# User Interface of the OSTIS Ecosystem

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***Abstract*—In the article, the principles of organizing user interaction with the OSTIS Ecosystem, the concept of the user interface of the OSTIS Ecosystem, the use of component approach to the design of adaptive intelligent multimodal interfaces of ostis-systems are considered.**

***Keywords*—adaptive intelligent multimodal interface, OSTIS Ecosystem, user interface of the OSTIS Ecosystem**

## I. Introduction

Modern information technologies have led to the emergence of a huge number of services and systems designed to solve a variety of problems. However, due to the variety of these services, the user faced the problem of the need to study the features of interaction with each of them, which can significantly complicate the use of such services. In addition, each system has its own unique *user interface*, which may be incomprehensible and require certain interaction skills from the user. Thus, the user has to independently study the features of interaction with each system in order to successfully solve their problems.

In this regard, there is an urgent problem of usability of information services, which requires the development of approaches to the unification of *user interfaces* and the creation of tools that simplify working with various systems. The development of such approaches can significantly speed up the process of user interaction with systems and increase the efficiency of their use.

The purpose of this article is to analyze existing solutions to this problem and an approach to eliminating this problem using the *OSTIS Technology*.

## II. Related works

Currently, in order to solve the problem of usability of various information services and unification of *user interfaces*, the following is used:

- *personal assistants*, which simplify the processes of user interaction with various systems;
- standards of protocols and *application interfaces* that simplify the integration and interaction of various systems with each other.

Digital *personal assistants* are programs based on artificial intelligence and machine learning technologies that help users perform everyday tasks, such as scheduling, managing contacts, searching for information, reminding about important events, etc. [1], [2], [3], [4].

Nowadays. many companies try to develop their own *personal assistant*, and the first company that managed to integrate such an agent into their operating systems was Apple when they introduced Siri [5] in 2010. Soon after, many other companies implemented assistance in the same area in order to help people perform ordinary everyday actions (Microsoft Cortana [6], Google Now [7], LG Voice Mate [8], [9]).

The *user interface* of the *personal assistant* must represent the system as a single unified set of back-end task assistants, enabling the user to conduct a dialog in which it is easy to switch between these domains. It involves getting user input commands either as text or speech and processing the input, which is in natural language, to understand it [10].

Using the *personal assistant* to interact with the user does not solve the problem of compatibility of various services and systems with each other. The use of standard protocols and *application interfaces* partially solves this problem, but the fully specified problem can only be solved by creating the *ecosystem* of semantically compatible systems.

As part of the work [9], it is proposed to use the LISSA *personal assistant* that is operating in a Virtual Education Space (VES) and whose purpose is to aid the students in their learning process. VES is built as an Internet-of-Things *ecosystem* consisting of autonomous intelligent components displaying a context-aware behaviour. This approach makes it possible to effectively use a *personal assistant* within the specified *ecosystem* with the possibility of further expansion of its application.

## III. Proposed approach

Based on the analysis, it can be concluded that the user does not have to know a lot of services from which they should choose the functionality that suits them. The complex of semantically compatible services should be located "behind the scenes". Therefore, all information resources and services used must be semantically compatible. The choice of a resource or service suitable for the user should be made by their *personal assistant*.

Thus, when implementing digital *personal assistants*, it is necessary to ensure their scalability and adaptability to user needs. This means that the system should be able

to automatically adapt to changes in user behavior, taking into account their preferences, work characteristics, and other factors.

The *OSTIS Technology* allows creating semantically compatible systems (*ostis-systems*) that are able to process user requests and problems, taking into account their context and meaning. This is achieved through the use of semantic networks that allow describing knowledge and the connections between them. Also, the *OSTIS Technology* provides scalability and flexibility of the system, which allows it to adapt to changes in user behavior and needs [11].

The *OSTIS Technology* provides a universal language for the semantic representation (encoding) of information in the memory of *intelligent computer systems*, called an *SC-code*. Texts of the *SC-code* (sc-texts) are unified semantic networks with a basic set-theoretic interpretation, which allows solving the problem of compatibility of various knowledge types. The elements of such semantic networks are called *sc-elements* (*sc-nodes* and *sc-connectors*, which, in turn, depending on orientation, can be *sc-arcs* or *sc-edges*). The *Alphabet of the SC-code* consists of five main elements, on the basis of which *SC-code* constructions of any complexity are built, including more specific types of *sc-elements* (for example, new concepts). The memory that stores *SC-code* constructions is called semantic memory, or *sc-memory* [12].

