Reducing cognitive load in interfaces with a large number of workflows

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Abstract. The article is devoted to the study of the problem of cognitive load in digital systems with a large number of workflows, in particular in SaaS platforms, cloud consoles and information dashboards. The purpose of the article is to identify the features of complex digital interfaces, analyze the cognitive difficulties that arise when working with them, and also substantiate approaches to reducing the cognitive load of users. To achieve the set goal, the following methods of scientific analysis were used in the study: analysis of scientific sources on the issues of usability and human interaction with information systems; comparative analysis of approaches to optimizing interfaces of complex digital platforms; generalization of research results on factors of cognitive overload in systems with high data density and workflows. The results of the study showed that the interfaces of systems with a large number of workflows are characterized by a number of structural difficulties. These include the difficulty of navigating between functional sections of the system, the multi-step nature of operational procedures, the overload of the interface with information elements, and the difficulty of adapting to new users. It has been established that the main cognitive difficulties when interacting with such systems are the overload of the user's short-term memory, the difficulty of orientation in the interface structure, the excessive number of information indicators, frequent context switching between tools, and the increased probability of errors when configuring system parameters. The generalization of modern research has allowed us to systematize approaches to reducing cognitive load, among which optimization of the interface structure, improvement of information dashboards, consolidation of digital tools, and standardization of monitoring of complex IT systems are highlighted. The practical significance of the study lies in the application of the author's Systems-to-Interfaces (S2I) methodology, which involves the transformation of the system logic of a software product into understandable interface work scenarios focused on real operational processes and user roles.

Keywords: cognitive load, complex interfaces, SaaS systems, usability, digital workflows, dashboards, interface optimization, S2I methodology.

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Introduction

The rapid development of digital technologies leads to the active implementation of complex information systems in various fields of activity, in particular in education, public administration and business. A special place among such systems is occupied by cloud platforms, SaaS services and monitoring systems, which provide management of a large number of processes and data. However, the growth of the functional complexity of digital platforms leads to the emergence of a new problem. The interfaces of such systems are often overloaded with a large number of parameters, controls and information indicators, which complicates the interaction of users with the software environment: 94% of employees face digital friction, which arises due to the complexity of software systems, an excessive number of tools and fragmentation of work processes [11]. 76% of users report difficulties in performing everyday digital tasks, which are associated with the complexity of interfaces and the need to process a large amount of information [11]; employees of modern organizations can use more than ten different digital tools during one working day, which leads to constant switching between systems and loss of concentration during work operations [12]. As a result, a significant part of working time is spent not on performing basic tasks, but on navigating interfaces and searching for necessary functions.

An additional factor that complicates user interaction with digital systems is the information overload of interfaces. The study by D. Camargo et al. notes that an excessive number of indicators in monitoring systems can complicate data interpretation and reduce the effectiveness of user decision-making [3]. At the same time, modern digital work environments often involve the use of a large number of tools, which forces employees to constantly switch between different software systems. Such conditions contribute to cognitive and psychological overload, which provokes fatigue and burnout [12].

Literature Review

The issue of reducing cognitive load when working with complex SaaS systems is not widely studied in the scientific literature. However, there are fragmentary studies, the analysis of which allows us to understand how to solve the key problem of interaction in the conditions of complex interfaces.

The issue of cognitive load when using cloud services is considered in the works of individual researchers. In particular, S. Roy, P. K. Pattnaik and R. Mall [9] investigated the cognitive aspects of user interaction with data storage services in a cloud environment. In their work, an approach to assessing the usability of Storage as a Service services is proposed, taking into account interface design factors and the peculiarities of information perception by users. The authors show that the complexity of the system structure and a large number of functional parameters can significantly increase mental load when performing work operations. Research by T.-M. Lim, A. S.-H. Lee and M.-K. Yap [6] also confirms the importance of psychological factors in the perception of SaaS solutions, in particular the impact of system performance, risks and cost of use on users' acceptance of software services. Similar results were obtained in the works of M. Pańkowska, K. Pyszny and A. Strzelecki [7], which investigated the factors of user acceptance of cloud technologies, including the complexity of systems and their impact on the effectiveness of interaction with the digital environment.

