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ANALYSIS OF DIGITALIZATION AND MODERN TELECOMMUNICATION STANDARDS

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Annotation

This graduation thesis is dedicated to the topic “Analysis of digitalization and modern telecommunications standards (on the example of Uzbekistan, 2015–2025)”, which analyzes the processes of introducing digital technologies, modernizing telecommunications infrastructure, and ensuring information security in the Republic of Uzbekistan.

The study covers the main directions of digitalization policy for 2015–2025, the implementation of the “Digital Uzbekistan – 2030” strategy, the expansion of 4G and 5G networks, the introduction of GPON technology, information security, and digital sovereignty.

The development of the national regulatory framework in the telecommunications sector in accordance with international standards (ITU, ISO, ETSI), public-private sector cooperation, and strategic directions for the period up to 2030 are also scientifically analyzed.

The results of the graduation qualification work will make a practical contribution to increasing the effectiveness of reforms in the digital economy, information technologies and telecommunications of the Republic of Uzbekistan, as well as to scientific and practical developments and the process of personnel training.

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INTRODUCTION

Today, the rapid development of information and communication technologies has a direct impact on every sector of the world economy. Telecommunication systems are the most important part of the infrastructure of modern society, because they ensure continuous communication of economic, political, scientific and cultural processes. The speed and reliability of information flows is becoming an important factor of the competitiveness and national security of states. From this point of view, the issue of introduction and improvement of telecommunication standards based on modern requirements is of not only technical, but also strategic importance.

After the Republic of Uzbekistan gained independence, the development of the field of communication and information technologies in the country became one of the priorities of the state policy. In the last decade, the government of Uzbekistan has carried out large-scale reforms to expand digital infrastructure, develop internet networks, update mobile communication technologies, and implement international telecommunication standards into national practice.

Within the framework of the "Digital Uzbekistan - 2030" strategy, important measures have been determined in the direction of modernization of the communications and telecommunications sector, strengthening of national information security, and creation of technological infrastructure in accordance with international standards. At the same time, active work is being carried out to establish telecommunication networks, in particular, broadband communication systems based on modern standards such as GPON, NGN, LTE, 5G, expand the network of optical fiber lines, increase internet speed, and strengthen network reliability.

The role of standards in the field of telecommunications is incomparable. They not only ensure technological compatibility, but also facilitate interoperability between different manufacturers, operators and users. The standards developed by such organizations as the International Telecommunication Union (ITU), European Telecommunication Standards Institute (ETSI), IEEE, and

3GPP have today formed a single technical language throughout the world. Uzbekistan is expanding its cooperation with these international organizations and is on the way to adapt its national legal framework to these standards.

In recent years, major operators such as "Uzbektelecom" joint-stock company, "Ucell", "Beeline", "Uzmobile", "Humans" have achieved significant results in the introduction of new technologies. The expansion of 4G LTE networks, the launch of 5G test projects, and the increase in the coverage level of optical fiber infrastructure are important steps towards making Uzbekistan one of the leading telecommunication centers in the region. At the same time, there is an increase in international rankings of Internet speed and coverage.

At the same time, problems remain in the existing system. Factors such as uneven development of telecommunication infrastructure in some regions, dependence of technological equipment and software mainly on imports, limited local production, and insufficient qualification of personnel slow down stability in the sector. Therefore, the creation of integrated, secure and high-quality communication systems based on international standards remains a strategic task for Uzbekistan.

Analysis of standards in the field of telecommunications, determination of their technical and economic advantages, development of ways to improve the national system based on international experience is the main goal of this graduate work. The practical significance of this study is that the proposals and conclusions developed in it can be used in the modernization of telecommunication networks, ensuring information security, implementing new technologies, and effectively implementing the "Digital Uzbekistan - 2030" program.

Also, within the framework of this work, the technical characteristics of GPON, NGN, LTE and 5G technologies used in telecommunication networks of Uzbekistan, their compatibility with international standards, infrastructure and economic efficiency are analyzed. It compares the recommendations of international organizations such as ITU, IEEE, 3GPP, ETSI and the current normative legal documents of the Republic of Uzbekistan. On the basis of the

results, scientifically based proposals will be developed on the directions of future development of the telecommunications industry.