The architecture of each *ostis-system* includes a platform for interpreting semantic models of *ostis-systems*, as well as a *semantic model of the ostis-system* described using the *SC-code* (*sc-model of the ostis-system*). In turn, the *sc-model of the ostis-system* includes the *sc-model of the knowledge base*, *sc-model of the interface*, and *sc-model of the problem solver*. The principles of the design and structure of *knowledge bases* and *problem solvers* are discussed in more detail in [13] and [14], respectively. The principles of the *sc-model of the user interface* were described in the articles [15], [16], and [17], on which this article is based.

Within the *OSTIS Technology*, the concept of the *OSTIS Ecosystem* is introduced [18].

The *OSTIS Ecosystem* is a socio-technical network, which is a collective of interacting:

- *ostis-systems* themselves;
- users of the specified *ostis-systems* (both end-users and developers);
- some *computer systems* that are not *ostis-systems* (they can be used as additional information resources or services).

The objectives of the *OSTIS Ecosystem* are:

- rapid implementation of all agreed changes in *ostis-systems*;
- permanent maintenance of a high-level of mutual understanding between all the systems that are part of the *OSTIS Ecosystem*, as well as all their users;
- corporate solution of various complex problems requiring the coordination of several (most often a priori unknown) *ostis-systems* and possibly some users.

Within the *OSTIS Ecosystem*, the concept of a *personal ostis-assistant* is specified. A *personal ostis-assistant* is the *ostis-system*, which is a *personal assistant* of the user within the *OSTIS Ecosystem*. Such a system provides opportunities:

- to analyze user activity and form recommendations for its optimization;
- to adapt to the mood of the user, their personal qualities, the general environment, the problems that the user most often solves;
- to permanently train the assistant in the process of solving new problems, while learnability is potentially unlimited;
- to conduct a dialog with the user in natural language, including in speech form;
- to answer questions of various classes, while if the system does not understand something, it can ask counter-questions itself;
- to independently receive information from the entire environment, and not just from the user (in text or speech form).

At the same time, the system can both analyze available information sources (for example, on the Internet) and analyze the physical world surrounding it, for example, surrounding objects or the appearance of the user.

Advantages of the *personal ostis-assistant*:

- the user does not need to store different information in different forms in different places: all information is stored in a single *knowledge base* compactly and without duplication;
- thanks to unlimited learnability, assistants can potentially automate almost any activity, not just the most routine one;
- thanks to the *knowledge base*, its structuring, and the means of searching for information in the *knowledge base*, the user can get more accurate information more quickly.

*Personal assistants* have a very different purpose and can be used for a wide variety of categories of users (patient, legal service, administrative service, customer, consumer of various services). The *personal ostis-assistant* can use the knowledge and data stored in other *ostis-systems*, such as *corporate ostis-systems*, to provide the user with more complete and up-to-date information. This can be especially useful for users who work with a lot of data and information. The *personal ostis-assistant* is automatically integrated with other *ostis-systems*, which allows it to work more efficiently with data and information. It can use machine learning and artificial intelligence technologies to adapt to user behavior and improve its productivity and efficiency. The *personal*

*ostis-assistant* can be created and configured to meet the specific needs of the organization and its processes, which can lead to significant economic and production advantages.

The *personal assistant* should take into account that the user roles in society can change, expand, as well as their interests and goals. At the same time, all *personal assistants* must be semantically compatible in order to understand each other and also have the ability to independently interact within various *corporate systems*, representing the interests of their users.

The *user interface* of the *personal intelligent assistant*:

- provides the user with the means to control their individual activities carried out jointly with the corresponding personal intelligent assistant;
- provides the unified nature of user interaction within the various communities in which they belong. The simplest type of community is a one-time dialog between two users.

Since the user interaction with the *OSTIS Ecosystem* occurs only through a *personal ostis-assistant*, the *user interface of the OSTIS Ecosystem* for the user is the *user interface* of their *personal ostis-assistant*. Such an *interface* should be *adaptive*, *intelligent*, and *multimodal*. The structure of such an *interface* was proposed in the work [17].

The *knowledge base of the ostis-system user interface* includes:

- usage context model:
  - user model;
  - environment model;
  - platform model;
- interface model;
- interface component model;
- user action model;
- logical rules for interface adaptation;
- model of sensory and effector subsystems to ensure multimodality;
- interface design techniques;
- model of interface design tools;
- etc.

