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[1]**V. V. Vyshnivskyi**
[2]**I. M. Sribna**
[3]**O. V. Zinchenko**

ANALYSIS OF TECHNICAL SOLUTIONS FOR IDENTIFICATION OF INTERNET THINGS IN MODERN COMMUNICATION NETWORKS

State University of Telecommunications, Kyiv, Ukraine
E-mails: [1]vish_vv@ukr.net, [2]isribnaya@gmail.com, [3]zinchenkoov@gmail.com

Abstract—*The article examines the current state of development of the Internet of Things and the principles of their identification; analysis of technical solutions for identification of the Internet of Things in modern communication networks; the parameters of quality of service and identification of devices and applications of the Internet of Things are investigated, and also the perspective method of construction of network architecture IoT with intermediate level of interaction which differs from known that allows to reduce network delay at exchange of service messages between local and global registers of system is investigated. Based on the obtained delay values, we can conclude that in order to minimize the delay, it is necessary to optimize the routes for accessing GHR servers. Considering the differences between the main components of the identification system, it is worth noting the combination of Global Handle Register and Local Handle Register in one object for testing. In the long run, this makes it possible to evaluate the multiple characteristics of the system at the application level. The resulting system in stationary execution also allows you to clearly demonstrate the speed of the identification rate, the route of service traffic and other parameters.*

Index Terms—Internet of things; digital object architecture; identification; delay; handle system; methods of queuing theory; digital object; global handle registry; local handle registry; local handle service.

I. Introduction

The Internet of Things is a modern concept that involves combining objects, "things", into a single global network that allows things to be intelligent to interact with each other and with a person at any time. Today, the number of devices connected to the network exceeds the number of all inhabitants of the planet and continues to grow rapidly, which raises the question of assigning each object a unique address, ensuring privacy and security in data transmission. Despite this, there is still no generally accepted method of identifying things that would meet all the requirements for both existing devices and applications of the Internet of Things, and for new ones.

An identifier is a dedicated, publicly known attribute or name (or set of attributes and names) for an individual device. One of the ways to ensure guaranteed and unambiguous identification of Internet of Things (IP) devices is to use the unique identifier of the IP device in public communication networks in conjunction with the parameters of the device itself. It should be borne in mind that the so-called universal identifier must support (be compatible) with existing identification methods, such as IMEI, MAC and others.

II. Problem Statement

Given that, according to the latest data, the number of already connected devices on the planet reaches 9 billion, which are located worldwide, it is also necessary to take into account the support of all types of languages and decentralization of digital registration systems on the Internet.

In this regard, one of the most important issues is the choice of identification system for all IP devices connected to the public communications networks. Many different software and hardware solutions are offered as a unique global identifier. One of the solutions that meets the proposed requirements for the identification of devices and applications of the Internet of Things is digital object architecture (DOA). Digital object architecture and its basic resolution system "Handle system" was originally created as a system of resolution of identifiers, with sufficient flexibility of use. Identifiers contain up-to-date information about the object - location, terms of use, encryption keys, etc. Due to the fact that DOA most fully meets the necessary requirements for the implementation of models and methods for the identification of devices and applications of IP based on DOA is a promising area of development of identification systems.

III. Review of Publications

In articles [1] – [5] the authors consider, and below summarize the main features of identification for the Internet of Things, namely: different life cycle of devices; the relationship of the objects of the Internet of Things with other extrasystem entities; special requirements for the context in which the devices operate; requirements for providing protection mechanisms; the ability to expand the identification system to a huge number of devices; ability to work effectively for a variety of devices; transparency of the addressing system and independence from the network; flexible and efficient mechanism for identifier resolution; security and storage of user data, etc.

IV. Problem Solution

Currently, the Internet of Things is a widely accepted concept for the development of communication networks in the short and long term, as well as an advanced platform for the development of digital intelligence in the concept of "Smart Country". According to most consulting and analytical companies, over the next five years, more than 25 billion devices will be present in each area of human life. Thus, we can talk about the pervasive nature of the penetration of the Internet of Things into our daily lives [6].