The relevance of this graduation work is that it analyzes the digitization policy of the Republic of Uzbekistan in the last decade, the stages of development of telecommunication networks and the processes of integration into international standards on a scientific basis. The scientific analyzes and conclusions presented in the work are of not only practical, but also scientific-theoretical importance, as they serve to adapt the national telecommunications system to the requirements of the global digital economy.

The development of telecommunication systems based on modern standards is an important factor in ensuring the economic stability, technological independence and international competitiveness of Uzbekistan. Therefore, this graduation qualification work on the topic "Analysis of modern telecommunication standards (in the case of Uzbekistan)" is aimed at providing a scientific analysis of the digitization policy carried out in our country, summarizing the existing results and determining the directions of future development.

1-CHAP. FORMATION AND DEVELOPMENT DIRECTIONS OF THE DIGITAL POLICY AND TELECOMMUNICATION INFRASTRUCTURE IN UZBEKISTAN

1.1. Stages of digitization policy formation

Since 2015, the introduction of information and communication technologies in Uzbekistan has risen to the level of state policy. From this year, programs for the development of the "Electronic Government" system have been implemented. At the initial stage, the internet infrastructure, information security and online services system were established.

In 2017, the concept of "Development of Digital Economy" was officially mentioned. Since then, digitization has become the main direction of state reforms.

The "Digital Uzbekistan - 2030" strategy, approved in 2020, created the legal basis for the comprehensive introduction of digital technologies in the country. According to this program:

construction of optical fiber communication lines in all regions;

transfer at least 80 percent of state services to electronic form;

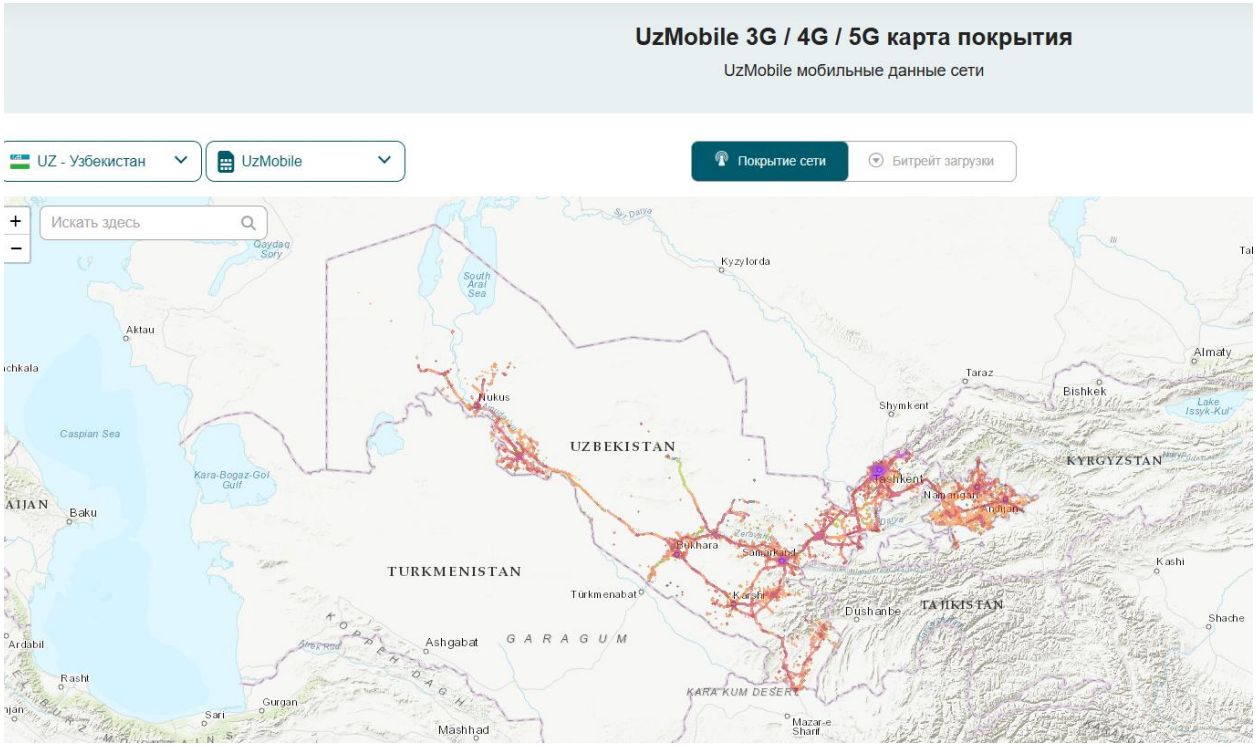
testing and implementation of 5G networks;

