UDC 004.8:621.39

THE ROLE OF ARTIFICIAL INTELLIGENCE IN THE FORMATION OF WIRELESS NETWORKS

[1]Oliinyk D.I., [2]Nizhnyi D.A.
[1]*National Institute for Strategic Studies,*
[2]*National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"*
E-mail: olijnukd@i.ua, nizhnyi.danyil@lll.kpi.ua

РОЛЬ ШТУЧНОГО ІНТЕЛЕКТУ У ФОРМУВАННІ БЕЗДРОТОВИХ МЕРЕЖ

У статті наводиться аналіз розвитку технологій Інтернету речей (*IoT*) та їх інтеграції з штучним інтелектом (*ШІ*), а також розглядаються майбутні напрямки використання цих технологій, зокрема в контексті бездротових мереж 5G та 6G. Встановлено, що майбутні мережі еволюціонуватимуть до інтеграції різних середовищ (космос, повітря, земля, море) та впровадження нових послуг, таких як масові комунікації машинного типу (*mMTC*), зв'язок з наднадійністю та низькою затримкою (*uRLLC*) і розширений мобільний широкосмуговий зв'язок (*eMBB*).

The article provides an analysis of the development of Internet of Things (IoT) technologies and their integration with artificial intelligence (AI), as well as considers future directions for the use of these technologies, particularly in the context of 5G and 6G wireless networks. It is established that future networks will evolve to integrate different environments (space, air, land, sea) and introduce new services such as mass machine-type communications (mMTC), ultra-reliability and low-latency communications (uRLLC) and advanced mobile broadband. communication (eMBB).

The Internet of Things (*IoT*) has created the need for massive connectivity for billions of devices that require system power far beyond the needs of current networks and the introduction of an efficient communication paradigm. Artificial intelligence (AI) technologies, which are equivalent to human intelligence based on machine learning systems, are now being integrated into all spheres of human activity. These have already found their implementation in self-driving car navigation, face recognition, language processing, logical reasoning, etc. Future research includes: augmented reality; autonomous *IoT* industry; digital doubles; the formation of the Metaverse, etc. [1]. There is a consensus in the research community that future networks will evolve towards the integration of space, air, land and sea, providing communication services with wide coverage [2]. Wireless networks of the future, particularly artificial intelligence-based 5G and 6G, are seen as the standard technology for cellular wireless networks. Massive machine-type communications (*mMTC*) are becoming the main driver to realize the vision of a scalable IoT with heterogeneous applications with mass access of telecommunications consumers. Thus, *mMTC* with ultra-reliability and low-latency communication (*uRLLC*) and enhanced mobile broadband (*eMBB*) form new types of diversified services in future networks.

Despite the development of 5G in recent years, the fifth generation of cellular technology still poses some challenges due to both wavelength limitations and cost debates. Data centers are already facing changes caused by wireless networks, such as: virtualization, programmable networks, edge computing, and the challenges of simultaneously supporting public and private networks. 5G and 6G technologies are expected to make greater use of the distributed radio access network (*RAN*) and terahertz spectrum to increase bandwidth, reduce latency and improve spectrum sharing.

RAN networks were once proposed to effectively reduce capital and operational costs and optimize resource allocation through information access [3]. The cloud RAN network makes it possible to allocate a subset of computing and caching resources, combine the necessary information and perform management functions (main signal processing, planning and allocation of radio resources, etc.). Accordingly, new cloud-based *RANs* will have greater capacity to support connectivity requirements initiated by various devices and users in globally integrated Metaverse scenarios. The need for new semiconductor components for the telecommunications market with higher bandwidth is a new serious challenge for the semiconductor industry that needs to be addressed in the medium term. Such components, such as power amplifiers, etc., significantly affect the operation of the entire system, including the output power, efficiency, throughput, etc.