Despite all the benefits of the Internet of Things, there have recently been cases of disclosure of data collected by IP devices, which raises concerns about the identity of devices and applications within the concept of the Internet of Things. Indeed, identification plays an important role in the Internet of Things. For example, attackers could use portable RFID/NFC readers to steal personal data from bank cards on public transportation, using vulnerabilities in technology such as PayPass. This is possible due to the lack of identification of the owner of the RFID reader. Another example is the ability of an attacker to intercept data from networks of IP devices in order to obtain IMEI-IDs of various end devices equipped with modems, in order to further broadcast intentionally distorted messages.

Today, identifiers are used for various purposes in Internet of Things applications. The main task of the identifier, assigned to a thing, is identification, which allows you to uniquely identify things and be the target entities of the Internet of Things applications. In addition to the identification of things, identification is also subject to additions and services, users, data, terminal equipment, protocols and locations of things.

The interaction of different entities with bound identifiers in the framework of IP concentration is shown in the application AIOTI WG03 High Level Architecture Fig. 1.

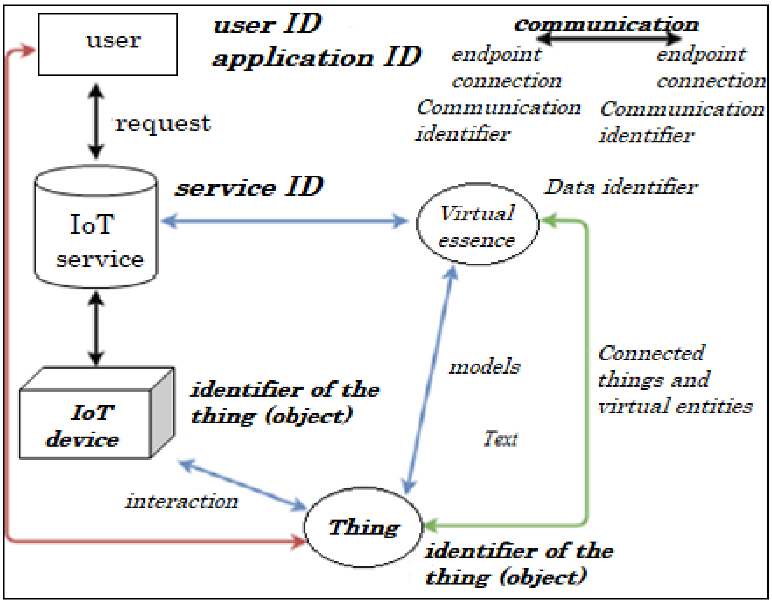

Fig. 1. Interaction of different entities with bound identifiers in ramkanh concentration of IP

One of the main tasks for engineers is to provide access to the Internet of Things to the Internet both directly and with the use of gateways. This is necessary so that each object (Internet thing) is presented virtually or physically, has an address and is accessible via the Internet at any time and in any place. Currently, the development of identification mechanisms for different classes and types of devices continues both in the Internet of Things and in the industrial Internet of Things is part of research in the International Organization for Standardization of both government and commercial.

Existing mechanisms for identification, used in various technologies of data forwarding, were invented at the turn of the century, when the question of the estimated number of devices to be connected was not raised IP. Analins has shown that it is possible to create an effective scheme for assigning unique identifiers only to a very small number of Internet of Things devices. In addition, the existing methods of identification in their majority do not support the device IP, briefly connected to the Internet, moving between different civic structures and closed communication networks. Also, the disadvantages of these methods include the fact that in communication networks, identifiers can contain information tied to a specific location of the location of IP devices. Internet of Things objects must have identifiers that do not depend on which network they are in or to which users they belong [7].

The digital object architecture and related Handle System resolutions were developed by the National Research Initiatives Corporation (CNRI) in the early 1990s. One of the initial motives for the creation of the DOA was the need to identify and obtain information about the object over a long period of time. The development of the architecture of digital objects has become an experimental transition from the presentation of data on the Internet with the help of sets of nodes and transport to the detection and delivery of information in the form of digital objects.

The purpose of creating the architecture of digital objects – to solve the following problems of digital information management: providing standard access to disparate information; interaction with various information systems; independence from specific basic technologies used for placement and maintenance of information; interaction over long periods of time; active management of the systems on which the information is disseminated; providing a large level of scale; distributed architecture; open architecture; standard protocols and procedures for the interaction of system components.

Architecture of digital objects – the architecture of a distributed system of storage, location and retrieval of information on the Internet. The fundamental components of the architecture of digital objects include those reflected in Fig. 2.

