UDC 004.5 https://doi.org/10.15407/pp2020.04.098

L.A. Girchenko, A.Y. Doroshenko, Y.V. Ziubrytska

MANAGEMENT OF THE COORDINATION PROCESS IN THE SOCIOTECHNICAL SYSTEM

The article considers the theoretical principles of management of the coordination process in the sociotechnical system. On the example of the selected IT company, the corporate knowledge base is researched, the problems of using the corporate knowledge base are analyzed and the directions of corporate knowledge base transformation are outlined with the help of software tools for its coordinated use and in-depth presentation of knowledge. As a result, the types of spaces in the corporate knowledge base are identified and recommendations for methods of managing them are offered.

Key words: knowledge management, corporate knowledge base, in-depth presentation of knowledge, information space, IT company, sociotechnical systems.

Introduction

A distinctive feature of the modern information society is that most employees are engaged in the production, storage, processing and sale of information, especially its highest form – knowledge. In the informatization of society, the main attention is paid to a set of measures aimed at ensuring the full use of reliable, comprehensive and timely knowledge in all human activities. The direction of knowledge management began to develop rapidly in the 90s of last century. This was due to a change in priorities in business and society, as well as the ongoing scientific and technological revolution, which is based on the use of the latest information technology in all areas of human activity. The most profitable and attractive area for investment is the development of high technology and service, which determine the rapid return on investment, reduce dependence on raw materials, provide an opportunity to capture new niches in the use of goods or services. Thus, the direction of research on the management of corporate knowledge bases in sociotechnical systems is relevant.

Important aspects considered from a practical point of view are methodological approaches and the practice of ensuring the management of the coordination process in the sociotechnical system. The research methods were general scientific methods, systematization, grouping, comparison, analogies, coefficients, structural, factorial, statistical and comparative analysis, empirical knowledge, expert assessments, design. Development tools: Confluence, XMind, Draw.io [1–3].

In recent years, there has been a growing interest in complex systems that involve both humans and computers that can be coordinated. Coordination can be seen as a process of *managing the relationships* between different activities. Coordination issues have been studied by many scholars Bond and Gasser, Huhns and Gasser, Malone and Crowston, A.V. Anisimov, F.I. Andon, A.Y. Doroshenko, S.D. Pogoriliy, G.E. Zeitlin, O.A Yatsenko and others. Thus, further progress may be possible by characterizing different types of dependencies and identifying coordination processes that can be used to manage them [4].

Coordination models and languages have attracted the attention of the scientific community in many fields, including the design of distributed and parallel computer systems. Parallel programs developed in the style of coordination have two components – a computational model and a coordination model, which are responsible for the algorithmic and behavioral aspects of computing, respectively. Coordination tools, as shown earlier, can serve not only as a software integrator, but also as a software accelerator in terms of improving the performance of parallel programs [5–7].

The purpose of this article is to outline the areas of management of the coordination process, to develop practical recommendations for the management and use of corporate

knowledge bases and to implement these recommendations in improving the effectiveness of sociotechnical systems.

1. Analysis of existing problems of using the corporate knowledge base

Any production organization is a complex sociotechnical system, which logically distinguishes material and human factors of production, and which is considered in terms of interaction of the two subsystems:

- technical and economic, which includes not only technical and technological factors, but also management knowledge, organizational structures, methods of production planning, job development, techniques and skills, the level of qualification and design of the labor process, which in turn improves economic efficiency of the organization.
- social, which includes values of the organization, attitude to the functions performed, forms of incentives for employees, management style, employee participation in decision-making, career opportunities, organizational culture, etc.

The term «sociotechnical system» was first coined in the 1960 s by Eric Trist and Fred Emery, consultants at the Tavistock Institute of Human Relations (London). The concept of sociotechnical systems, in contrast to the unilateral action of technology on man, is based on the idea of human-machine interaction. The design of technical and social conditions should be carried out in such a way that technological efficiency and humanitarian aspects do not contradict each other.

Researchers cite several characteristics of the sociotechnical system, which ensure success in the intensified competition and at the same time characterize the level of development of new managerial thinking. One of them is the organizational philosophy, which provides knowledge and understanding by the employees of the organization's goals and mission, readiness to take full responsibility for the final results of the activity. Second, the organizational structure of management provides employees with the right to participate in the management of the organization. An innovative approach to job development and the role of the executor in the decision-making process is also important. The characteristics also include innovative forms and methods of training and retraining, more flexible personnel policy aimed at guaranteeing employment. Training should be based on mastering a wide range of specializations, as well as on acquiring knowledge that enables employees to perform various functions, be competent in various aspects of work, master related professions and master the so-called professions of the future. Another important characteristic is the new criteria in assessing the economic efficiency of the use of modern technologies and capital investments in the development of production [8].

