



Transformation of System Logic into Interface Solutions

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ABSTRACT

The article is devoted to the study of interface patterns of digital services and methods of translating the complex system structure of a product into understandable interface solutions. Particular attention is paid to digital systems that work with large volumes of interconnected data and are characterized by high complexity of interaction processes. In such environments, the interface acts not only as a tool for displaying information, but also as a mechanism for supporting the user's cognitive processes during data analysis and decision-making. The purpose of the article is to study modern interface patterns of digital systems and to substantiate methods for translating the system structure of products with high data complexity into effective interface solutions. To achieve this goal, the methods of scientific generalization, system analysis, comparative analysis of scientific approaches in the field of human-computer interaction, as well as the method of structural modeling of user interaction processes with digital systems, were used. The results of the study show that the effectiveness of interfaces of complex digital products largely depends on the ability of interface solutions to reflect the internal logic of the system in the form of understandable interaction scenarios. It was established that in systems with high data density, approaches aimed at reducing the cognitive load of users, structuring information and supporting decision-making in the process of working with the interface play an important role. The paper summarizes existing approaches to translating system logic into interface solutions and proposes the author's Systems-to-Interfaces (S2I) approach, which involves deconstruction of system logic, modeling of user workflows, role-based adaptation of the interface and organization of a decision-making support environment. The practical value of the study lies in the formation of a methodological approach to transforming the system structure of complex digital products into scalable interface patterns.

KEYWORDS

interface patterns, human-computer interaction, cognitive load, information architecture, complex digital systems, system logic, interface design, S2I.

Introduction

The relevance of the study is due to the rapid growth in the complexity of digital systems and interfaces, which act as the main channel of interaction between humans and information technologies. In modern conditions, the success of digital products is determined not only by their functionality, but primarily by the effectiveness of interaction with the user. As shown by the study of C. Diehl, F. M. Zahedi and D. Hwang, the interface of a digital solution should provide natural and understandable user interaction with the system, which involves the correct definition of interface elements, navigation and task execution logic (Diehl et. al., 2022). At the same time, human-computer interaction studies emphasize that the creation of effective interfaces is associated with the need to take into account a wide range of factors, in particular, the context of use, user characteristics and the structure of the system's information (Islam, 2017). An important problem of modern interface design is the limited cognitive capabilities of a person when working with information-rich digital environments. According to the Interaction Design Foundation, cognitive load characterizes the amount of mental resources that a person uses when perceiving and processing information (Interaction Design Foundation (a)). If the amount of information exceeds the capabilities of working memory, the efficiency of task performance is significantly reduced. In the study of K. Whitenton, it is noted that information overload of users can lead to errors, loss of important details or even refusal to complete the task (Whitenton, 2013). In this regard, one of the key tasks of modern interface design is to minimize excessive cognitive load through structured presentation of information and the use of understandable interaction models.

Another aspect of the problem is the need to align the interface structure with the mental models of users. As M. Chen notes, the mental model reflects the user's understanding of the principles of system operation and determines his expectations regarding interaction with the interface (Chen, 2024). If the interface structure does not correspond to such ideas, users may misinterpret the functions of the system or spend additional effort on understanding its logic. Similar conclusions are contained in the works of D. Loeffler, A. Hess, A. Maier, J. Hurtienne and H. Schmitt, which emphasize the presence of the so-called "design gap" between the requirements for the system and their implementation in the form of interface solutions (Loeffler et. al., 2013).

Literature Review

The issue of designing interfaces for digital systems, in particular interface patterns and methods for organizing user interaction with systems with a complex data structure, is not sufficiently comprehensively covered in the scientific literature. Despite this, individual components of this issue are considered in the works of researchers in the field of human-computer interaction. In particular, the issue of forming recommendations for interface design was studied by C. Diehl, F. M. Zahedi and D. Hwang (Diehl et. al., 2022). In their work, the authors analyze the principles of developing user interfaces and offer systematic approaches to forming recommendations that can be used when creating digital products. The study by Z. Shen, Y. Wang, J. Liu and Y. Zhang (Shen et. al., 2024) is devoted to the issue of designing interfaces for complex technical systems. The paper considers the features of interface organization in environments with a large amount of data and shows the importance of maintaining user situational awareness during interaction with the system.