The model of the user and their actions in the context of the *user interface of the OSTIS Ecosystem* should be stored only within the user's *personal ostis-assistant* and share this knowledge with other *ostis-systems*, if necessary.

User interface design is based on a component-based approach. Any *user interface component* can be described in the *ostis-system knowledge base*. An example of the "calculator" *user interface component* with its corresponding description fragment in the *ostis-system knowledge base* in the *SCg-code* is shown in Figure 1.

The *user interface of the personal ostis-assistant* by default contains only the *interface components* necessary for the user to start interaction. At the same time, the *interface* is constantly being adapted based on the user model and adaptation rules.

At the same time, *ostis-systems* that are not *personal ostis-assistants*, as a rule, should not have a *user interface*. However, developers of such systems can add the necessary *user interface components* to the *knowledge base*, which can be displayed by a *personal ostis-assistant* when interacting with the user.

Thus, the general process of interaction of a *personal ostis-assistant* with a user can be described as follows:

- the *user interface of the personal ostis-assistant* is displayed to the user by default;
- when interacting with the user, the *user interface of the personal ostis-assistant* automatically adapts;
- the *personal assistant*, when interacting with the user, can use the *user interface components* of any *ostis-system* within the *OSTIS Ecosystem*, adapt such a *component*, and display it to the user, if necessary.

An example of using a *user interface component* within the *OSTIS Ecosystem* is shown in Figure 2.

The user, their *personal ostis-assistant*, and other *ostis-systems* (in the Figure, *intelligent systems* in mathematics, chemistry, biology, and geography are shown) are part of the *OSTIS Ecosystem*.

The developer of each *intelligent system* can describe the *user interface components* necessary for this system. In the example given, the "calculator" *component* was described for the mathematics system and the map component – for the geography system.

Since the user interacts with all *ostis-systems* only through a *personal ostis-assistant*, the *assistant* itself accesses the system necessary for interaction at the moment and loads the necessary *user interface component* of some applied *ostis-system* into its part of the *knowledge base* with the purpose of subsequent display to the user, taking into account the rules of adaptation, which are also stored in the *knowledge base of the personal ostis-system*.

It is important to note that a wide variety of *interfaces* entails the development of a large number of *components*. Both already designed *interfaces* and specified *interface components* can act as *reusable interface components* of the *ostis-system*. A large number of *reusable interface components* of the *ostis-system* creates the problem of storing and searching them. To solve this problem, within the *OSTIS Technology*, a *library of reusable interface components* of *ostis-systems* and a *manager of reusable ostis-systems components* are used [19]. The use of a library of *reusable interface components* of *ostis-systems* in the design of an applied system *interface* can significantly reduce the time for design, as well as reduce the requirements for the initial qualification of the developer. This is achieved by designing the *interface* from pre-prepared *interface models*, which also allows improving the quality of the designed *interface* [20].