The investigated sub-approach of the modified registrar system was tested on the basis of a model network to test performance and reduce network latency compared to the existing registrar system.

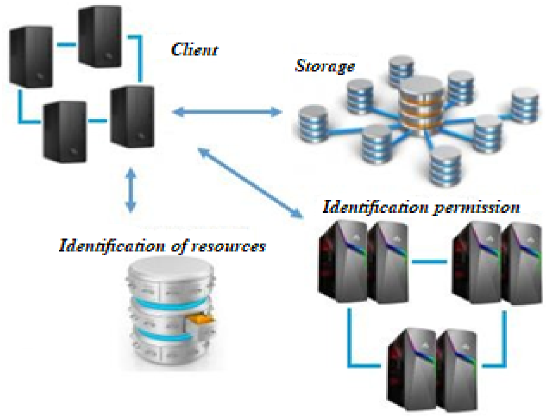

Fig. 2. Fundamental components of digital object architecture

The MatLab software package was used for modeling. Assume that the proposed MHR system contains $N = 10$ intermediate registers, which are located in different countries and work with all groups of local LHR registers around the world. Each intermediate register has its own arrangement with latitude φ_j and longitude λ_j. In addition, we introduce an approximate distance GHR_j^D between each LHR intermediate register and the global GHR register. The total number M_j of local LHR registers connected to each MHR register.

Descriptions (specifications) include the latitudinal φ_j and longitude λ_j of the LHR server location, approximated by the distance between each local LHR register and the corresponding intermediate register MHR $(D_i^j D_j)$ and approximated by the distance GHR_j^D between each intermediate LHR register and the main GHR register. The initial parameters for modeling are given in Table I.

TABLE I. INITIAL PARAMETERS FOR MODELING

Parameter	Addition	Value
Speed of propagation	v	200 m/µs
Approximate location thinning GHR	φ GHR, λ GHR	46.2044°*N*; 6,1432°*E*
N	–	10

To illustrate the reduction of network latency in the modified registry system architecture compared to the existing registry system, we will look at the simulation results. Figure 3 compares the network delays in the modified and traditional architecture: between each local LHR register and its corresponding intermediate register MHR (Case 1, solid blue curve), and between each local register

RH red curve). In Figure 3, and delays are shown for all tens of LHR*s* related to the intermediate register MHR_1 (M_1 = 10); Fig. 3b describes the eight LHR, located in the territory of the register MHR_2 (M_2 = 8); etc. up to Fig. 3, where the delays for the four LHR intermediate registers are shown MHR_{10} (M_{10} = 4).

As can be seen in the graphs of Fig. 3a–j, the average network delay of the modified register system (Case 1) is less than the average network delay of the existing register system without MHR (Case 2). Moreover, the reduction of the delay is achieved for all dispersed LHR, which are randomly distributed around the world.

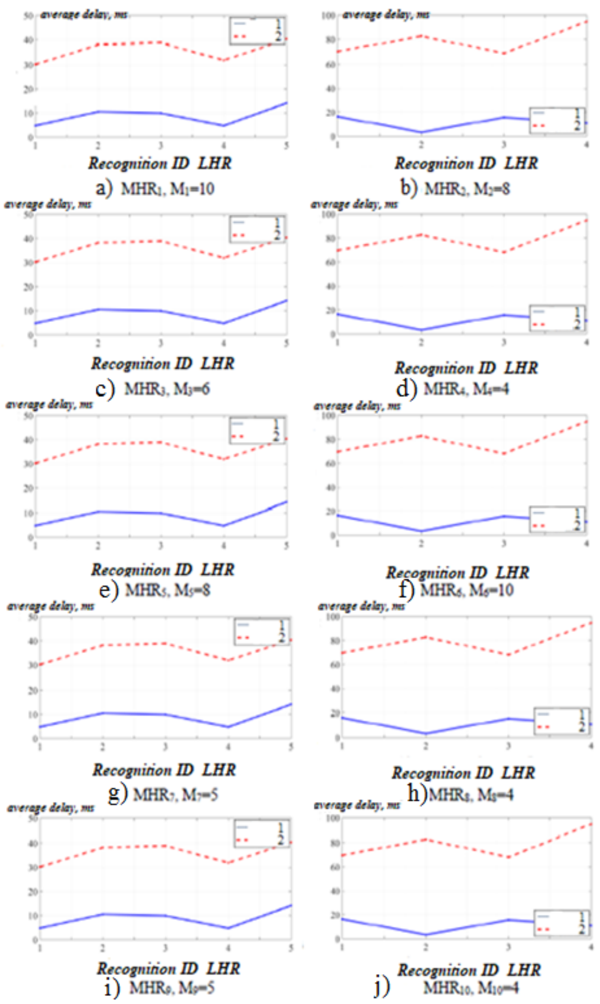

Fig. 3. Average network latency for the modified (Case 1) and traditional (Case 2) architecture of the Handle System resolution system for all MHRs