As for the research on interfaces and usability of cloud platforms, this issue has been considered by several authors. Among them, it is worth highlighting S. K. Ganja and P. N. N. Cherukuri [5], who carried out a comparative analysis of the interfaces of popular cloud services AWS and Google Cloud. The study used cognitive walkthrough and heuristic assessment methods to identify problems in user interaction with systems, in particular when performing complex multi-step workflows within cloud service interfaces. D. Camargo, F. N. Gaia, T. Basso and R. Moraes [3] investigated the usability of system monitoring dashboards,

focusing on the need to optimize the interface structure to increase user trust in digital systems. The study by F. J. Rodríguez Lera, D. Fernández González, F. Martín Rico, Á. M. Guerrero-Higueras and M. Á. Conde [8] also confirms that the level of interface usability and navigation clarity directly affect the acceptance of cloud services by users and the effectiveness of their use in educational and professional environments. A separate group of sources is expert analytical materials and applied studies devoted to the use of digital tools in work processes. The work of D. A. Tamburri, M. Miglierina and E. Di Nitto [10] analyzes the use of cloud application monitoring systems in industrial environments, emphasizing the importance of clear information presentation for the effective management of complex systems. Expert reports also confirm that an excessive number of digital tools and the complexity of interfaces can reduce employee productivity and create additional workload when performing operational tasks [4]. Similar conclusions are contained in modern analytical reports on the digital workplace, which note that frequent switching between tools and the complexity of digital systems negatively affect the effectiveness of teamwork [11; 12]

The scientific novelty of this study lies in the application of the author's interface optimization methodology, which is aimed at reducing the cognitive load of users when performing operational tasks in SaaS systems. To achieve the goal, the study used methods of scientific analysis, in particular, the analysis of scientific sources, a comparative analysis of existing approaches to interface design, as well as a generalization of research results in the field of human interaction with information systems.

The purpose of the article is to study the features of the interfaces of digital systems with a large number of workflows and to substantiate approaches to reducing the cognitive load of users when interacting with such systems. To achieve the goal, the research involves the following tasks: to analyze the features of interfaces of complex digital systems with high data density and operational processes; to identify the main cognitive difficulties that users encounter when working with such interfaces; to summarize existing approaches to reducing cognitive load and to substantiate the possibilities of applying the author's interface optimization methodology Systems to Interface (S2I).

Research Results

Interfaces of systems that support a large number of workflows have a complex functional structure. Such systems are used in SaaS environments, where users perform various operational tasks, including data management, infrastructure configuration, or monitoring of digital services. Such interfaces combine a large number of tools, parameters, and dashboards. Based on the study by R. Agarwal and S. Dhingra, it was found that the quality of cloud services largely depends on the clarity of the interface and the ease of performing work operations by users [1]. If the system contains an excessive number of functions or a complex navigation structure, this complicates the interaction process and reduces the level of user satisfaction.

A feature of such interfaces is the combination of a large number of operational scenarios within one digital environment. As shown by the study by S. K. Ganja and P. N. N. Cherukuri, when working with cloud platforms, users often perform multi-step procedures, involving navigation across multiple interface sections and interaction with various system settings [5]. Each of these processes involves interacting with different interface elements, which can lead to information overload. D. Camargo et al. also note that complex dashboards and a large number of indicators in monitoring systems can reduce the clarity of the interface and complicate decision-making for users [3].

Statistics show that cognitive overload is becoming a significant problem in today's digital workplace. In particular, a report by TeamViewer found that about 76% of employees face difficulties when using digital tools that make it difficult to perform everyday work tasks [11].

In addition, 94% of respondents noted that they regularly encounter digital friction, which occurs due to the complexity of software systems, insufficient integration of tools and overloaded interfaces [11]. Such factors force users to spend a significant part of their working time searching for functions, navigating between systems and processing large amounts of information, which directly increases the level of cognitive load.

