Model of Interoperability of Information Systems of Information and Communication Environment of Secondary Special Education Institution

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***Abstract*—The paper proposes a model of interoperability of information systems of information and communication environment of secondary vocational education institution. It shows what should be understood under the interoperability of information systems in relation to the industry of education on the example of secondary special education institution. The system of business processes in the institution of specialized secondary education in the following directions: controlling, operating (basic, describing the educational process of the institution) and supporting is presented. The author's root model of business processes of educational institution is given. The well-known reference model of interoperability in the form of three levels - organizational, semantic and technical - is specified and supplemented by the parameters which were detailed for the college. The three-level model of interoperability of college information systems is refined on the basis of the processor approach, which allowed creating a flexible and adaptive management in the institution of secondary special education.**

***Keywords*—digital transformation, interoperability, information and communication environment, process management**

I. Introduction

At present, information systems, different in their composition, parameters and characteristics, are developing towards their integration and globalization. The term unified information space, which is understood as the interaction of various information systems for the exchange and use of information under common protocols, standards and rules, sounds more and more often. In this case, such knowledge-intensive areas as economics, industry, and defense are mainly analyzed.

Digital transformation, in the new era of digital economy, is impossible without the creation and development of a heterogeneous information and communication environment, the transparency of which is ensured through the use of open systems principles. One of the most important features of such open systems is interoperability, which is understood as the ability of systems and components to interact (exchange information and use the information obtained from the exchange), based on the use of information and communication technologies (ICT) [1], [2]. The main property of interoperability is the seamless information integration of individual elements and systems as a whole. The relevance of ensuring interoperability increases significantly with the transition of all areas of ICT application (Fig. 1) to the stage of digital transformation.

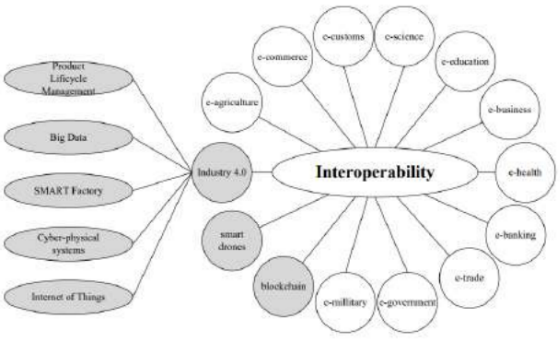

Figure 1: Interoperability — a key requirement for different applications.

All these domain areas should be seen as subsystems of the information society, and not isolated, but closely interacting. As it follows from the figure, the problem of interoperability extends to such subsystems of the information society as e-government, e-science, e-health, e-education, e-businness and other areas, since virtually no area of knowledge and economy can develop today without the use of information and telecommunication technologies. The process integration of socio-electronic systems into the information society is carried out with the help of the Industry 4.0 platform. The provision of interoperability acts as one of the key factors of the industrial concept of Industry 4.0, which also includes:

1) Product Lifecycle Management (PLM) is the

process of managing a product at all stages, from idea, design and production to sales, service and withdrawal from the market.

2) Big Data is a variety of big data stored on digital media.
3) SMART Factory — this concept provides a flexible modular multi-platform production system with a high level of informatization and visualization, organized according to the principles of "lean manufacturing".
4) Cyber-physical systems is a system consisting of various physical entities of any kind, artificial subsystems, such as various sensors and sensors, and controllers, allowing to present such an entity as a whole.
5) The Internet of Things (IoT) is a global computing network, combining various kinds of physical objects, capable of interacting with each other and the outside world [3].

Industry 4.0 enables the creation of an efficient enterprise business model, where efficiency is achieved primarily through the rational management of automation systems for physical production operations and related processes integrated into a single information space.

Blockchain technology is crucial for the realization of a single information space with interoperability in mind. This decentralized, open-source technology allows the creation of interoperable products between blockchains, allowing more users, businesses and institutions to remain interconnected."

One new technology in industrial automation is "smart drones," which are unmanned aircraft with automatic or remote control capabilities. They are used for various purposes, including photo and video shooting, aerial photography, aerial scanning, assessment of different terrains, detection of security threats, field research, etc.

The key area of e-government development is the formation of the national information and educational environment, which should ensure the consistent implementation of digital transformation processes and their effective management. Transferability, interoperability and scalability should be the prerequisites for the successful implementation of the national information and educational environment.

When solving the problems of interoperability, organizational changes aimed at the introduction of flexible and adaptive information and education systems (IES) of different levels in educational institutions are of primary importance. The necessary flexibility in managing the process of educational activity can be provided by the process approach to its organization.

The process management of educational institution in this study is understood as an activity aimed at the implementation of business processes with the highest possible efficiency under given constraints (human, material, immaterial, financial resources) [4].

To move to process management, it is necessary to formalize all business processes, determine which processes are the most demanded and most effective, how they are organized and how to control their effectiveness. The task of formalization is always solved by the introduction of a system of standards.