As for methodological approaches to the study of interface design processes, this issue is also considered in the works of several authors. Among them, it is appropriate to single out M. N. Islam (Islam, 2017), who studies the use of the design science research approach in human-computer interaction projects and describes its capabilities for creating new methodological solutions in the field of digital design. A significant contribution to the study of interface intuitiveness was made by D. Loeffler, A. Hess, A. Maier, J. Hurtienne and H. Schmitt (Loeffler et. al., 2013). In their work, the authors justify the need to integrate users' mental models into the process of forming interface requirements, which allows creating more understandable and predictable interaction models. An important source of formation of modern approaches to interface design is normative literature. In particular, the international standard ISO 9241-210:2019 "Ergonomics of human-system interaction - Human-centred design for interactive systems" defines the basic principles of human-centred

design of digital systems and emphasizes the need to take into account the context of use, user needs and system characteristics in the process of creating an interface (International Organization for Standardization, 2019). Similar approaches are also supported in the materials of the National Institute of Standards and Technology, where human-centred design is considered as the basis for creating digital systems focused on effective user interaction with information technologies (National Institute of Standards and Technology, 2021).

In addition to scientific and regulatory sources, a significant role in the formation of modern approaches to interface design is played by expert literature and analytical materials of professional organizations. In particular, the publications of the Nielsen Norman Group consider the use of mental models in the process of interface design. In the work of M. Chen (Chen, 2024) it is emphasized that the structure of the interface should correspond to users' ideas about the operation of the system. The issue of user task analysis is considered in detail by M. Rosala (Rosala, 2020), who shows that the interface structure should be built on the basis of user interaction scenarios with the system. At the same time, the Interaction Design Foundation publications reveal the concepts of cognitive load and information architecture, which are important for the organization of interfaces in systems with a large amount of data (Interaction Design Foundation (a), (b)).

Similar issues are also investigated by experts from the Nielsen Norman Group, in particular K. Whittenton (Whittenton, 2013) and H.-H. Wang (Wang, 2025), who consider methods for reducing cognitive load during user interaction with digital interfaces. Despite a significant number of studies, the scientific literature does not sufficiently address the issue of translating complex system logic of digital products into scalable interface solutions. Within the framework of this study, it is proposed to consider this process through the prism of the author's Systems-to-Interfaces (S2I) approach, which involves analyzing the system structure, modeling workflows, and adapting the interface to user roles. To achieve the goal, the work uses methods of scientific generalization, system analysis and comparison of approaches to designing interfaces in digital systems with a complex data structure.

Problem Statement

Thus, the problem of translating complex system logic into understandable interface models remains insufficiently developed in modern research. Systems with high data density and a complex interaction structure require special attention. The study by Z. Shen, Y. Wang, J. Liu and Y. Zhang shows that in such systems the interface acts as a key element in the formation of the user's situational awareness and directly affects the quality of decision-making (Shen et. al., 2024). In complex digital environments, the interface must not only display information, but also support the user's cognitive processes, in particular, perception, analysis and prediction of how the situation will develop. That is why there is a need to develop methodological approaches that allow for the systematic translation of the internal structure of digital products into understandable interface solutions.

Methods and Materials

The purpose of the article is to study modern interface patterns of digital services and determine approaches to translating the system logic of complex products into understandable interface solutions.

To achieve this goal, the methods of scientific generalization, system analysis, comparative analysis of scientific approaches in the field of human-computer interaction, as well as the method of structural modeling of user interaction processes with digital systems were used.

To achieve the goal, the following tasks will be performed during the study: to analyze the essence of interface patterns and their development in modern digital systems as of 2026; to investigate the features of using interface patterns in services and websites that work with products with high data complexity; to consider the method of translating the system structure and internal logic of the product into appropriate interface solutions that ensure clarity and efficiency of user interaction with the system.