The widespread use of information technology has changed the way people work together. Coordination can take place in different types of systems. For example, specialized software was developed to support the collaboration of several authors on the same document; now it helps people display and manipulate information more effectively in meetings; helps people use the email process productively.

The continued development of new computer programs in this area is guided by a consistent theory of how people coordinate their activities without information technology, and how they can do so much more productively with computer support. It is important to understand the effects of information technology on the activities of human organizations and markets, the design of cooperative working tools and the design of distributed and parallel computer systems.

Well-established coordination is often invisible, but its absence immediately becomes visible. Examples of fuzzy coordination are when we book and pay for an apartment in a foreign country, but spend an hour waiting for the keys or cleaning finishing, or when our favorite word processor stops working on a new version of the operating system. We can become very aware of the consequences of poor coordination.

Coordination can be used in many types of systems: human, computational, biological, and so on. As for the question of dependency management in human activity, it is central to the theory of organizations, eco-

nomics, management science, sociology, social psychology, anthropology, linguistics, law and political science. In computer systems, the dependencies between different computational processes must be managed, and, as many researchers point out, certain types of interactions between computational processes resemble interactions between people [8].

One of the advantages of the definition used for coordination is that coordination offers a direction for addressing issues. If coordination is defined as dependency management, then further progress can be made by characterizing the different types of dependencies and identifying coordination processes that can be used to manage them.

For interdependence between components, coordination is important because it explicitly or implicitly affects the performance of certain activities (eg, design or redesign of components) [4].

Many coordination processes require decisions that affect the activities of the organization. For example, in sharing resources, the group must "decide" how to allocate resources; in task/subtask management, the group must "decide" how to segment the task. In all these cases, alternative ways of making group decisions generate coordination processes. For example, any group decision may be made by management (e.g., a "manager" who makes a decision), a vote, or a consensus (as a result of negotiations) [4].

An obvious way to generate new coordination processes are alternative forms of communication (synchronous versus asynchronous, paper versus electronic) for everywhere in the process where information needs to be transmitted. The coordination structure also emphasizes new aspects of the problems. For example, when we view communication as a way to manage the relationship between producer and consumer, we need to take care of how to make the information "usable." Coordination models can include parameters for things like incentives, productivity, and communication costs that vary widely across human, computing, and biological systems [4].

In order to analyze the terminology of coordination, it is important to clearly define the components of coordination. It is useful to define evaluation criteria. For example, we may define some general "goals" of the activity (for example, car production or report printing) and other measurements to assess how well these goals are being met (for example, minimizing time or cost). Some coordination processes may be faster or more accurate than others, for example, greater coordination is not always worth it. It is important to realize that there is no "right" way to determine the components of coordination in different situations. For example, we can sometimes analyze everything that happens in a production unit as one "activity", and at other times we can analyze each station on the assembly line as a separate "activity". As another example, we can give the example of muscle coordination, when different parts of the body of the same person are implicitly considered as separate "actors" performing separate "actions". When analyzing coordination in human organizations, it is often helpful to simply ask people what their goals are and evaluate their behavior in terms of these criteria. Another important example is the coordination of market operations. The goal of market participants may be to maximize their individual benefits, but the market as a coordination mechanism must be assessed in terms of how well it meets such general criteria as maximizing the needs of market participants [4].

Coordination is an activity that in itself involves certain costs. Although there are many other factors that can affect the way organizations and markets coordinate (e.g., global competition, national culture, government regulation, and interest rates). One important feature, of course, is its cost. And it seems plausible that information technology can significantly reduce the cost of certain types of coordination.

You can make a few simple predictions about the possible consequences of reducing coordination costs. It is useful to illustrate these effects by analogy with similar changes in transportation costs caused by the introduction of trains and cars:

1. The effect of reducing the "first order" of transport costs trains and cars were

achieved simply by a certain replacement of the old transportation technologies with new ones: people began to ride trains more and in carriages with horses less.

2. The effect of reducing the "second order" of transport costs was reflected in the increase in the number of used vehicles: people began to travel more, and it goes without saying that it could be done cheaper and more convenient on trains than on foot.

3. Finally, the effect of the "third order" allowed to create more structures of intensive transportation: people eventually began to live in a remote suburb and use shopping malls outside the city. These two examples of new structures undoubtedly depend on the wide availability of cheap and convenient transportation.

You can also expect several effects from the use of new information technologies to reduce coordination costs:

1. The "first order" effect of reducing the cost of coordination with information technology may be a replacement for information technology of some types of coordination of people. For example, many banks and insurance companies have replaced large numbers of human officials in their offices with automated systems. It has also long been predicted that computers will lead to the demise of middle management, as communication tasks performed by middle managers can be performed more cheaply, namely with the help of computers. This prediction has not been realized for decades, but many people believed that it would finally begin to happen en masse in the mid-1980 s and 1990 s.