Table II presents data on the percentage reduction of network delay of each LHR when using a modified system of registers in comparison with the existing system of registers, as well as the average values of delay reduction for each group of LHR associated with a particular MH. The average network delay of all LHRs used in the proposed system with intermediate MHRs is 61.56% less than in the existing LHR system. Thus, the modified registry system can reduce network latency by up to 60% compared to the existing MHR-free registry system.

The analysis showed that the server part includes a functional for solving identifiers, which is a prerequisite for verification of the identifier in the architecture of digital objects. In preparation for the creation of the simulation model, a number of restrictions were introduced, taking into account the allowable level of abstraction, which allowed to present the server part in the form of two servers: GHR and LHS, each of which has access to its database. The general scheme of the structure of the appendix is presented in the figure below [7]. The GHR stores information about content owners. Product information is stored on the LHS. The general scheme of the structure of the appendix is presented in Fig. 4.

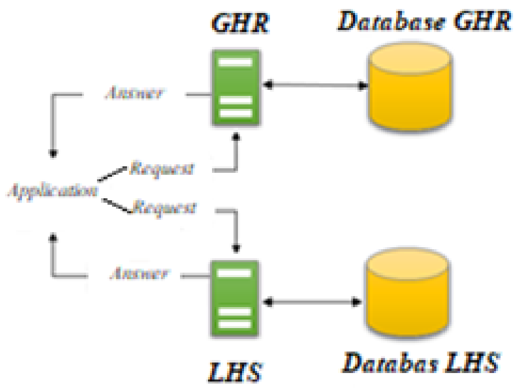

Fig. 4. General scheme of identification structure

V. APPROBATION OF IDENTIFICATION METHODS

Approbation of methods of identification of devices of the Internet of Things on the basis of architecture of digital objects the laboratory stand which was based on direct interaction of the identified device with Handle-server via the Internet Fig. 5. In the course of the research the scenario of identification of the device with the use of the intermediate device of verification was considered.

The laboratory stand for identification of IP devices was implemented with the introduction of a new component (as opposed to the traditional approach) – the level of verification of objects in the DOA system.

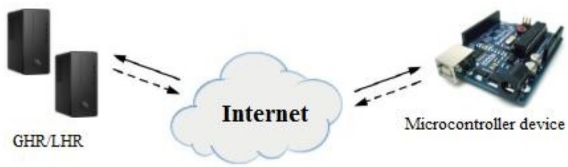

Fig. 5. Schematic representation of the interaction of elements in the identification of IP devices on the basis of DOA (traditional approach)

TABLE II. PERCENTAGE REDUCTION OF RELAY WHEN USING MHR

	Reduce network latency LHR_i, %										**The average value of the reduction delays *t*, %**
MHR_j	LHR_1	LHR_2	LHR_3	LHR_4	LHR_5	LHR_6	LHR_7	LHR_8	LHR_9	LHR_{10}	
MHR_1	73.82	40.70	61.86	84.82	80.55	43.09	1.59	46.16	26.19	27.19	48.60
MHR_2	93.17	47.18	24.97	62.11	50.68	83.48	55.38	61.04	–	–	59.75
MHR_3	27.24	48.23	25.74	61.11	13.67	16.15	–	–	–	–	32.02
MHR_4	61.52	66.53	54.21	33.94	–	–	–	–	–	–	54.05
MHR_5	39.75	74.39	66.94	62.12	85.03	88.06	44.33	59.54	–	–	67.54
MHR_6	76.98	86.87	76.96	70.36	98.75	74.97	81.23	92.70	37.43	42.62	73.89
MHR_7	45.25	78.69	38.50	28.35	1.29	–	–	–	–	–	38.42
MHR_8	79.57	75.66	85.57	82.75	–	–	–	–	–	–	80.89
MHR_9	84.09	72.33	74.40	85.06	64.88	–	–	–	–	–	76.15
MHR_{10}	76.41	95.68	76.93	88.25	–	–	–	–	–	–	84.32
Reducing the average network delay of all MHR											61.56%

The stand consists of the following components of Fig. 6:

- handle-server, which contains information about the identified device;
- network Internet in the quality of network infrastructure;
- finite device (IoT device or any other identified object);
- additional level of object verification in the Digital Object Architecture system.