Results and Discussion

Interface patterns are formed as generalized solutions used when designing digital interfaces to ensure understandable user interaction with the system. They arise as a result of repeated use of the same logical structures in different products. Interaction design studies emphasize that such patterns allow to reduce cognitive load and make the system behavior predictable for the user (Whitenton, 2013). That is why in modern digital services interface solutions are built on repeating models of element organization, navigation and information presentation (Interaction Design Foundation (b)). In the scientific literature, interface patterns are considered from different methodological positions. In particular, M. Chen treats them as established models of interface organization, which are formed on the basis of users' mental models and reflect the expected logic of interaction with a digital system (Chen, 2024). In the study by C. Diehl, F. M. Zahedi and D. Hwang, attention is focused on the fact that interface solutions should be formed as recommendations for the design of user interfaces that help structure interaction and simplify the performance of user tasks (Diehl et. al., 2022). In contrast, the works of D. Loeffler, A. Hess, A. Maier, J. Hurtienne and H. Schmitt emphasize the importance of integrating users' mental models into the interface development process, which allows for the creation of intuitive interaction patterns (Loeffler et. al., 2013). Thus, interface patterns in modern research are considered not only as design elements, but as structural mechanisms that combine the system logic of a digital product with user expectations. The formation of interface patterns is directly related to the process of designing human interaction with digital systems. According to the human-centred design approach, the interface should reflect the logic of the tasks that the user performs in the system, and not only the internal technical structure of the software product (International Organization for Standardization, 2019). As a result, patterns act as a kind of mediator between complex system logic and a clear form of its presentation in the interface. Research on user task analysis confirms that repetitive interface solutions help users to navigate the structure of the service faster and achieve their own goals more effectively when working with the system (Rosala, 2020).

As of 2026, interface patterns continue to evolve along with the development of digital services and the growth of data complexity. Particular attention is paid to the scalability of interfaces, adaptability to different types of devices, and the ability to display complex information structures. Studies of modern human-computer interaction systems emphasize that the interface should support the user's situational awareness and provide a clear display of system processes in a clear visual form (Shen et. al., 2024).

A generalization of current trends in the development of interface solutions allows us to identify several key trends that determine the development of interaction patterns in digital systems (see Table 1).

Table 1. Main trends in the development of interface patterns in 2026

Interface pattern trend	Characteristic	Practical manifestation
Scalable interface structures [4]	the interface is designed so that the same logical structure can be used across different sections of the product and remain effective as the volume of data increases	use of modular cards, repeatable information blocks, unified list structures
Cognitive load reduction patterns [12]	the design of interface elements focuses on simplifying information perception and reducing the number of decisions a user needs to make	use of progressive disclosure of information, step-by-step forms, logical grouping of elements
Task-oriented interfaces [9]	the interface structure is organized around user scenarios rather than around the internal architecture of the system	organization of services according to the logic of task execution rather than according to the structure of the database
Interfaces supporting situational awareness [10]	the interface should ensure understanding of the current system state and the user's actions	use of status panels, visual process indicators, information dashboards

Note: Compiled by the author based on sources (Interaction Design Foundation (b), Rosala, 2020, Shen et. al., 2024, Whitenton, 2013)

The trends shown in Table 1. demonstrate that interface patterns are formed not only as design solutions, but as a tool for organizing interaction between the user and a complex digital system, and their practical implementation largely depends on the type of digital resource. That is why when designing interfaces, it is necessary to take into account the specifics of a particular type of system, since this directly affects the choice of appropriate interface patterns.

Let us consider an example of digital products with high data complexity. They are characterized by a significant amount of information, a multi-level structure of its organization and the need to simultaneously display several interconnected parameters. In such systems, the interface should not only display information, but also provide the possibility of its rapid analysis and use in the decision-making process. This category includes, in particular, analytical platforms, financial systems, technical design software, flight control systems or simulation environments. The study by Z. Shen, Y. Wang, J. Liu, and Y. Zhang emphasizes that interfaces of systems with high information density should support the user's situational awareness and provide a clear display of key system parameters (Shen et. al., 2024). At the same time, information architecture studies emphasize that working with large amounts of data requires special approaches to structuring information and organizing navigation in the interface (Interaction Design Foundation (b)).

In digital design practice, products with high data complexity include various types of systems. Among the most common examples are:

- Analytical and business intelligence systems. This group includes data analysis platforms that work with large sets of indicators and complex analytical models. The interface of such systems should display numerous indicators, graphs, and interdependencies between them, in particular in the form of dashboards and interactive visualizations (Interaction Design Foundation (b));
- Financial and trading platforms. Online trading or financial management systems contain significant amounts of dynamic data that change in real time. In such interfaces, it is important to provide quick access to information and a clear navigation structure so that the user can make decisions quickly (Whitenton, 2013);
- Professional technical systems. This category includes aviation simulators, engineering systems, or tools for managing complex technical processes. The study by Z. Shen et al. shows that the interfaces of such systems should reflect complex processes in a form that allows the user to quickly assess the current state of the system (Shen et. al., 2024).

