Office and industrial information systems and networks in the training of modern specialists

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Abstract. Article discusses an interdisciplinary optional course “Office and industrial information systems and networks”. Course provides skills in preparing of hardware-software platform formation of a workplace. This course is developed for students whose field of study is not related to information technologies, but whose professional activities will be carried out in the modern enterprises in the context of Industry 4.0 development.

1. Introduction

Industry 4.0 is characterized by use of high-tech electronics and equipment, the widespread introduction of Internet technologies. An actual task is adaptation of educational system to the requirements of this stage of society development [1]. The concept of Education 4.0 is understood as education that should correspond to Industry 4.0 and prepare students for the next industrial revolution that will happen in their life. Progress of educational environment of Education 4.0 requires development of interdisciplinary content in such areas as: “Designing CPS (Cyber Physical Systems), Modularity, Interoperability (Objects, machines and people need to be able to communicate through the Internet of Things and the Internet of People), Virtualization, Decentralization, Real-Time Capability, Service-Orientations” [2].

In [3] we considered, how educational content for training of modern IT specialists can be developed on a basis of the infocommunication infrastructure of modern enterprise and interdisciplinary connections, including study of foundations of wide range of technologies and development perspectives of these technologies. Every level of infocommunication infrastructure of modern enterprise designed to perform specific management functions. Each management level has its own computing environment, which is generally a network. Informational networks with their functioning characteristics are formed on every management level. At the same time, different specialists work on every management level in a network environment.

Currently Kazan National Research Technical University arranges a survey among students of all study programs. It summarizes their preferences on studying of the interdisciplinary optional course “Office and industrial information systems and networks”. The course features elements of digital economy and technologies used for their implementation. Besides, course discusses digital forms of management and enterprise functioning. This course is developed for students whose field of study is not related to information technologies, but whose professional activities will be carried out in the context of development of Industry 4.0.

2. Educational content of discipline “Office and industrial information systems and networks”
Duration of the course “Office and industrial information systems and networks” is 72 hours. Methodical support is provided by electronic resources [4-6]. Purpose of the course is training of skills which are necessary for creation of network management environment.

The course has following tasks:
- To provide general understanding about information systems and networks.
- To teach how to form network management environment.
- To teach how to set up local computer networks based both on cable and wireless connections.

Course features such elements of infocommunication infrastructure of an enterprise as its’ structure, applied environments for data transmission, equipment and network services. Table 1 shows main topics of the discipline.

| Chapter                              | Lecture topics                                                                 |
|--------------------------------------|-------------------------------------------------------------------------------|
| Basic concepts                       | Structure of an industrial enterprise management system Information Systems   |
|                                      | Information Networks                                                         |
| Management technologies              | Technologies for lifecycle management                                         |
|                                      | Technologies for business processes management                                |
|                                      | Technologies for technological processes management                           |
|                                      | Digital forms of enterprise functioning                                       |
|                                      | Information systems for management                                            |
| Infocommunication infrastructure of  | Structure of infocommunication infrastructure of an enterprise                |
| an enterprise                        | Data transfer environment                                                      |
|                                      | Technologies for office information networks                                   |
|                                      | Technologies for industrial information networks                               |
|                                      | Communication tools and network equipment                                      |
|                                      | Network services                                                               |
|                                      | Network addressing                                                            |
| Administration and maintenance       | Administration of information systems and networks                             |
|                                      | Maintenance of information systems and networks                                |
|                                      | Installation of office networks                                                |
| Prospects for information systems    |                                                                                |
| and networks                         |                                                                                |

First two sections contain educational content of discipline "Enterprise information systems" [4]. They focus on issues of enterprise management system, which consists of functional and supporting parts. Functional part is divided into subsystems that perform basic functions of enterprise management services. The next concepts of enterprise architecture are considered: Zahman’s model for enterprise architecture, model TOGAF (The Open Group Architecture Framework), FEA (Federal Enterprise Architecture), SOA (Service-Oriented Architecture).

The enterprise management system can be represented in a form of a multi-level structure, where at each level specific tasks are solved, and management functions are implemented. Every level is designed to perform specific management functions and has its own network environment. Information networks with their functioning characteristics are formed at every management level [3].