2. The effect of reducing the "second order" You can increase the cost of coordination of the total amount on second-hand coordination. In some cases, this may interfere with the first-order effect. For example, in one case studied by the authors of the study, a computerized conference system was used to eliminate middle managers [4]. However, a few years later, almost as many new positions were created for corporate staff, many of whom were helped by new computer systems. This example demonstrates that the resource management task can now be applied to more complex analysis that was not possible before.

3. The "third order" effect of reducing coordination costs may encourage the transition to more "intensive coordination" of structures. In other words, coordination structures that were previously too "expensive" will now become more effective. Technologies such as e-mail and computer conferencing can help reduce the cost of these types of communications and advanced means of information exchange [4].

Reducing the cost of coordination through information technology can lead to a general shift to smaller firms and a proportional increase in the use of markets, from internal decision-making within firms to the coordination of economic activity in general. It is clear that the coordination of market operations is much more expensive than internal coordination.

IT can lead to both centralization and decentralization, depending on how they are used. This conclusion can be made by clearly defining the main factors. When IT implementation reduces information costs for decision making, it leads to greater centralization. For example, Otis Elevator used IT to centralize reporting and manage customer service functions, instead of distributing these functions to numerous remote field offices. On the other hand, when IT primarily reduces agency costs, it leads to greater decentralization. In this case, agency costs are the costs of employees who do not act in the interests of the firm. For example, when one insurance company developed a system to more effectively monitor the overall performance of its vendors, they were able to decentralize many decisions to vendors, whereas previously they were made centrally [4]. Coordination theories are also useful in the following areas:

- in the empirical study of human coordination or other biological systems (eg, field, laboratory or econometric studies);
- in the development of new technologies to support human coordination;
- when designing and experimenting with new methods of coordination of distributed and parallel computer systems;

– in formal modeling of coordination processes (for example, mathematical or computer modeling).

Thus, we can conclude that the ideas of coordination are useful, because they offer new systems, by classifying systems and analyzing how systems use them; that scientists have been paying attention to coordination since the middle of the twentieth century, and that new information technologies have an impact on both markets and organizations, in particular: the size of organizations and the degree of centralization of decision-making in them. General coordination mechanisms can manage many dependencies: both market operations, centralized and decentralized management decisions, and internal decision-making processes in an individual organization. Coordination helps address a variety of immediate practical needs, including:

– designing computer and communication tools that allow people to work together more effectively;

– using the power of several computer processors working simultaneously on common problems;

– creating more flexible and efficient ways of organizing collective human activity.

The knowledge management system in the set of applied tools and the mechanism of information support on the basis of modern information technologies is called to provide innovative development of the company, so necessary in the conditions of development of a society.

IT companies, more than others, should focus on the use of the latest technologies for more efficient organization of the external and internal environment: electronic document management, gamification, socialized corporate portal, BigData, BI-analytics, OLAP, automated controlling and more. All this is absolutely close to the understanding by the information technology professionals.

Therefore, IT companies must act as representatives of the innovation sector of the economy, creating unique mechanisms of management systems to stimulate their innovative development, including comprehensive controlling systems to assess the effectiveness of implemented tools based on selected indicators.

Effective solutions help create new products, improve old ones and increase customer satisfaction. When the support service answers questions faster and more accurately, solves problems of users, dissatisfied customers become less. This reduces the outflow of users, which increases financial performance.

Knowledge management is the process of processing, managing and using the knowledge and experience of employees (internal experts) to effectively solve problems.

Coding Sans conducted research in European IT companies (see Fig. 1). Employees were asked one question: "What is the main challenge in the field of software development do you see for yourself?" A fifth of respondents from various positions indicated that this is an exchange of knowledge. This is the second result after «capacity» – the ability to solve more problems in less time.

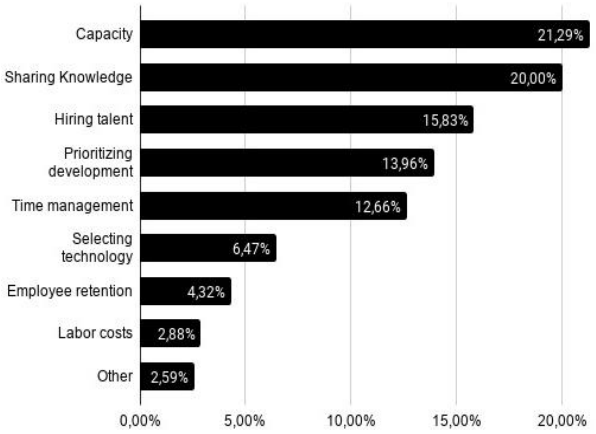

Fig. 1. Results of respondents' answers to the main challenge in the field of software development

But it is much more interesting to compare the voices between those who write the code and their managers (Fig. 2).

