doctor are connected to video conferencing at the time appointed in their personal accounts. During the consultation, a patient and a doctor can use the chat to send text information and exchange documents. Based on the consultation result, a doctor issues a medical report that a patient can read and download in the appropriate section of the personal account. A patient can request an additional consultation indicating convenient date and time. A patient also receives an electronic prescription or medical certificates that are formed by a doctor in the personal account and can be saved and printed. An administrator might also be included in the doctor-patient interaction, to approve the telemedicine consultation date and distribute extra requests from patients.

Patients can have a consultation not only in real time, but also in a deferred mode (provided that a medical organization supports this mode). When forming an application, a patient describes the requested information and attaches the documents required, for instance, the results of medical examinations and tests or pictures (links to documents from the electronic medical records of a patient, individual files). A consultant receives an application, studies with the information provided, and, in case of online consultation, forms a medical report.

The scheme of information interaction in the "Doctor-patient" telemedicine consultation in real time is shown in Fig. 11.

To schedule a consultation in distant mode, a doctor uses the telemedicine service ("Telemedical consultation") from the "Doctor's Portal", and the "Telemedicine consultation" service transfers information to the notification subsystem. A patient receives a notification and contacts the "Telemedicine Consultation" in the personal account on the "Patient Portal", accepts the terms and conditions for the consultation and confirms it (an extra consultation can be requested). Next, the information is sent to the notification subsystem. Then a doctor receives a notification of the confirmed