Another challenge when it comes to *AI* is the availability of data using frequencies up to 330 GHz for the neural network. In the scientific literature of the field of telecommunications, special attention is paid to the research of terahertz range (THz) technologies, the purpose of which is to develop a suitable wireless system with built-in antennas in THz, where the range from 110 GHz to 170 GHz is considered one of the main prospective frequency ranges for the technologies of the future generation.

The combination of future wireless networks based on *AI* and terahertz technologies is a new research area that requires deep skills with big data, service-aware security, deeper virtualization and networks for cloud *RAN* based on international standards. The European Consortium of Academic and Industry Leaders (*Hexa*-X[1]), which is headed by the Finnish communications company Nokia, is currently forming a policy on systematization and preliminary standardization, as well as harmonization of global standardization of innovative technologies [4]. The standardization outlines potential system designs, use cases and performance targets for new technologies that aim to enable widespread user access, high bandwidth efficiency for future heterogeneous services and applications, including virtual/augmented reality (VR/AR), holographic telepresence, Industry 4.0 and robotics. According to research by Ecorys, in Europe the VR/AR market size was estimated at €9.6 billion in 2021, up 26% from 2020, and its market value is expected to grow from 35 to 65 by 2025 billion euros [5].

[1] For reference. Hexa-X also includes the Swedish operator Ericsson and other operators.

The ISO/IEC JTC 1/SC 42 "Artificial Intelligence" Joint Technical Standardization Committee has now developed and published standards in the field of testing AI-based systems, functional safety and AI systems, big data, etc. [6].

The use of a large array of electronic data and digital technologies in the field of telecommunications and their interconnection leads to rapid changes and requires the outline of a holistic, standardized approach to the functioning of systems. In Ukraine, the creation of a new platform for the development of the technological innovation system has been launched. The Ministry of Economy initiated the pilot project "Digitization of standardization processes" regarding the involvement of AI, and the corresponding technical standardization committee was formed, the purpose of which is to ensure the standardization system in the field of AI technologies. The development of standards with the help of *AI* will allow speeding up the process of creating standards, reduce labor costs for development, and digitize the processes of forming standards texts. Bringing domestic standards into line with international norms and regulations with the help of AI will accelerate the selection of the optimal model of the Metaverse. The Metaverse is a future, sustainable and interconnected virtual environment of augmented reality using RAN and terahertz spectrum.

The most famous studies on the telecommunications market and related applications and services are: spectrum testing for frequencies from 95 GHz to 3 THz (US Federal Communications Commission (*FCC*); terahertz frequency range, which provides a data transfer rate of 100 times faster than 4G (*LTE*) networks (South Korea Research Institute of Electronics and Telecommunications); development of microchips for data separation and more efficient management of terahertz waves (Universities of Osaka (Japan), Oulu (Finland) and Australian University of Adelaide); testing of integrated joint communication and sensing (*Rohde & Schwarz* company) and others.

References

1. Braten, A.E.; Kraemer, F.A.; Palma, D. Autonomous IoT Device Management Systems: Structured Review and Generalized Cognitive Model. *IEEE Internet Things J.* 2021, *8*, 4275–4290.
2. Cheng, N.; Quan, W.; Shi, W.; Wu, H.; Ye, Q.; Zhou, H.; Zhuang, W.; Shen, X.; Bai, B. Space-air-ground Network Integration: A Comprehensive Simulation Platform. *IEEE Wirel. Commun.* 2020, *27*, 178–185.
3. Checko, A.; Christiansen, H.L.; Yan, Y.; Scolari, L.; Kardaras, G.; Berger, M.S.; Dittmann, L. Cloud RAN for Mobile Networks-A Technology Overview. *IEEE Commun. Surv. Tutor.* 2014, *17*, 405–426.
4. 6G series: Leading the way to 6G with Hexa-X II. URL: https://www.ericsson.com/en/blog/2023/1/hexa-x-ii-leading-the-way-to-6g
5. XR and its potential for Europe. URL: https://glue.work/2022/10/18/xr-and-its-potential-for-europe/
6. ISO/IEC JTC 1/SC 42 Artificial intelligence. URL: https://www.iso.org/committee/6794475.html