Similar results are confirmed in other analytical studies. According to expert analysis of the digital work environment, employees can use more than 10 different software tools during one working day, which leads to frequent context switching and loss of concentration during task performance [12]. At the same time, a study by Freshworks shows that the complexity of digital systems and the excessive number of functions in software create additional time costs for personnel training and increase the operational complexity of organizations [4]. Thus, statistical data demonstrate that the problem of cognitive load is systemic in nature. This reinforces the relevance of developing approaches to optimizing SaaS system interfaces in order to simplify user interaction with digital tools. The problems of implementing interfaces with a large number of workflows are associated with the need to simultaneously ensure the functionality of the system and its ease of use. As noted by F. J. Rodríguez Lera et al., the level of adoption of cloud solutions by users directly depends on the ease of navigation, the logical structure of the interface and the clarity of the implementation of operational procedures [8]. In the case of interface overloading with information, the probability of user errors increases, and the time for completing tasks increases. This creates the need to systematize the main difficulties that arise during the design and implementation of such interfaces (see Table 1).

Table 1 – Main difficulties in implementing interfaces with a large number of workflows

Problem	Characteristic	Example of manifestation
Complexity of navigation within the system [5]	a large number of functions and menus complicates user orientation within the interface structure	during cloud infrastructure configuration, a user has to move between several system sections to complete a single operation
Overload of informational elements [3]	the interface contains a large number of indicators, panels, and parameters	monitoring systems display a significant number of metrics, which complicates the rapid identification of critical indicators
Multistep workflows [5]	performing operations requires going through several sequential stages	creation and launch of a virtual machine include configuration of network settings, resources, and access parameters
High level of user cognitive load [9]	a large number of operations and parameters requires significant mental effort while working with the system	a user must simultaneously control several service configuration parameters
Difficulties in the adaptation of new users [1]	complex interfaces require additional training and time to master	new employees spend significant time understanding the logic of the system

Note: compiled by the author based on sources [1;3;5;8;9]

Analysis of the difficulties that arise when designing interfaces with a large number of workflows indicates a variety of factors that complicate user interaction with digital systems. These include the complexity of navigation, a large number of functional parameters, multi-step procedures for performing operations, and overloaded information panels. However,

generalizing the results of scientific research allows us to conclude that most of these difficulties have a common basis. They are directly related to the cognitive load that users experience when working with information-rich interfaces. As noted by S. Roy, P. K. Pattnaik, and R. Mall, complex system structures and a large number of parameters in cloud services increase the mental costs of users, which complicates the performance of operational tasks [9].

In such conditions, users are forced to simultaneously process significant amounts of information, analyze system parameters, and make decisions about further actions. Such processes require constant attention and active use of short-term memory. Based on the study by F. J. Rodríguez Lera et al., it was found that the complexity of the interface and the lack of a clear navigation structure can reduce the effectiveness of user interaction with cloud platforms [8]. At the same time, other researchers emphasize that an excessive number of control elements and information indicators in systems leads to user overload and an increase in the likelihood of errors when performing tasks [3].

Thus, among the various groups of difficulties that arise when using complex digital systems, it is advisable to pay special attention to cognitive load. It manifests itself in the complexity of information perception, the need to constantly switch attention between different interface elements and the processing of a large number of parameters within one workflow. The generalization of scientific sources allows us to identify the main manifestations of cognitive difficulties that users experience when interacting with such systems (see Table 2).

Table 2 – Main cognitive difficulties when working with interfaces of complex digital systems

Cognitive difficulty	Characteristic	Example of manifestation
Short-term memory overload [9]	a user must keep a significant number of system parameters and settings in memory	during cloud service configuration it is necessary to simultaneously consider resource parameters, security settings, and network configuration
Difficulty in interface navigation [5]	a large number of menus and functions complicates the search for the required tools	a user spends additional time determining the correct system section to perform an operation
Overload of informational elements [3]	the interface contains a significant number of indicators, metrics, and panels	monitoring systems simultaneously display many technical parameters
Frequent context switching [12]	users are forced to constantly switch between different tools or screens	completing a single task requires the use of several subsystems
Increased probability of errors [8]	interface complexity increases the risk of incorrect parameter selection	a user may mistakenly apply an incorrect service configuration

Note: compiled by the author based on sources [3;5;8;9;12]

Modern research on the problem of cognitive overload in complex digital systems offers various approaches to overcoming it. Most of them are related to the optimization of interfaces, improving the structure of workflows and reducing information overload for users. For example, the study by S. K. Ganja and P. N. N. Cherukuri emphasizes the importance of

adhering to usability principles, in particular, visibility of the system state and understandable navigation logic, which allows users to better navigate complex cloud consoles [5]. Similar approaches demonstrate that the correct organization of the interface can significantly reduce mental load when performing work tasks.