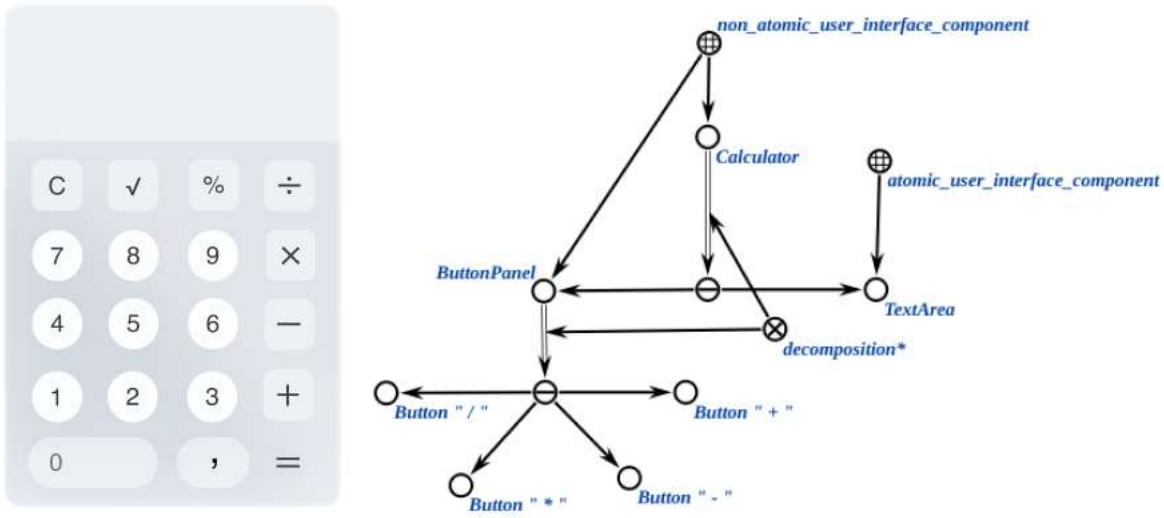


Figure 1. Example of a description of a user interface component

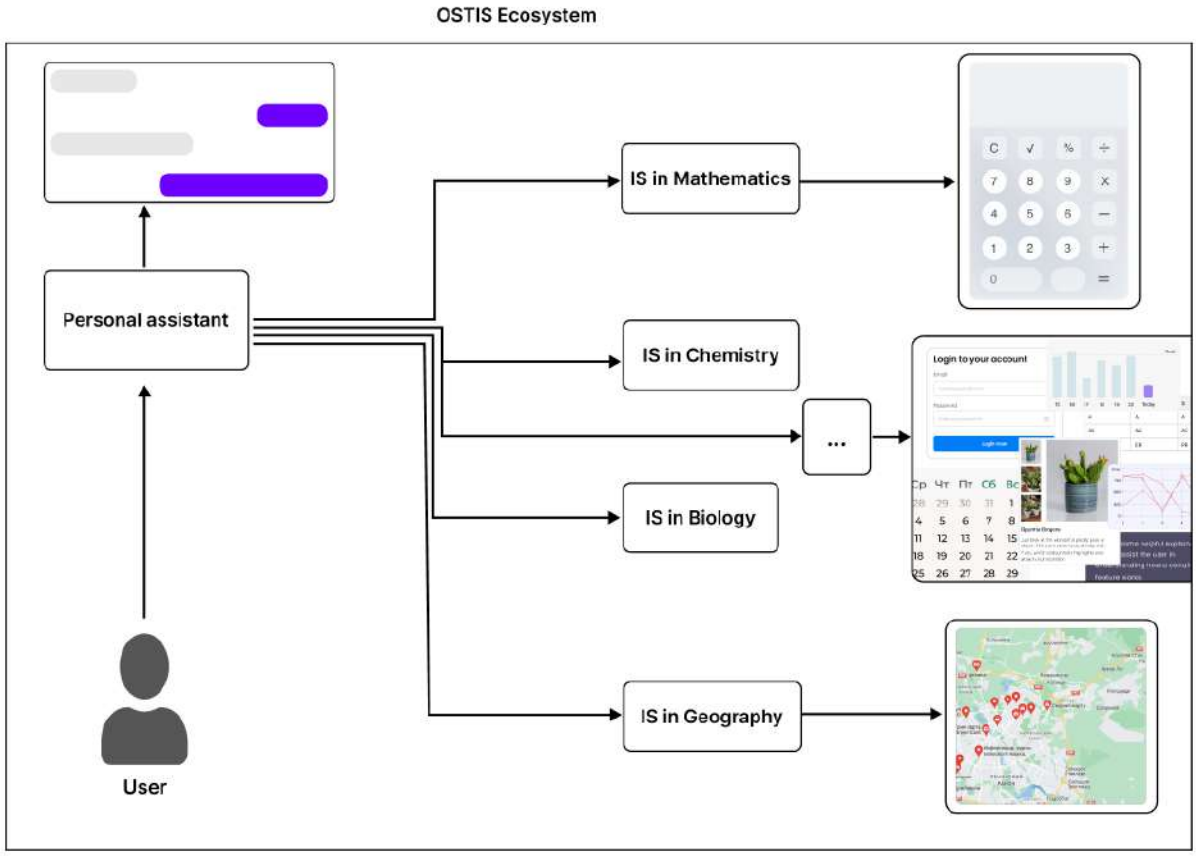


Figure 2. Components of the user interface of the OSTIS Ecosystem

A unique feature of the *OSTIS Technology* is ensuring the compatibility for the *components of ostis-system knowledge bases*, *ostis-system problem solvers*, and *ostis-system interfaces* due to a single unified formal basis. Thus, a *user interface component* for its work must usually include not only a description of its visual characteristics in the *knowledge base* but also *components of the problem solver* (for example, *sc-agents*), as well as the necessary fragments of some *subject domain*. So, in Figure 3, fragments of the *interface components*, the *problem solver*, the *knowledge base* for the "calculator" *user interface component* are represented in the *SCg-code*.