strengthen the national system of information security;

goals were set, such as increasing the level of digital literacy.

As a result of this strategy, more than 200,000 kilometers of new optical fiber communication lines were laid across the republic between 2021 and 2025, the Internet speed increased 5 times, and the coverage of mobile communication reached almost 98%.

Uzbekistan has made great progress in the field of telecommunications in recent years. 4G LTE technology was introduced by UZTELECOM, Beeline, Ucell, Humans and other operators. Starting from 2023, 5G networks were launched in some cities and regions on a trial basis.



1.1.1- Picture. Coverage of the UzMobile operator in the Republic of Uzbekistan.

The total length of optical fiber networks will reach 300,000 kilometers by 2025. This improved the quality of Internet services and enabled the stable operation of the electronic government system.

1.1.2- Picture. 5G technology at the ICT WEEK UZBEKISTAN 2024 exhibition.

The number of mobile subscribers increased from 22 million in 2015 to 33 million in 2025. The number of Internet users increased from 10 million in 2015 to 30 million in 2025.

Along with digitization, ensuring information security has become an important issue. The Government of Uzbekistan adopted the Laws "Concept of Cyber Security", "On Ensuring Information Security".

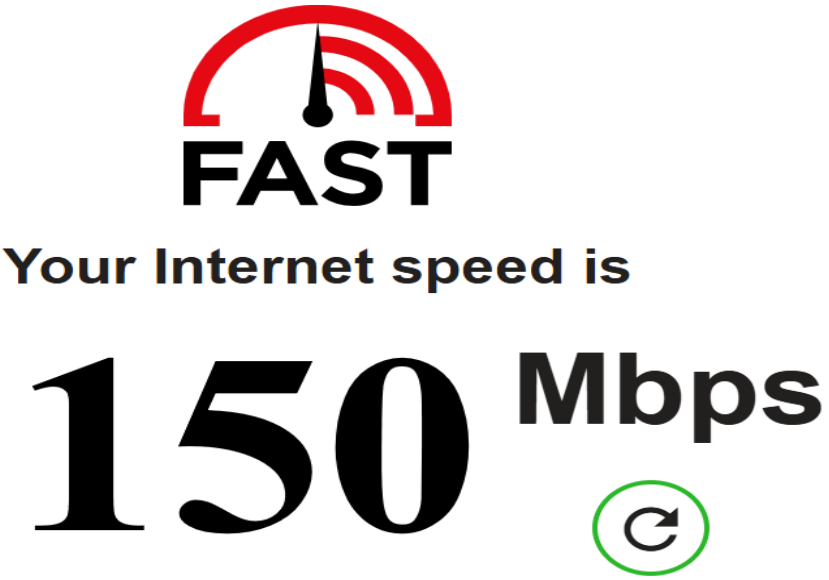
1.1.3- Picture. The concept of data visualization.

Also, in order to increase the digital literacy of the population, starting from 2021, the subjects "Basics of the Digital World" were introduced in schools and higher education institutions.

Over the past 10 years, the telecommunications industry has become one of the fastest growing sectors in the economy. The following results are examples of this:

The volume of telecommunication services reached 14 trillion soums in 2025 from 4.5 trillion soums in 2015.

The volume of industry investments increased from 1.2 trillion soums in 2015 to 16 trillion soums in 2025.



1.1.4- Picture. Average internet speed increased from 10 Mbps to 150 Mbps.

85% of government services are provided digitally.

These results show that Uzbekistan is moving rapidly towards the transition to a fully digital economy by 2030.