Process standardization in this case is understood as a set of measures, methods, tools and elements of the organizational structure that ensures the development, implementation, enforcement, maintenance and timely cancellation of outdated regulatory and procedural documents of the organization [5].

II. Interoperability of information systems in institutions of secondary special education

Let's consider interoperability in education on the example of a specialized secondary education institution. The activity of training specialists with specialized secondary education includes a system of business processes represented in the form of the following areas:

- *controlling* — manage the functioning of the educational system of the educational institution;
- *operational (basic)* — describe the educational process of the educational institution;
- *supporting* — serve the main activities of the educational institution (Fig. 2).

Figure 2: Business processes of secondary special educational institution.

These processes must be considered from a systemic approach, i.e., their interconnection and mutual influence on each other.The presented processes are basic, in particular educational institutions new modules can be added to them, new interrelations can be formed, so the presented scheme is open.

The implementation of the process approach must begin with the construction of a ROOT MODEL of business processes which are necessary for organizing and managing the activities of an educational institution. The ROOT MODEL of business processes is used to compile a classifier of business processes, and also shows the links between structural divisions, which allows at the output of the model to correlate business processes with structural divisions and their functions.

The scheme of the root business process model is shown in Figure 3.

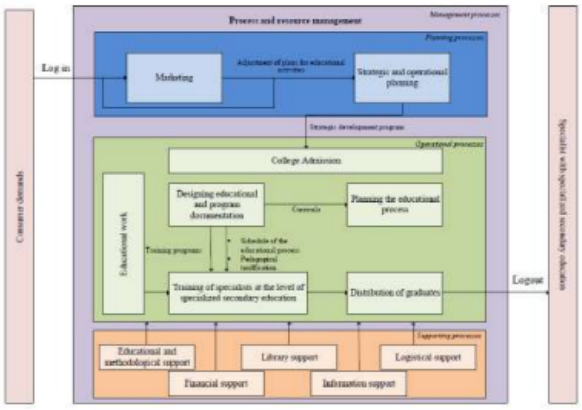

Figure 3: Root model of business processes of educational institution.

The ROOT MODEL of business processes includes three modules, each of which consists of generalized business processes and reflects their relationship through the flow of information.

The main module is operational processes. They determine the educational vector of the educational institution: the design of educational and program documentation, planning the educational process, the training of specialists at the level of secondary special education, ideological and educational work, the distribution of graduates.

The control processes module covers all business processes and is mainly focused on planning processes, whose activities are focused on providing educational services in accordance with the requirements of society and the state, which is the input data for the evaluation and subsequent adjustment of the strategic and operational plans of the educational institution.

The supporting processes module includes business processes that provide conditions for effective functioning of operational processes.

The result of the organized interconnected activity of all modules is a specialist with specialized secondary education. The root model of business processes can further serve as the basis for the classifier of business processes.

To ensure the interoperability of the information system modules it is reasonable to develop a problemoriented interoperability model.

To date, there are many different models describing the interaction of information systems. In order to select a basic model by analogy with the approach implemented in the Russian Federation, let us distinguish four levels of interoperability (Fig. 4):

1) no interoperability;
2) technical level;
3) semantic level;
4) the organizational level [6].

Note that each level of interoperability should correspond to a set of standards and specifications, so that the system developers could create a profile that includes a set of harmonized standards from all the necessary levels.

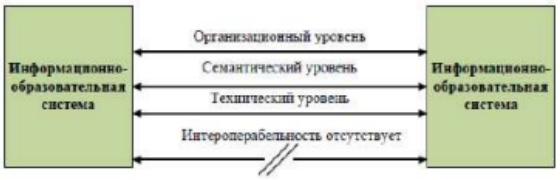

Figure 4: Basic levels of interoperability.

The first level of the interoperability model — no interoperability — means that all communication between information systems is done manually.

Thus, the college interoperability model can be based on the interoperability reference model presented in GOST R 55062-2012. This model consists of three levels: organizational, semantic, technical [7]. For each of the levels the interoperability parameters have been identified, which have been detailed to represent the college interoperability model. To form the sublevels and taking into account more parameters in the problemoriented model of the college information system, the international experience of interoperability formalization, presented in the SCOPE-model, can be used.

As we know [8], SCOPE-model is designed for qualitative-quantitative assessment of interoperability of different aspects of the analyzed system at its different levels, according to a certain set of parameters.

Today there are many technologies for interoperability. However, these tools are used in isolation from each other and are not linked into a coherent methodological system. All the many known approaches to solving interoperability problems at the technological, semantic and organizational levels can be roughly divided into the following categories [8]:

1) bottom-up approach (bottom-up approach), which focuses primarily on solving the problems of technological interoperability of information systems by using common standards and technologies for transmitting, storing, representing and processing information at all levels of integration of these systems;
2) top-down approach (top-down approach), which focuses on the decomposition of the solution of interoperability problems from the perspective of the system architecture as a whole, and then from the perspective of individual subsystems and processes down to atomic elements;
3) system-wide approach, based on the analysis of internal communications between components within