During the course, students get an understanding of technologies of enterprise management, based on product lifecycle and business processes, as well as management technologies for technological processes. Such management technologies as concept of MRP / ERP, Data Warehouse, OLAP (Online
Analytical Processing) are considered. Interaction between business entities can be carried out in accordance with block-chain technology. It is based on such information resources as decentralized global database and lists of users who have authorized access.

The next three (see Table 1) sections contain educational content on network technologies [5]. Enterprise management system can be represented as a structure with specific network technologies, shown in Table 2.

**Table 2. Enterprise management system.**

| Management system levels | Management functions                  | Network technologies                      |
|---------------------------|---------------------------------------|-------------------------------------------|
| Enterprise                | Financial management                   | Fast Ethernet                             |
|                           |                                       | Gigabit Ethernet                          |
|                           |                                       | 10Gigabit Ethernet                         |
|                           |                                       | ...                                       |
| Company                   | Production management                  | Fast Ethernet                             |
|                           |                                       | Gigabit Ethernet                          |
|                           |                                       | Bitbus                                    |
|                           |                                       | Profibus                                  |
| Manufactory               | Manufactory management                 | Fast Ethernet                             |
|                           |                                       | Gigabit Ethernet                          |
|                           |                                       | Bitbus                                    |
|                           |                                       | Profibus                                  |
| Industrial controllers    | Production process management          | Industrial Ethernet                       |
|                           |                                       | CAN                                       |
|                           |                                       | Profibus                                  |
|                           |                                       | ASI                                       |
|                           |                                       | LON ...                                   |
| Sensors                   | Sensors data, control of machine tools |                                           |

The next components can be distinguished in infocommunication infrastructure of enterprise management systems:

- enterprise management;
- management of technological processes of production;
- management of life support systems in buildings and structures;
- communication of employees;
- security system.

All components include cable and communication devices that ensure integration of elements and components into systems.

Following topics of network infrastructure of information systems are considered: possible structures of distributed information processing systems, network architecture, network protocols and interfaces, concept of "open systems", international standards for network interactions implementation, an OSI/ISO model, “client-server” technology.

Besides, course reviews issues of administration, operation of information systems and networks, as well as prospects of their development.

3. **Teaching and educational student activities on discipline “Office and industrial information systems and networks”**

Since a subject area of the course is constantly changing and getting updated, it requires constant work on educational content. Course materials are constantly updated and posted online by responsible teachers. At the same time, students are encouraged to prepare presentations with relevant information on studied topics.

To obtain practical skills, students are invited to perform following work during lab sessions:

- Network installation based on cable infrastructure.
- Network installation based on wireless connections.
Formation of a workplace.

Table 3 shows the types of practical educational activities of students during lab sessions.

**Table 3.** Lab sessions of discipline “Office and industrial information systems and networks”.

| Lab sessions                                      | Leaning activity                                                                 | Lab tasks                                                                 |
|---------------------------------------------------|----------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Network installation based on cable infrastructure | Create separate fragments of local network, installation of cable systems, computers and communication equipment. | Provide skills in connecting equipment, installing cable system and equipment, testing connections and verifying network working capacity. |
| Network installation based on wireless connections | Implementation of wireless networks schemes: ad-hoc and with an access point. Each option is created both with open access and with encryption. Installation of equipment and drivers, station availability check. | Provide skills in installation of equipment and creation of wireless local networks, as well as in testing connections, checking network working capacity. |
| Formation of a workplace                          | Preparation of a hardware-software platform for full-scale experiments on single-board computers. Installation of equipment, OS (operating system) and other software. | Provide skills in preparing a hardware-software platform for full-scale experiments on single-board computers. |

Cable infrastructure network installation is based on Gigabit Ethernet technology with IEEE 802.3ab standard. Process of training is divided into four following stages:

1. Preparation.
   Preparation of workstations for created network includes preparation of hard drives, installation of OS with required configuration and installation of drivers for network adapters Equipment and components (switchboard, cable pieces, devices and tools, connectors) are prepared for work.