The policy of digitalization in the Republic of Uzbekistan has been gradually formed since the years of independence and has penetrated deeply into all areas of the country's economy, public administration, education, health care and social spheres. The introduction of digital technologies initially began with the modernization of communication networks, the creation of information exchange systems and the automation of public services, and later it became a strategic direction covering the entire economy and society. Today, Uzbekistan is on the path of complex digital transformation based on the concept of "Digital State".

Since the 2010s, Uzbekistan has taken the digitization policy to a new level. In 2012, the draft Law "On Electronic Government" was developed, in 2013, the decisions "On Ensuring Information Security" were adopted. During this period, the single interactive state services portal "my.gov.uz" was launched. As a result, many services began to be provided to the population in electronic form: tax payments, registration, obtaining a license and other bureaucratic processes went

digital. At the same time, GPON, NGN and broadband Internet technologies have been introduced in the field of communication infrastructure.

The next phase of digitalization policy has entered a new phase in 2015-2020. During this period, the government of Uzbekistan implemented a number of state programs for the development of information and communication technologies. On June 30, 2017, the President's decision "On measures to further develop information technologies and communications" was adopted, and new tasks were set in the direction of expanding the "Electronic Government" system, developing digital services and strengthening national information security. During this period, the activities of such important organizations as "Uzkomnozorat", "ICT Ministry" and "IT Park" were activated. The establishment of the IT Park was of great importance in supporting young professionals, developing startups, and forming the infrastructure of the digital economy.

2020 was a turning point in the history of digitalization policy of Uzbekistan. In the context of the COVID-19 pandemic, government agencies, educational institutions, the banking system and business entities were forced to switch to remote activities. This has increased the importance of digital technologies in our lives. In this year, the "Digital Uzbekistan - 2030" strategy was adopted, and the priority directions, target indicators and implementation mechanisms of digital transformation were determined. As part of this strategy, special attention was paid to creating digital platforms in all sectors, improving the quality of electronic services, ensuring cyber security and developing digital literacy.

In 2021-2025, Uzbekistan continues to form a management system based on the "digital state" principle. Today, the activities of state agencies are fully automated, an electronic document circulation system has been introduced, and more than 300 types of services are provided online to the population through the unified identification system (OneID). Also, the possibilities of using utility, banking, tax and educational services through mobile applications have expanded. In the field of telecommunications, the expansion of 4G LTE networks, the trial

launch of 5G technology, the development of cloud technologies and data centers are being observed.

Digitalization policy deepened not only technological but also socio-economic changes. E-government, e-education, e-health, e-commerce, online banking systems and remote work formats have been widely introduced in the country. As a result, the digital literacy of the population has increased, the openness and efficiency of public administration has increased, and bureaucratic obstacles in the business environment have decreased. At the same time, issues such as information security, personal data protection, and network infrastructure stability remain relevant in the digitalization process.

Uzbekistan's digitization policy is implemented today based on a comprehensive approach. It is not only technological modernization, but also a strategic policy aimed at improving human capital, management culture and economic efficiency. By 2030, the country aims to fully implement digital solutions in all areas, reach 100% Internet coverage, increase the speed of information exchange, and train highly qualified personnel in the IT field. Therefore, digitization policy is one of the main factors that is leading Uzbekistan to a new stage of development today.