The column with information about managers is marked in white, and the column with information about developers is marked in dark color. The difference between the values is almost a third in relative terms. It turns out that the developer finds channel for knowledge management more important.

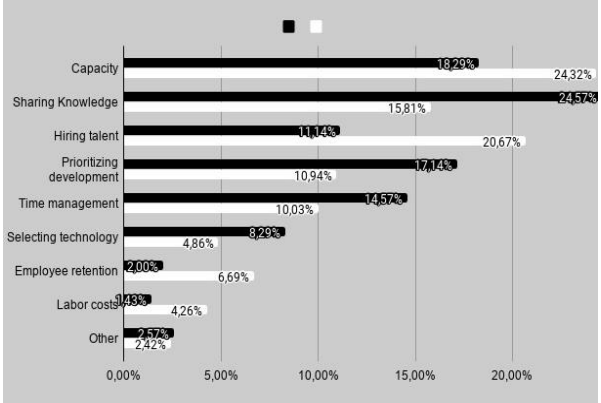

Fig. 2. Respondents' responses to the main challenge in software development compared to code writers and managers [9]

It is more important for managers to keep up with everything. Typically, they delegate tasks to subordinates: they turn to HR, hire more developers, and expect for tasks to be closed on time.

Even if the recruiter collects all the cream of the market, the problem will not go anywhere. Developers don't have a way to get information operatively in order to close tasks quickly, so the problem will arise again, but on a larger scale. This is an endless cycle from which the manager himself will not come out.

Software companies face the challenge of developing, selling, supplying and maintaining increasingly sophisticated solutions and products. This can be done most effectively only with a knowledge management system.

2. General characteristics of the company

An international technology product company with a full cycle of development in the field of Entertainment was selected for the study. It is part of a global holding company with a total staff of almost 2,000 people.

The company is an ecosystem that combines IT products, marketing and other areas. Works on the development of product innovations, the creation of competitive advantages of products and the company as a whole, accumulates expertise and speed of implementation, unites in research teams of professionals and implements bold and risky ideas.

3. Corporate knowledge base management tools

Effective management of the corporate knowledge base requires the use of modern tools. The choice of tools depends on the tasks, problems and opportunities in a particular organization. For example, for one company it is necessary to create an effective and stable communication space for interaction between departments, and for another it is necessary to start processes of continuous selection and evaluation of ideas and proposals of employees, for the third it is necessary to focus on creating special relationships with its customers. Let's consider the features of using the tools Confluence, XMind, drow.io for the collection, analysis, exchange and transfer of corporate knowledge.

Confluence – Web-based corporate wiki, which is used mainly within the organization, forming a single whole organization to achieve its goals, and is a space for teamwork, which accumulates information and opportunities for collaboration. It was developed by Atlassian Software Systems and more than 50 million companies worldwide use the company's products (the most popular are JIRA and Confluence). Confluence simplifies collaboration within the team and allows you to organize effective information management. Integration with Microsoft Office facilitates its use in a familiar environment: create content and collaborate on documents, spreadsheets and presentations on Confluence pages, edit pages directly from Microsoft Office.

Confluence has a sophisticated information retrieval system with the ability to quickly search for keywords. The information in Confluence is placed by sections or spaces that contain pages. Spaces allow you to share information between projects or teams, can have a unique data structure and appearance depending on the goals of the project. You can create a space using appearance templates for easier data organization. The basic editing tools available in the panel at the top of the window are used to edit and add information to pages. Macros are used to add files, charts, content, various reports, etc. [1].

XMind is software for creating so-called mind maps for brainstorming, which help to organize information in a visual associative form. XMind is a tool that helps capture thoughts and chart them. In other words, with this program you can detail your task and work on it more purposefully. Each element of the map can be an idea connected to other ideas through hierarchical connections. The program allows the user to capture their thoughts, build them into different charts, use these charts with other users. XMind supports intelligence maps (connection diagrams), Ishikawa diagrams (also known as causal or fishbone diagrams), tree diagrams, and tables. XMind is convenient to use for corporate knowledge management, during meetings, in task management, in time management [2].

Draw.io – a service designed for the creating of classic diagrams, relationship diagrams of logical objects, network diagrams, organizational charts of diagrams, graphs, flowcharts, electronic circuits, UML-models, business process models, interactive design prototypes and layouts, inserts in image diagrams, etc. [3].