2. Creation of network with two stations without communication device. It means, that two stations are connected through sockets.
   For implementation of such scheme it is necessary to carry out next operations:
   - To create three patch-cords with connectors on the ends with the same wiring in accordance with the EIA / TIA-568B standard. To accomplish this task, students required to use crimp pliers to connect (crimp) connectors to cable segments, then test created patch-cords using LAN- tester.
   - Installation of sockets. In this case, one socket has to be assembled according to the EIA / TIA-568B standard, and the other socket - according to the EIA / TIA-568A. After that test of complex of patch-cords and sockets are carried out. This complex can be implemented without sockets. In this case, it is necessary to prepare a patch-cord in a way that one end is crimped in accordance with EIA / TIA-568B and the other - in accordance with EIA / TIA-568A.
   - Connection of computers to a network using cable and sockets.
   After turning on workstations’ connections are searched and operability of the network segment is checked (using ping, messaging and working with shared resources).

3. Creation of network from two stations using a switch. To implement such a scheme, similar to described above sequence of actions should be carried out.

4. Creation of network with hierarchical structure. To implement such scheme, all student teams carry out the same sequence of actions: performing installation, searching for connections and verifying operability.
For network installation based on wireless connections, technology IEEE 802.11g/n/ac is used. Leaning activity for wireless network installation consists from the following stages:

1. Preparation of network workstations, i.e. installation of necessary OS with desired configuration.
2. Preparation of equipment and components (switch, access point, network adapters, patch-cords).
3. Installation of drivers and mount adapters on workstations.
4. Creation of network corresponding to Ad-hoc scheme on a workstation without encryption use. Other stations connect to this network. Operability of the network is checked.
5. Installation of a wireless access point.
6. Configuration of access point is based on one of the workstations of the network using cable infrastructure.
7. Wireless workstations connect to the network created by the access point. Created scheme of network installation featured by Fig.1. Operability of the network is checked.

![Figure 1. Scheme of network installation with access point.](image_url)

8. Creation of a new network using one of encryption methods, through one of the network stations access points.
9. Connection of remaining stations to the new network. Operability of the network is checked.

Under formation of a workspace students obtain new skills for preparation of a workplace for researcher. They prepare a platform for conduction of full-scale experiments based on single-board computers. They install equipment and form research environment (install OS and software necessary for the experiments).

**4. Conclusion**

Professional activities of various specialists in a process of development of Industry 4.0 are carried out with information systems in a networked environment. Thus, for all modern specialists working in industry, professional skills require the understanding of enterprise management technologies, as well as structure and functioning of office and industrial networks.

An interdisciplinary optional course “Office and industrial information systems and networks” is intended for training of skills, which are necessary for creation of network environment of modern enterprise management. Modern infocommunication infrastructure of an enterprise is formed by combination of cable and wireless components. Students are invited to perform necessary operations to create local network infrastructure using provided to them computers. Students consistently create separate fragments of local network, installing cable systems, computers and communication equipment, making necessary adjustments and tests of elements of infocommunication system and networks.

Described course provides skills in preparing of hardware-software platform formation of a workplace. This course can be recommended for training of professionals of various specialties, whose professional activities will be carried out in a context of Industry 4.0 development.
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References
[1] Kolesnichenko E A, Radyukova Y Y and Pakhomov N N 2018 The role and importance of knowledge economy as a platform for formation of Industry 4.0 Industry 4.0: Industrial revolution of the 21st century (Springer, Cham) pp 73-82
[2] Jeganathan L, Khan A N, Raju J K and Narayanasamy S 2018 On a Frame Work of Curriculum for Engineering Education 4.0 World Engineering Education Forum - Global Engineering Deans Council (WEEF-GEDC) (Albuquerque, NM, USA,12-16 Nov. 2018)
[3] Eminov F I, Golitsyna I N and Eminov B F 2018 Enterprise infocommunication infrastructure in training of IT-professionals Int. Conf. Information Technologies in Business and Industry IOP Conf. Series: Journal of Physics: Conf. Series 1015 (2018) 042014
[4] Eminov B F, Eminov F I 2019 [Corporate Information Systems: training manual] (Kazan: KNITU-KAI Press) (Russ) - https://elibrary.ru/download/elibrary_38555075_96165444.pdf
[5] Eminov B F, Eminov F I 2019 [Network technologies: training manual] (Kazan: KNITU-KAI Press) (Russ) - https://www.elibrary.ru/download/elibrary_39138744_25365426.pdf
[6] Eminov B F, Eminov F I 2018 [Network technologies: educational-methodical manual] (Kazan: KNITU-KAI Press) (Russ) https://www.elibrary.ru/download/elibrary_37148755_95068185.pdf