The presence of a large amount of interconnected data creates specific requirements for the construction of interface patterns in such systems. The generalization of scientific research allows us to highlight the main features of the organization of the interface of digital services with high data complexity (see Table 2).

Table 2. Features of interface patterns in systems with high data complexity

Feature of interface pattern	Content	Practical application
Multilevel information structure [4]	data is organized into several levels, which allows information to be revealed gradually depending on the user's needs	use of nested menus, information panels, structured modules
Progressive disclosure of information [12]	the interface displays only the main data, while detailed information is revealed when needed	use of expandable blocks, filters, additional panels
Visualization of complex data [10]	complex information structures are presented in the form of graphs, diagrams, or information panels	interactive dashboards, process maps, indicator systems
User task orientation [9]	the interface structure is organized around usage scenarios rather than around the technical architecture of the system	organization of work panels according to user tasks

Note: Compiled by the author based on sources (Interaction Design Foundation (b), Rosala, 2020, Shen et. al., 2024, Whitenton, 2013)

As a result, the design of such interfaces requires a special approach to modeling the system structure and data display methods. That is why, when creating digital services with high information saturation, separate methods of translating system logic into understandable interface solutions are used, which allow to harmonize the internal architecture of the product with real user work scenarios.

Methods of translating the system structure into understandable interface solutions are considered in scientific research as an important stage of designing complex digital products. Within the framework of human-centered design approaches, it is emphasized that the interface structure should reflect not only the functionality of the system, but also the logic of performing user tasks (International Organization for Standardization, 2019). That is why the interface design process begins with an analysis of the context of using the system, user roles and the information architecture of the product. In works on information architecture, it is also emphasized that complex digital systems require special approaches to structuring information that allow users to navigate in large volumes of data (Interaction Design Foundation (b)). Accordingly, the translation of system logic into interface solutions is considered as the process of transforming the technical structure of the product into a clear model of interaction. One of the common approaches to such translation is the use of user task analysis. As M. Rosala notes, building an interface based on task analysis allows you to determine the sequence of actions performed by the user in the system and structure interface elements accordingly (Rosala, 2020). This approach allows you to form the logic of transitions between screens and system functions. Another area of research is related to the use of mental models of users. In the works of M. Chen it is emphasized that users interact with systems according to their own ideas about their work. If the structure of the interface corresponds to such mental models, the interaction process becomes more predictable and understandable (Chen, 2024). In addition, the studies of D. Loeffler, A. Hess, A. Maier, J. Hurtienne and H. Schmitt emphasize the importance of integrating users' mental models into the process of forming interface requirements, which allows creating intuitive interface solutions (Loeffler et. al., 2013).

In modern digital products, where the volume of information and the number of interconnected processes are growing significantly, traditional approaches to interface design need further development. In particular, the studies of Z. Shen, Y. Wang, J. Liu and Y. Zhang emphasize that systems with high data density should support the user's situational awareness and provide a clear display of key system parameters (Shen et. al., 2024). In such a context, the interface acts not only as a tool for interaction, but also as a means of supporting decision-making. This is precisely what determines the need to use systems approaches to translating the internal architecture of the product into understandable interface solutions.

One such approach is the author's Systems-to-Interfaces (S2I) methodology developed by Liudmyla Shumilina. Its conceptual basis is consistent with the principles of human-centered design and research on users' mental models. At the same time, the methodology extends these approaches, as the focus shifts from the analysis of individual interface elements to the system logic of the product. Within the framework of the methodology, the interface is viewed as the result of translating the internal structure of the system into a comprehensible interaction model (Figure1)

The first stage of the methodology is the deconstruction of the system logic (System Truth First). At this stage, an analysis of the real data structure, technical limitations of the system and the relationships between its components is carried out. This approach correlates with research on information architecture, which emphasizes the importance of understanding the structure of information before designing the interface (Interaction Design Foundation (b)). Identifying the "system truth" allows you to form the basis of the future interface logic and avoid a gap between the functionality of the system and the way it is displayed to the user.

The second stage is design through workflows (Workflow-based design). In this case, the basic unit of design is not a separate screen, but a complete task execution scenario. This approach is consistent with task analysis methods, which allow you to structure the interface according to the sequence of user actions (Rosala, 2020). As a result, a holistic interaction logic is formed, covering all stages of working with the system.