The described tools are modern means of conceptual design of information systems that can significantly improve the productivity and coordination of joint work.

4. Practical recommendations

Let's define the transformation of corporate knowledge databases. To put documentation in defined order, firstly, it's recommended to logically separate it into product (which relates to description of the product) and operating (which relates to internal processes of company). They have different business requirements, working regulations, accounting, etc. This logical separation is offered to be done with the help of Confluence labels or another pages attributes. Also, the structure of the corporate knowledge database is developed considering the future necessity to take out part of information into external databases with minimal efforts, for example, for customers.

To such kind of information belongs general description of product/module, manuals, user guidance's, description of external API's, articles about malfunction eliminations.

Some part of information in the corporate knowledge database will be presented just for internal use, information about system's architecture, information about physical infrastructure (servers, networks, etc), technical support, administrators guidances, different operating documentation of the team (reports, statuses of projects and tasks, etc).

Recommended steps for realization during creating of new united corporate knowledge database:

1. Poll final users and formulation of requirements for internal Wikipedia.
2. Analysis current database to highlight popular and not relevant blocks.
3. Creating a plan and vision of corporate knowledge database development.
4. Creating a clear corporate knowledge database structure on Confluence and descriptions in schemas for every space.
5. Transformation of the database main page.
6. Creating a glossary with all local terminology for team synchronization.
7. Implementation of a new safety principle, which will be defined in the next clause.
8. Making the transition when working with Confluence from «everything is secret» to «everything is open» on Read (if there is any secret information – hide it on the closed page).
9. Database modification in the way that any employee of any department can find the necessary information, without previously knowing where to look for it.

After modification of all spaces they can be classified due to three types.

The first type includes space, where documentation of one team of developers is kept (see Fig. 3).