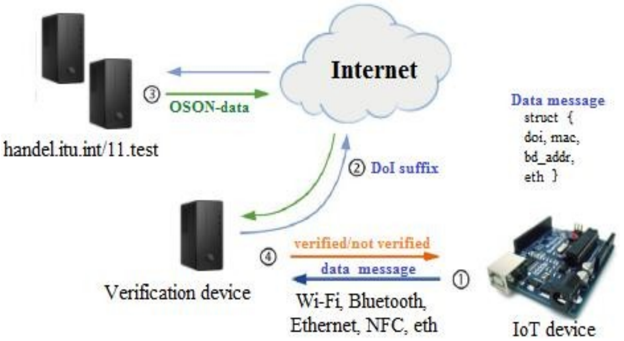

Fig.6. Improved concentration of DoA-based device identification system using verification level

Considering the differences between the main components of the system, it is worth noting the combination of Global Handle Register and Local Handle Register in one object for testing on a laboratory bench, study participants were given access to the DOA test zone with the prefix "11.test", which allows to place own identifiers in the existing system of Digital Object Architecture. In the long run, this makes it possible to evaluate multiple system characteristics at the application level.

VI. RESULTS

Introduction to the traditional scheme of the verification device will determine the average access time of the system to the DOA-server and provides the verification status. Access to the test device using special technologies, such as NFC or BLE, creates additional delays on the interfaces, but this is not the target scenario for this study. It can be concluded that to minimize the delay, it is necessary to optimize the routes for accessing GHR servers.

VII. CONCLUSIONS

The analysis of construction of network architecture of digital objects was carried out. The main components of DOA architecture and the principles of their interaction are considered. In order to increase the indicators of the quality system of identification, the modernized architecture of interaction was introduced by introducing an intermediate level between the global register and the local register. A review of the simulation results showed that the introduction of an intermediate level of MHR registers will reduce the delay compared to the existing architecture.

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Vyshnivskyi Viktor. Doctor of Engineering Science. Professor.
Head of Department of Computer Science, State University of Telecommunications, Kyiv, Ukraine.
Education: State University of Telecommunications, Kyiv, Ukraine, (2017).
Research interests: Computer Science, Artificial Intelligence.
Publications: 289.
E-mail: vish_vv@ukr.net

Sribna Iryna. Candidate of Science (Engineering). Associate Professor.
Department State Information Systems and Technologies, State University of Telecommunications, Kyiv, Ukraine.
Education: Kiev branch of the Ukrainian Academy of Communications A. S. Popova, Kyiv, Ukraine, (2002).
Research interests: information systems and technologies.
Publications: 19.
E-mail: isribnaya@gmail.com

Zinchenko Olha. Candidate of Science (Engineering). Associate Professor.
Head of the Department of Artificial Intelligence, State University of Telecommunications, Kyiv, Ukraine
Education: State University of Information and Communication Technologies, Kyiv, Ukraine, (2008).
Research interests: Artificial Intelligence, intelligent systems.
Publications: 25.
E-mail: zinchenkoov@gmail.com

В. В. Вишнівський, І. М. Срібна, О. В. Зінченко. Аналіз технічних рішень для ідентифікації Інтернет речей у сучасних мережах зв’язку

У статті досліджено сучасний стан розвитку Інтернету речей та принципів їхідентифікації; аналіз технічних рішень ідентифікації Інтернет речей в сучасних мережах зв’язку; досліджено параметри якості обслуговування та ідентифікації пристроїв і додатків Інтернету речей, а також досліджено перспективний метод побудови мережевої архітектури IoT з проміжним рівнем взаємодії, який відрізняється від відомих тим, що дозволяє знизити мережеву затримку при обміні службовими повідомленнями між локальними і глобальними регістрами системи. Грунтуючись на отриманих значеннях затримки, можна зробити висновок, що для мінімізації затримки необхідно оптимізувати маршрути для звернень до серверів Global Handle Register. Розглядаючи відмінності основних компонентів системи ідентифікації, варто відзначити об’єднання Global Handle Register і Local Handle Register в один об’єкт для здійснення випробувань. У перспективі, це дає можливість оцінити множину характеристик системи на прикладному рівні. Отримана система в стаціонарному виконанні також дозволяє наочно продемонструвати швидкість процесу ідентифікації, маршрут прямування службового трафіку та інші параметри.