At the same time, a significant part of modern research is aimed at developing system solutions that allow optimizing complex work environments. In particular, D. Camargo and co-authors emphasize the importance of correctly structuring information in dashboards to simplify data interpretation and support decision-making [3]. Other authors emphasize the need to reduce the so-called digital friction that arises from the use of a large number of tools and frequent switching between systems [12]. A separate group of approaches are methodologies aimed at system-based interface design. Such approaches include the author's Systems-to-Interfaces (S2I) methodology, which considers the interface as the result of the transformation of the internal logic of a complex system into understandable user interaction scenarios (see Table 3).

Table 3 – Approaches to reducing cognitive load in complex digital interfaces

Approach	Main idea	Practical solution
Heuristic usability analysis [5]	evaluation of interfaces based on usability principles	ensuring visibility of system status and clear navigation
Optimization of information panels [3]	simplification of the structure of data presentation in dashboards	prioritization of indicators and semantic structuring of information
Consolidation of digital tools [12]	reduction of the number of systems and switches between them	integration of workflows into a single platform
Standardization and automation of monitoring [10]	use of standardized approaches to the management of complex IT systems	automation of monitoring of software service functioning
Systems-to-Interfaces (S2I) methodology	transformation of system logic into understandable interface workflows	interface design based on real workflows and user roles

Note: compiled by the author based on sources [3;5;10;12].

A feature of the author's Systems-to-Interfaces (S2I) methodology is that it considers the interface not as a separate level of visual design, but as the result of a systems analysis of the internal logic of the digital system. Within the framework of this approach, the complex architecture of the internal system structure is first decomposed to identify real data flows and system limitations. After that, the interface is designed around the user's workflows, and not around individual screens. An important component of the methodology is also the role adaptability of the interface, when each user receives access only to the information and functions necessary to perform his tasks. In addition, the interface design is focused on supporting decision-making at critical points in the workflow, which allows reducing the likelihood of errors and increasing the reliability of digital systems. Therefore, this approach has practical significance for the development of complex digital platforms, in particular in the fields of education, public services and financial systems, and the use of the S2I methodology allows to reduce the so-called "cost of complexity", optimize workflows and increase the reliability of information systems in critical sectors of digital infrastructure.

Conclusions

As a result of the conducted study, it was found that the interfaces of digital systems with a large number of workflows are characterized by high functional saturation and a complex structure of user interaction with the system. As shown in the tabular analysis of the difficulties of implementing such interfaces, the key problems are the complexity of navigation between functional sections, multi-step operational processes, overload with information elements and the complexity of adapting new users to the system. The presence of a large number of parameters and tools within one environment complicates the performance of even typical work operations and increases the time of user interaction with the system.

Analysis of cognitive difficulties showed that the main reason for the decrease in the efficiency of work with such interfaces is the overload of the user's short-term memory and the need to simultaneously process a significant number of information parameters. The cognitive difficulties table identifies five key manifestations of this problem. These include short-term memory overload when working with system parameters, difficulty navigating the interface due to the large number of menus and functions, an excessive number of information indicators in dashboards, frequent context switching between screens or tools, and an increased likelihood of errors when configuring system parameters.

A generalization of approaches to reducing cognitive load showed that modern research offers several practical directions for solving this problem. Among them, heuristic usability analysis for optimizing navigation, structuring information in dashboards, consolidation of digital tools for reducing context switching, and standardization of monitoring complex IT systems are highlighted. Of particular importance is the author's Systems-to-Interfaces (S2I) methodology, which involves transforming the system logic of a software product into understandable interface operating scenarios. The use of this approach allows you to systematically optimize workflows, reduce information overload of the interface, and increase the reliability of using complex digital systems in practical activities.

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