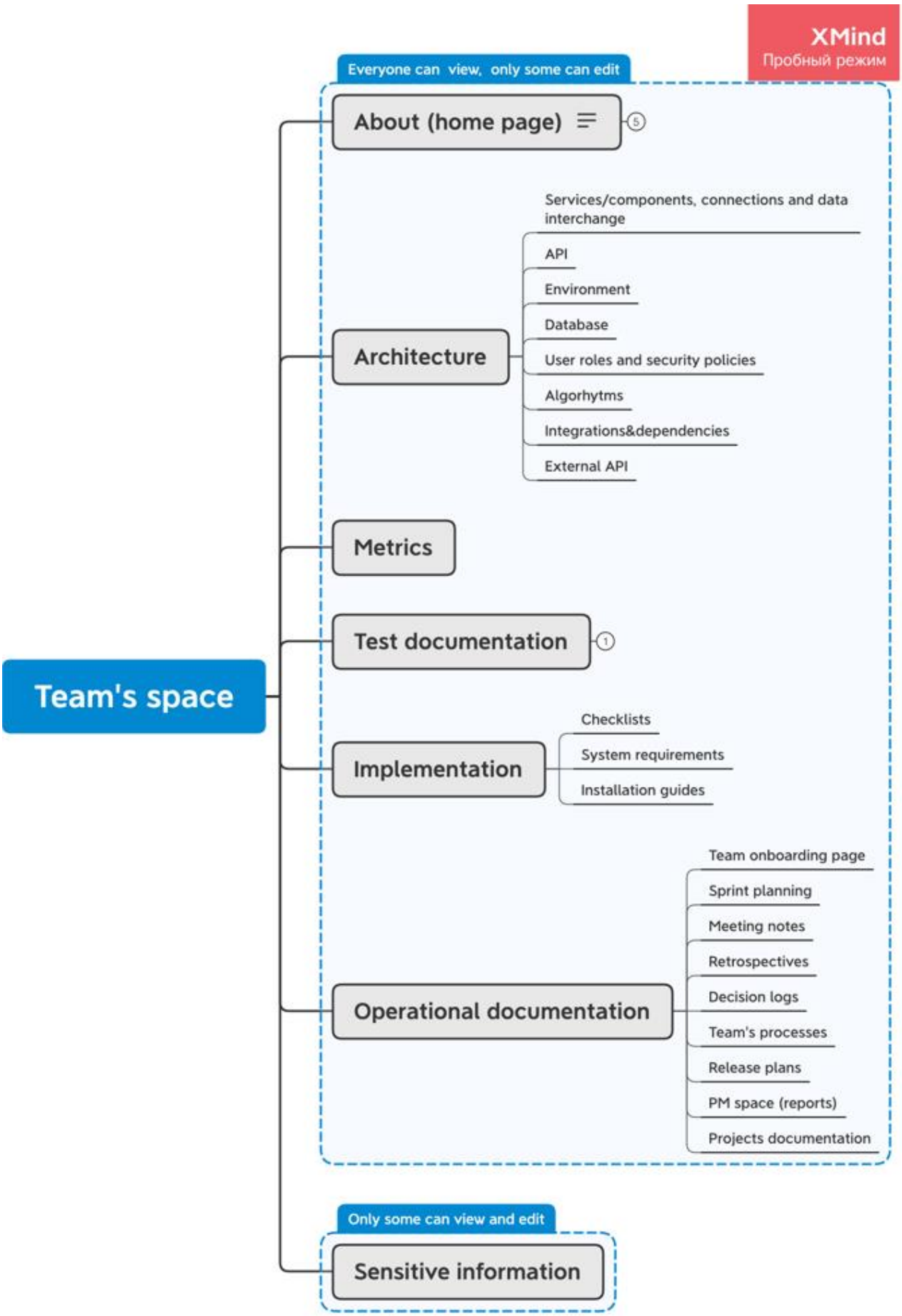

Fig. 3. Space of the first type

It is necessary to adhere to the principle of division documentation into product (all, that relates directly to the product: architecture, interaction with others, environment, API, etc) and operating which concerns directly the working process within the team).

The second type includes space, where there is processed documentation of a few teams or only one team, but including a few products. For successful use of created schemes it is recommended to use additional navigation tools: pages will be assigned team labels, then a list of all labeled pages will be automatically compiled by the content by label macro into content for one team.

Version 1: At the first level we create separate sections for each team, within these sections we repeat the distribution, presented in drawing. The documents of each team are collected together, which is convenient for the team. For a third-party user looking for information, extra levels of page hierarchy are added, and it may not be obvious which section contains the document you want.

It may turn out that the documentation for the same product is divided into different sections (see Fig. 4).

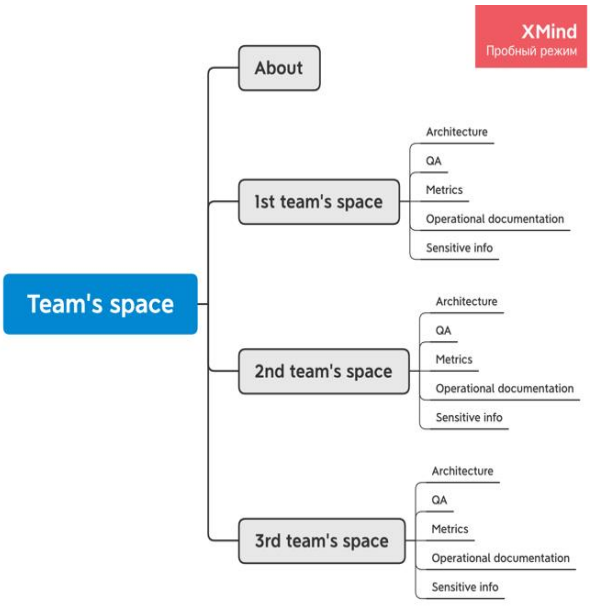

Fig. 4. Space of the second type of ver.1

Version 2: At first level we save distributions, for example, Architecture, Metrics, QA, Operating Documentation, at the next levels we divide into specific teams. Documents for the product are collected, which makes finding information more easily, positively affects its integrity and fullness. The team may feel uncomfortable when its documents are classified for different sections. To reduce this uncertainty it is suggested to use an additional navigation tool: pages will have teams labels and then a list of all labeled pages should be automatically collected by macro content by label into the content for one team (see Fig. 5).

The third type includes a space in which there is no documentation for specific products, and only reporting and other documentation is maintained (see Fig. 6).

The first page of all spaces should be as informative as possible for the user who entered this space for the first time. It should contain information about the team / products, links to the most important and frequently visited pages, it should simplify navigation in space.

Below is a list of sections that are recommended to be presented on a first page of each space:

1. For which team/product or for what purpose does this space exist. Optionally should be added, on what questions this team is responsible and in which way. Example message for one of the teams: “Hi, this is a space of a team of technical writers. We write documents for everyone, keep a glossary, maintain the relevance of documentation. If you need to add your term to the glossary, draw the architecture of the program or write a user manual, we will help. Write an application to the Technical Writers project at JIRA”.
2. The composition of the team or at least the leader and the one that is responsible for the product.
3. How to look for information in space. Links to the most commonly used product and operating documentation, necessarily including the link to the onboarding page.
4. Recently edited pages.
5. Popular documents.
6. Search.
7. Useful links.