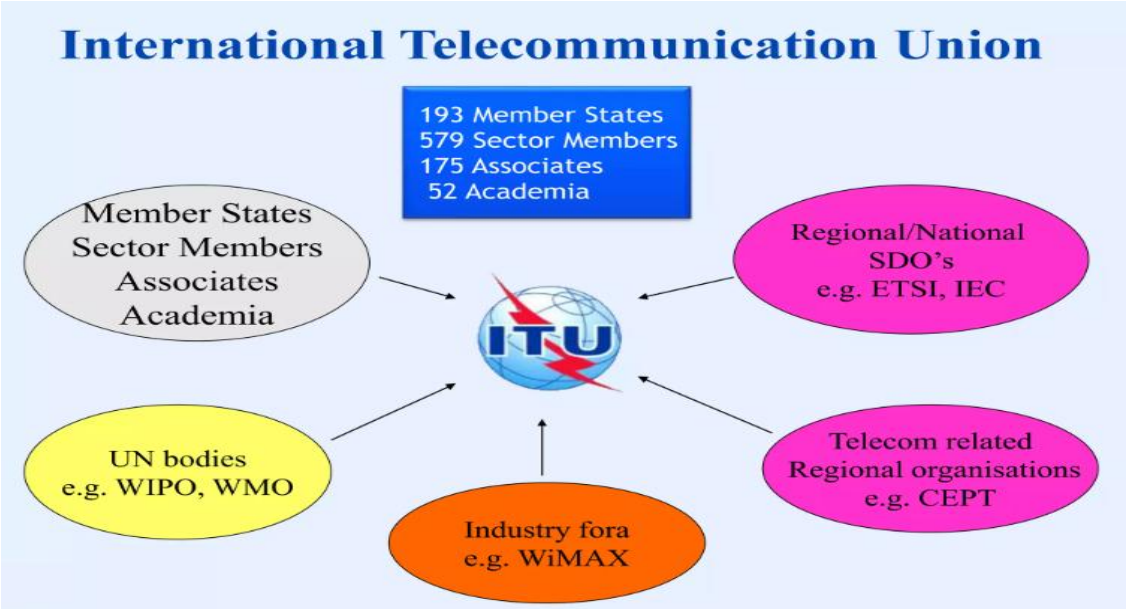
The digitization policy of the Republic of Uzbekistan, starting from the informatization stage in the 1990s, has developed continuously until 2025, fundamentally changing public administration, economy and social spheres. The main stages of this policy - creation of information infrastructure, formation of electronic government, development of digital economy and implementation of the strategy "Digital Uzbekistan - 2030" - formed the country as an active participant in the global digital arena. As a result, digital technologies have become the main force that ensures the economic stability, social well-being and international competitiveness of Uzbekistan.

1.2. Formation of telecommunication standards

Telecommunication standards are a system of international norms that determine the interoperability and quality of networks, devices and services. Mobile communication, Internet, radio and television, satellite systems and data transmission networks work on their basis.

After independence, mobile communication network was developed in Uzbekistan based on GSM (2G) technology. Since 2010, UMTS (3G) technology has been widely introduced. Since 2015, LTE (4G) networks have started to work actively.

In 2023-2025, 5G networks were tested in some regions. This technology is characterized by 10 times faster internet speed, low latency and high bandwidth.



1.2.1- Picture. Structure of the International Telecommunication Union.

The Ministry of Communications, Informatization and Telecommunication Technologies of the Republic of Uzbekistan (now the Ministry of Digital Technologies) in cooperation with the international organization ITU (International Telecommunication Union) is conducting implementation and adaptation of national standards.

Uzbekistan officially launched 4G networks in 2015. High-speed Internet services were provided to the population through the networks of UZTELECOM, Beeline, Ucell and Humans operators.

By the mid-2020s, 4G coverage exceeded 90 percent. The average mobile internet speed reached 25-50 Mbit/s. It has played an important role not only in the convenience of users, but also in the digitization of public services, the banking system, education and healthcare.

In 2023, 5G technology was launched as a test in the cities of Tashkent, Samarkand, Bukhara and Fergana. UZTELECOM and Huawei have developed a plan to expand the 5G infrastructure in 2024-2025. As of 2025, 5G networks have reached 60% coverage in the capital and large cities.

Optical fiber communication is the basis of modern telecommunication systems. This technology provides high-speed data transmission, minimal delay and wide coverage.

In 2015, the length of optical fiber lines in Uzbekistan was 36,000 km, and by 2025, it will exceed 300,000 km. With this, almost all district centers of the republic, more than 10,000 schools, hospitals and state organizations were connected to the optical network.

Companies such as "UZINFOCOM", "Uztelecom", "TT Mobile", "East Telecom" are the main infrastructure suppliers in this area.

As a result of this expansion, "cloud technologies" (cloud computing), "data centers" (data centers) and "digital platforms" (digital platforms) have been actively introduced in the republic.