In the demonstrated Figure, the representation for the *operator of the sum of two numbers* and a fragment of the *Subject domain of numbers and numerical structures* necessary for the operation of the "calculator" *component* is displayed. Due to the unified representation of all the necessary parts, such a *component* can be easily integrated into any *ostis-system*, including the *personal ostis-assistant system*.

## IV. Conclusion

Within the article, the problem of usability of information services and systems was considered. Their existing diversity requires additional efforts from users to explore their features and gain interaction skills.

To solve this problem, relevant works on the use of *personal assistants* were considered. It was concluded that in addition to using *personal assistants*, it is necessary to ensure the compatibility of various services and systems, which can be implemented by creating an *ecosystem* of *semantically compatible systems*.

An approach was proposed, which assumes the use of the *OSTIS Technology*, which includes the *OSTIS Ecosystem* and *personal ostis-assistants* to ensure effective and comfortable user interaction with the *ecosystem*.

Within the proposed approach, the *user interface of the OSTIS Ecosystem* is considered as the *user interface of a personal ostis-assistant*, since the user interacts with the *ecosystem* only through their *personal assistant*. The principles of the *user interface of the OSTIS Ecosystem* were described, the main of which is the *component approach* to design and the possibility for a *personal assistant* to use any *user interface component* within the *OSTIS Ecosystem*.

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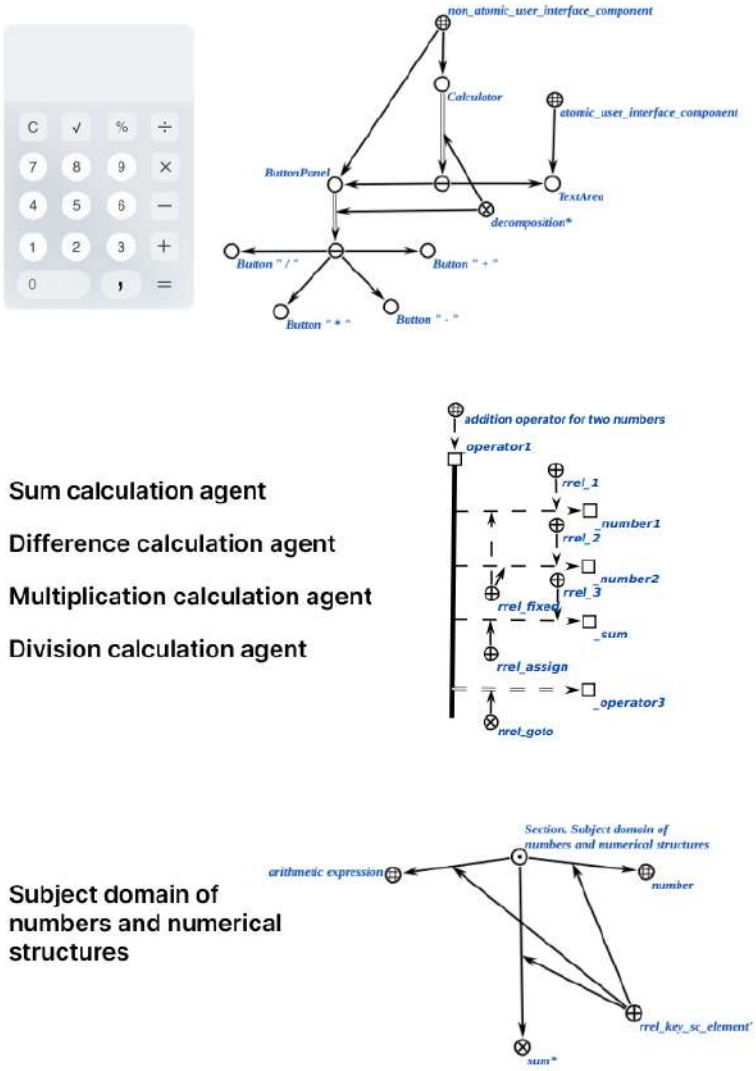


Figure 3. Components of the interface, the problem solver, and the knowledge base for the “calculator” component

## Пользовательский интерфейс Экосистемы OSTIS

Садовский М. Е.

В статье рассматриваются принципы организации взаимодействия пользователя с Экосистемой OSTIS, понятие пользовательского интерфейса Экосистемы OSTIS, применение компонентного подхода к проектированию адаптивных интеллектуальных мультимодальных интерфейсов ostis-систем.

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