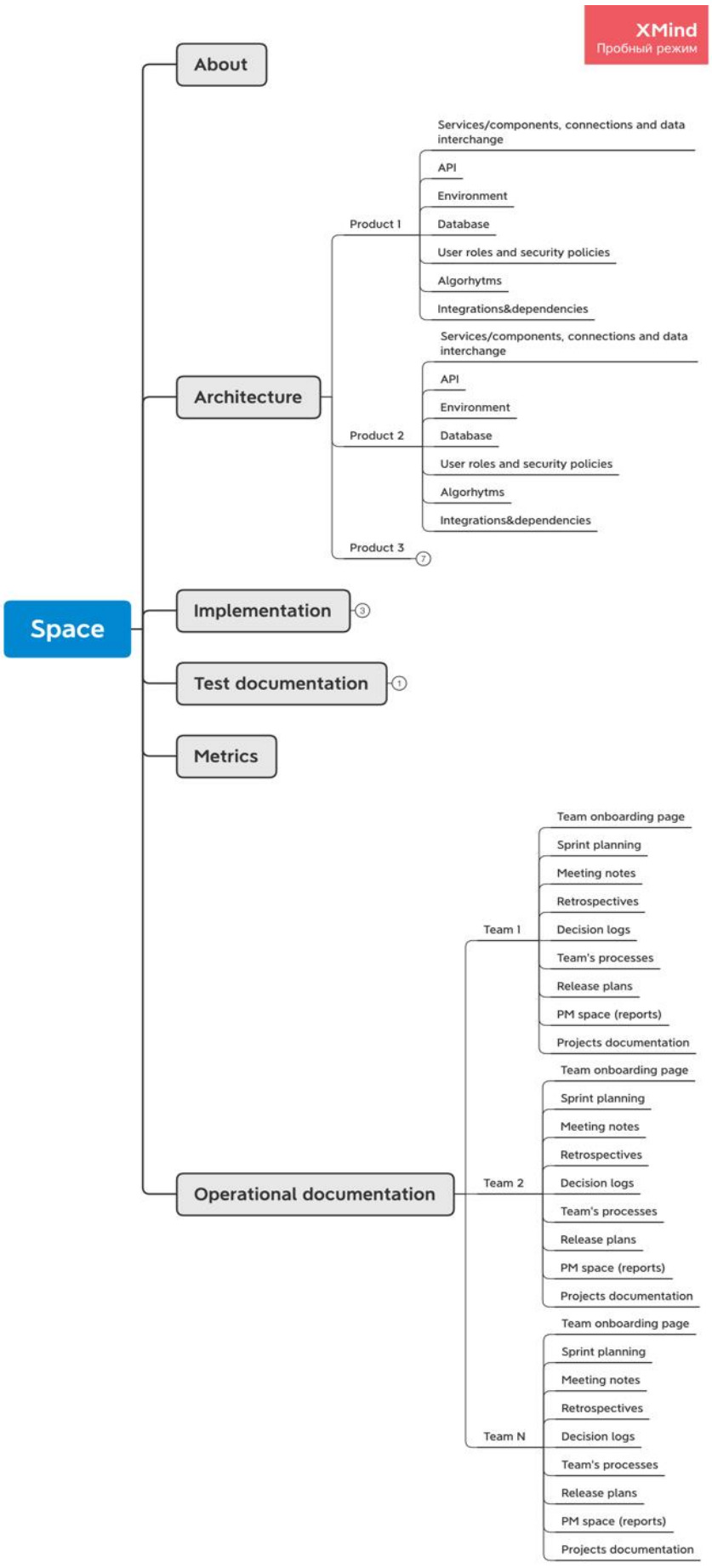

Fig. 5. Space of the second type of ver.2

Fig. 6. Space of the third type

8. You can also place a tree of space pages here, but this is optional because it is always presented in the menu on the left. By default, all Confluence spaces will be created open for viewing to all logged-in users. Anyway, each space will have a section for confidential information, access to which by default will be open only to the owner of the space and closed to all others.

Since the access permissions for Confluence pages are inherited by hierarchy, i.e. if the user is denied access to the parent page, it is automatically closed to all children, then access within the space will be easy to control: the page placed in the confidential information section or created in it will automatically disappear from public access, and to share the page, just move it from this section to any other.

Conclusions

Thus, the analysis of a large array of statistics, the study of existing software, foreign experience and the current state of knowledge management allows us to conclude that the ideas of coordination are useful because they offer new systems, by classifying systems and analyzing how present systems use them. Scientists have been paying attention to coordination since the middle of the twentieth century, and new information technologies have an impact on both markets and organizations, in particular: the size of organizations and the degree of centralization of decision-making in them. General coordination mechanisms can manage many dependencies: both market operations, centralized and decentralized management decisions, and internal decision-making processes in an individual organization. Coordination helps to address a variety of immediate practical needs. Research of the corporate knowledge base on the example of an IT company, analysis of the problems of its use and features of the use of development tools allowed to structure the spaces of the corporate knowledge base of the IT company; unify the pages of the corporate knowledge base of the IT company; create a convenient navigation of the corporate knowledge base of the IT company; introduce templates for key pages in space (about, processes, metrics, etc.) and new approaches to data storage in terms of company security. As a result of the study, the methods of renewal, updating, supplementing and avoiding duplication of information in the corporate knowledge base were improved.