Ключові слова: інтернет речей; Digital Object Architecture; ідентифікація; затримка; Handle system; методи теорії масового обслуговування; цифровий об’єкт; Global Handle Registry; Local Handle Registry; Local Handle Service.

Вишнівський Віктор Вікторович. Доктор технічних наук. Професор.
Завідувач кафедри комп’ютерних наук, Державний університет телекомунікацій, Київ, Україна.
Освіта: Державний університет телекомунікацій, (2017).
Напрямок наукової діяльності: комп’ютерні науки, штучний інтелект.
Кількість публікацій: 289.
E-mail: vish_vv@ukr.net

Срібна Ірина Миколаївна. Кандидат технічних наук. Доцент.
Кафедра інформаційних систем і технологій, Державний університет телекомунікацій, Київ, Україна.
Освіта: Київський філіал Української академії зв'язку ім. А. С. Попова, (1996).
Напрямок наукової діяльності: інформаційні системи і технології
Кількість публікацій: 19.
E-mail: isribnaya@gmail.com

Зінченко Ольга Валеріївна. Кандидат технічних наук. Доцент.
Завідувач кафедри штучного інтелекту, Державний університет телекомунікацій, м. Київ, Україна.
Освіта: Державний університет інформаційно-комунікаційних технологій, (2008).
Напрямок наукової діяльності: штучний інтелект, інтелектуальні системи.
Кількість публікацій: 25.
E-mail: zinchenkoov@gmail.com

В. В. Вишневский, И. Н. Срибная, О. В. Зинченко. Анализ технических решений для идентификации интернет вещей в современных сетях связи

В статье исследовано современное состояние развития Интернета вещей и принципов их идентификации; анализ технических решений идентификации Интернет вещей в современных сетях связи; исследованы параметры качества обслуживания и идентификации устройств и приложений Интернета вещей, а также исследован перспективный метод построения сетевой архитектуры с промежуточным уровнем взаимодействия, который отличается от известных тем, что позволяет снизить сетевую задержку при обмене служебными сообщениями между локальными и глобальными регистрами системы. Основываясь на полученных значениях задержки, мы можем сделать вывод, что для минимизации задержки необходимо оптимизировать маршруты для обращений к серверам GHR. Рассматривая различия основных компонентов системы идентификации, стоит отметить объединение Global Handle Register и Local Handle Register в один объект для осуществления испытаний. В перспективе, это дает возможность оценить множество характеристик системы на прикладном уровне. Полученная система в стационарном исполнении также позволяет наглядно продемонстрировать скорость процесса идентификации, маршрут следования служебного трафика и другие параметры.
Ключевые слова: интернет вещей, Digital Object Architecture, идентификация, задержка, Handle system, методы теории масового обслуживания, цифровой обьект, Global Handle Registry, Local Handle Registry, Local Handle Service

Вишневский Виктор Викторович. Доктор технических наук. Профессор.
Заведующий кафедрой компьютерных наук, Государственный университет телекоммуникаций, Киев, Украина.
Образование: Государственный университет телекоммуникаций (2017).
Направление научной деятельности: компьютерные науки, искусственный интеллект.
Количество публикаций: 289.
E-mail: vish_vv@ukr.net

Срибная Ирина Николаевна. Кандидат технических наук. Доцент.
Кафедра информационных систем и технологий, Государственный университет телекоммуникаций, Киев, Украина.
Образование: Киевский филиал Украинской академии связи им. А. С. Попова, (1996).
Направление научной деятельности: информационные системы и технологии
Количество публикаций: 19.
E-mail: isribnaya@gmail.com

Зинченко Ольга Валерьевна. Кандидат технических наук. Доцент.
Заведующая кафедрой искусственного интеллекта, Государственный университет телекоммуникаций, Киев, Украина.
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E-mail: Zinchenkoov@gmail.com