The third stage is Role-Driven Interfaces. In complex digital systems, different users have different functions, access rights, and responsibilities. Therefore, the interface structure should take into account the specifics of user roles. This approach is consistent with research in the field of mental models, which shows that the perception of the interface depends on the experience and tasks of a specific group of users (Chen, 2024).

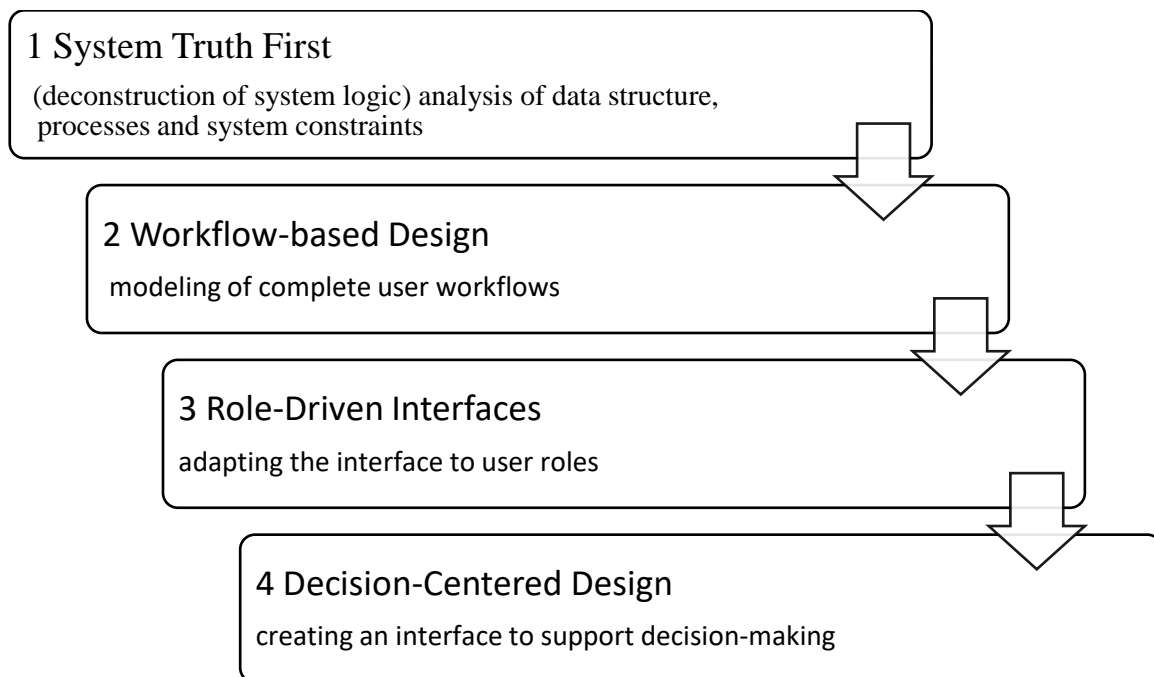


Figure 1. Stages of development of individual interface elements Systems-to-Interfaces

The final stage is Decision-Centered Design. The interface is organized in such a way that at key moments of interaction the user receives the necessary context for making a decision. In systems with high data complexity, this is achieved through the use of dashboards, status indicators, and structured data representations. This approach is consistent with the results of research on complex technical systems, which emphasize the importance of user situational awareness when working with information-rich interfaces (Shen et. al., 2024).

Conclusion

As a result of the study, the essence of interface patterns was revealed: they are recurring models of organizing user interaction with the system, which are formed based on established approaches to structuring information and building navigation. It was established that the modern development of digital products leads to the transformation of such patterns in the direction of: 1) scalability of interface structures, 2) intuitive decision-making without thinking; 3) orientation to the user's focus.

The study also analyzed the specifics of interface solutions in digital services, where products with high data complexity are used. It was shown that such systems are characterized by a significant amount of information, a multi-level data structure and the need to simultaneously display interconnected parameters. This necessitates the use of special approaches to organizing the interface, in particular, structuring information, phased data disclosure and the use of visual tools for their analysis. As a result, the interface acts not only as a means of displaying information, but also as a tool to support decision-making.

Special attention is paid to methods of translating system structure into understandable interface solutions. The work substantiates the author's Systems-to-Interfaces approach, which involves a sequential analysis of system logic, modeling of work processes, taking into account user roles and designing the interface as a decision-making support environment. The proposed approach expands traditional methods of interface design and allows you to effectively work with digital systems characterized by a complex data and process structure.

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