References

1. https://www.atlassian.com/software/confluence
2. https://www.xmind.net/
3. https://drawio-app.com/
4. Malone T.W., Crowston K. The Interdisciplinary Study of Coordination. *ACM Computing Surveys*. 1994. Vol. 26. N. l. P. 87–119.
5. Doroshenko A. Coordination Facilities to Enhance Concurrency of Race-Free Parallel Algorithms "High Performance Computing and Networking", Proc.Int. Conf., Amsterdam, Netherlads. *Lect. Notes in Computer Sci*. 1998. Vol. 1401. Springer Verlag. P. 950–952.
6. Doroshenko A., Thorelli L.-E., Vlassov V., Coordination Models and Facilities Could be

Parallel Software Accelerators. in *"High Performance Computing and Networking"*, Proc. 7-th Int. Conf. HPCN'99.-LNCS, Vol. 1593. P. 1219–1222.
7. Doroshenko A. Coordination Programming Abstractions for Efficient Parallel Programs. in UkrPROG'98: Proc. I Int. Scientific and Practical conf. in programming UkrPROG'98, Kyiv, Sept. 2-4.1998, Glushkov Institute of Cybernetics. P. 235–242.
8. Gary M. Olson, Thomas W. Malone, JOHN B. Smith (eds.). Coordination theory and collaboration technology. Lawrence Erlbaum Associates, Inc., 2001. 816 p.
9. https://codingsans.com/state-of-software-development-2019

Література

1. https://www.atlassian.com/software/confluence
2. https://www.xmind.net/
3. https://drawio-app.com/
4. Malone T.W., Crowston K. The Interdisciplinary Study of Coordination. *ACM Computing Surveys*. 1994. vol. 26. No. l. P. 87–119.
5. Doroshenko A. Coordination Facilities to Enhance Concurrency of Race-Free Parallel Algorithms "High Performance Computing and Networking", Proc.Int. Conf., Amsterdam, Netherlads. *Lect. Notes in Computer Sci*. 1998. Vol. 1401. Springer Verlag. P. 950–952.
6. Doroshenko A., Thorelli L.-E., Vlassov V., Coordination Models and Facilities Could be Parallel Software Accelerators. in *"High Performance Computing and Networking"*, Proc. 7-th Int. Conf. HPCN'99.-LNCS, Vol. 1593. P. 1219–1222.
7. Doroshenko A. Coordination Programming Abstractions for Efficient Parallel Programs. in UkrPROG'98: Proc. I Int. Scientific and Practical conf. in programming UkrPROG'98, Kyiv, Sept. 2-4.1998, Glushkov Institute of Cybernetics. P. 235–242.
8. Gary M. Olson, Thomas W. Malone, JOHN B. Smith (eds.). Coordination theory and collaboration technology. Lawrence Erlbaum Associates, Inc., 2001. 816 p.
10. https://codingsans.com/state-of-software-development-2019

Received 23.10.2020

About authors:

Girchenko Liudmyla Andriivna,
Graduate student
Faculty of Computer Science and Cybernetics.
Number of scientific publications in Ukrainian publishing houses – 7.
Number of scientific publications in foreign publishing houses – 3.
http://orcid.org/0000-0002-5433-2399,

Doroshenko Anatoly Yuhymovych,
Doctor of physical and mathematical sciences,
Professor, Head of the Theory Department computer computing of the Institute software systems of the NAS of Ukraine,
Professor of Automation and management in Technical systems.
Number of scientific publications in Ukrainian publishing houses – more than 150.
Number of scientific publications in foreign publishing houses – more than 50.
h-index – 6.
http://orcid.org/0000-0002-8435-1451,

Ziubrytska Yuliia Viacheslavivna,
Graduate student
Faculty of Computer Science and Cybernetics.
http://orcid.org/0000-0001-5025-8614.

Affiliation:

Taras Shevchenko National University of Kyiv.
60 Volodymyrska Street, City of Kyiv, Ukraine, 01033

National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"
37, Prosp. Peremohy, Kyiv, Ukraine, 03056

E-mail: girchenkoliu@gmail.com,
doroshenkoanatoliy2@gmail.com,
yuliia.ziubrytska@gmail.com