The formation of telecommunication standards is one of the most important scientific and technical processes in the history of mankind, and it plays a decisive role in the economic, social and cultural development of society. Standards are a set of rules that ensure interoperability, stability of information exchange and technological flexibility between communication systems. The existence of uniform standards in telecommunication systems simplifies cross-industry

integration, increases the quality and speed of services, and enables the introduction of new technologies on a global scale.

The first formation of telecommunication standards dates back to the end of the 19th century. After the invention of the telephone by Alexander Bell in 1876, various companies began to develop their networks independently. However, these systems were not compatible with each other. Therefore, the International Telecommunication Union (ITU), founded in 1865, later became the center for the development of global standards in the field of telecommunications. The first documents developed by ITU defined the rules for formatting, frequency allocation and transmission of telecommunication signals.

In the first half of the 20th century, analog telecommunication systems became widespread. In the 1920s and 1960s, telephone communication was based mainly on analog transmission technologies. During this period, ITU-T (Telecommunication Standardization Sector) developed telephone signal digital coding systems, network interfaces and communication protocols. One of the most important achievements was the creation of PCM (Pulse Code Modulation) technology. PCM made it possible to convert audio signals into digital form and later became the basis of all digital communication systems.

The 1970s and 1980s were a period of digital revolution in the history of telecommunications. During this period, the first forms of computer networks, data transmission systems and the global Internet appeared. The OSI (Open Systems Interconnection) model gained special importance in these processes. The OSI model adopted by ISO (International Organization for Standardization) in 1984 defined a 7-level network architecture and ensured the interoperability of devices from different manufacturers. The TCP/IP protocol, created on the basis of the OSI model, has become the main standard of the Internet.

In the late 1980s and early 1990s, mobile communication standards emerged. The first generation (1G) mobile systems were based on analog technologies and served only for voice communication. GSM (Global System for Mobile Communications), created by European countries in 1987, started a new

era in the history of telecommunications. GSM has been adopted globally as the single mobile communication standard. It greatly contributed to the popularization of mobile communication by introducing features such as SIM card, digital encryption, roaming and SMS.

With the advent of 2G and 3G technologies in the early 2000s, not only voice but also data transmission was expanded through mobile networks. The UMTS (Universal Mobile Telecommunications System) and CDMA2000 standards developed by the 3GPP (Third Generation Partnership Project) consortium laid the foundation for the development of the mobile Internet. At the same time, in the mid-2000s, fiber-optic communication systems were widely introduced, and data transfer rates reached the gigabit level.

A new stage in the field of telecommunications is the widespread introduction of IP technologies. VoIP (Voice over IP), IPTV (Internet Protocol Television) and NGN (Next Generation Network) systems have appeared, which allow voice, video and data transmission based on the Internet protocol. The NGN architecture made it possible to manage voice, data and multimedia services through a single platform. These technologies have improved service quality and reduced infrastructure costs.

In the 2010s, the widespread introduction of the 4G (LTE – Long Term Evolution) standard has fundamentally changed the telecommunications industry. 4G networks have enabled the widespread adoption of high-speed mobile Internet, video streaming, online services and cloud technologies. During this period, global standards meeting the requirements of IMT-Advanced were developed by ITU-R. Agreements on uniform frequency bands and signal formats were developed between telecom companies, which ensured global adaptation of mobile communications.

In recent years, one of the most important achievements in the field of telecommunications has been the introduction of 5G technology. 5G networks provide ultra-fast data transfer (up to 1-10 Gbit/s), low latency (1 ms), high reliability, and simultaneous connection of billions of devices. This standard laid

the foundation for the development of areas such as IoT (Internet of Things), autonomous transport, networks based on artificial intelligence, smart cities and industrial automation. International organizations such as 3GPP, ITU-R, IEEE, ETSI play an important role in the development and implementation of 5G technology.

Uzbekistan also actively participates in the development of telecommunication standards. In the late 1990s, digital PBX (automatic telephone exchange) was introduced in the country, and analog systems were abandoned. Since 2000, GSM and CDMA mobile networks have been launched. In 2010, 3G and 4G LTE technologies were introduced, and the Internet coverage was expanded throughout the republic. In 2023, 5G networks were tested in Uzbekistan and launched commercially in some regions. At the same time, broadband Internet networks based on GPON (Gigabit-capable Passive Optical Network) technology are developing rapidly in the country.