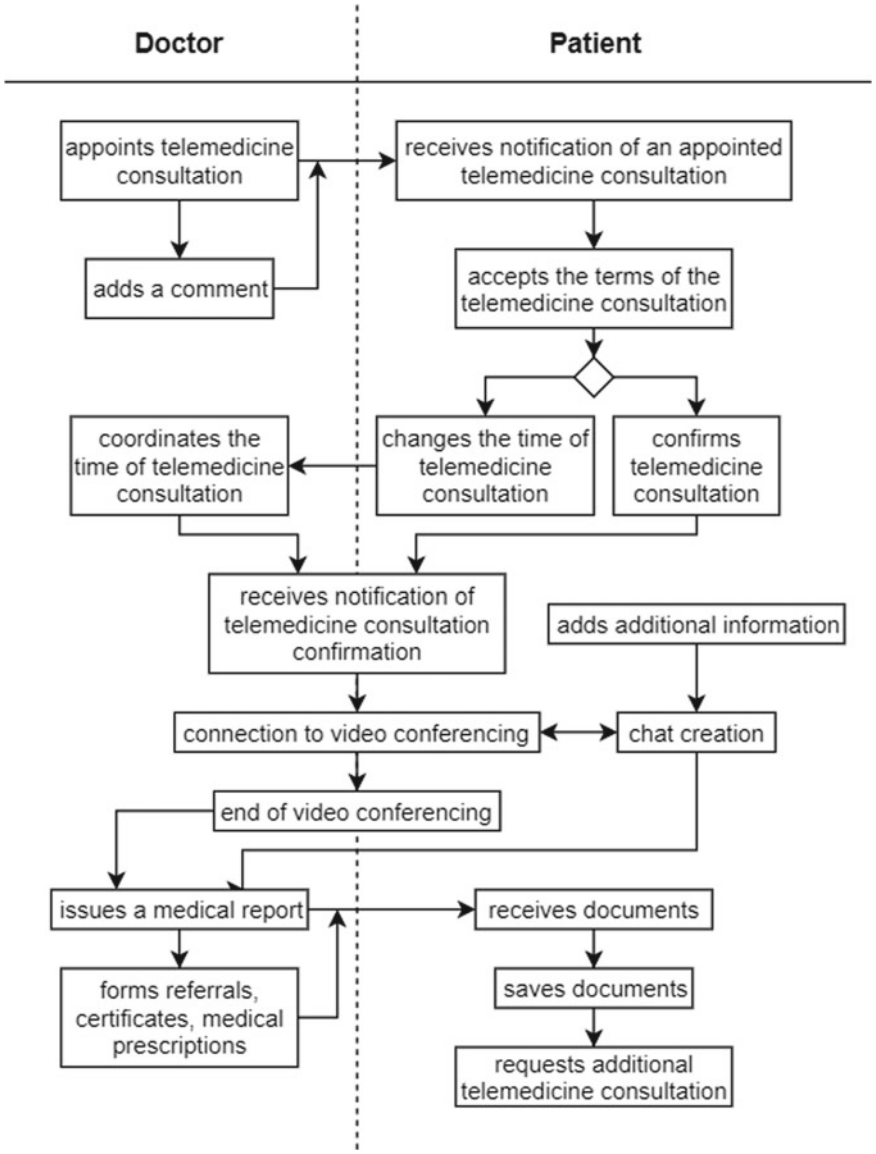


Fig. 10 The scheme of business interaction in the framework of the "Doctor-patient" telemedicine consultation in real time

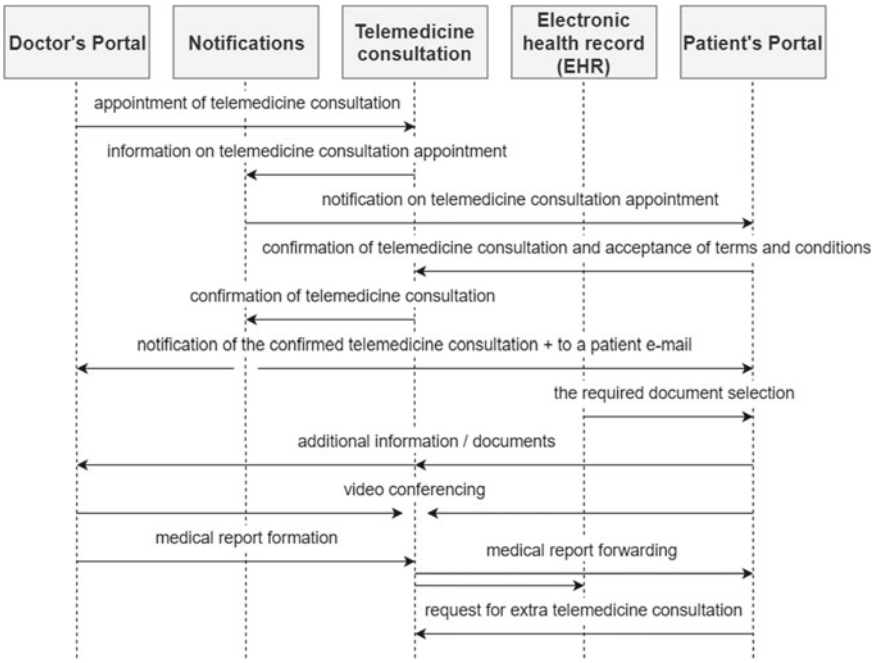


Fig. 11 The scheme of information interaction in the framework of the "Doctor-patient" telemedicine consultation in real time

consultation. In the "Telemedicine Consultation" service, a doctor and a patient can use video conferencing and/or chat. Here, a doctor forms and issues a medical report, which is sent to a patient and to the "EHR for a citizen of St. Petersburg".

5 Conclusions and Recommendations

The study showed that telemedicine and telemedicine consultations practice in Russia correspond to global trends of Digital Healthcare development. These spheres are being developed in Russia both at federal and regional levels. The increase of interest to these spheres has been growing since 2017 due to implementation of a full-scale program for electronic medicine development, which is an integral part of the Digital Economy of the Russian Federation national program. The issues of telemedicine development are discussed not only by the scientific community, but also in the socio-political discourse, and in the media.

The legal and regulatory framework of the Russian Federation allows for the "Doctor-patient" consultations in distant mode, while imposing some requirements and restrictions that must be considered when designing a service. A review of telemedicine consultations, their procedure and implementation, allowed to identify

basic issues and formulate problems in this research area. The results of business and information processes study in the "Doctor-Patient" telemedical consultation will be applied in St. Petersburg medical information and analytical center to create a new electronic service in the framework of the "Electronic Healthcare", a priority project of St. Petersburg.

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