International cooperation has a special place in the process of formation of telecommunication standards. The Republic of Uzbekistan has established cooperation with ITU, CIS Regional Commonwealth in the Field of Communications (RCC) and other international organizations. This cooperation makes it possible to modernize national networks, introduce international technical requirements and strengthen cyber security.

Today, telecommunication standards not only determine the technical standards of communication systems, but also have a direct impact on economic development, digital economy, and the quality of social services. Networks based on uniform standards increase the speed of data transfer, guarantee network stability and create a suitable infrastructure for the introduction of new services. Therefore, the improvement of telecommunication standards is an integral part of the global digital transformation.

In short, the formation of telecommunication standards is a long historical process, which includes the evolution from analog systems to digital networks, from 1G to 5G, from local communication to the global Internet system. At each

stage, technological advances, international cooperation and scientific research created the basis for the emergence of new standards. Today, telecommunication standards penetrate into all aspects of human life and form the foundation of the digital society.

1.3. Public and private sector cooperation

Although the role of the state in the digitization process is important, the participation of the private sector also ensures the success of this process. Since 2018, the "Public-Private Partnership (PPP)" model has been introduced in Uzbekistan.

Based on this model, domestic and foreign investors were involved in the financing of telecommunication projects. For example:

"TIER III Data Center" project in Tashkent - in cooperation between Huawei and Uztelecom;

"Digital Tashkent" project - with the participation of Tashkent city administration and private IT companies;

"One ID" unified identification system was developed by IT Park residents.

As a result of such cooperation, new digital platforms (for example, my.gov.uz, id.egov.uz, online.mehnat.uz) are actively working and providing convenient services to millions of citizens.

In the modern world, the development of telecommunications and digital infrastructure is closely related to the economic growth, competitiveness and quality of life of citizens. The unique feature of the telecommunications industry is that it requires huge financial investment, high technological knowledge and long-term strategic planning. Therefore, most of the countries are actively using the Public-Private Partnership (PPP) model in this field. This mechanism aims to expand the network infrastructure, introduce new technologies and improve the quality of services by combining the resources of the public and private sectors.

In recent years, PPP mechanisms have been widely introduced as an important component of digitalization policy in Uzbekistan. First of all, this

cooperation plays an important role in the implementation of the goals set in the "Digital Uzbekistan - 2030" strategy. In this program, the main task of the state is defined as a regulator, creating a regulatory legal framework and providing conditions for the development of digital infrastructure, while the private sector appears as the main driving force for developing innovative solutions, attracting investments and implementing services in practice.

Telecommunications infrastructure is a very capital intensive industry. For example, the construction of base stations, optical fiber cables, data centers and cloud infrastructures for mobile communication networks requires investments of billions of soums. Therefore, the state cannot finance such projects on its own. It is for this reason that the PPP model was chosen as the optimal solution. Through this model, private companies invest their funds, and the state provides them with tax incentives, land areas, technical permits or guarantees for the use of services. As a result, the burden on the state is reduced, but social benefits are ensured to the maximum.

One of the most important projects implemented in Uzbekistan on the basis of PPP is the program for the expansion of optical fiber communication networks implemented in cooperation with the Uztelecom company. Within the framework of this project, the state has set a general strategic direction, while private companies (for example, "Huawei", "ZTE", "Nokia", "Ericsson") are actively involved in the introduction of technological solutions and technical infrastructure. As a result, broadband Internet coverage in all regions of Uzbekistan increased significantly during 2020-2025.

Public-private sector cooperation also gives significant results in the direction of modernization of mobile communication infrastructure. For example, in the development of 4G LTE networks, operators such as "Beeline Uzbekistan", "UMS", "Ucell", "Perfectum Mobile" are making investments based on licenses issued by the state and expanding mobile coverage throughout the country. In 2023, 5G networks were launched in test mode in some cities of Uzbekistan. In this process, conditions were created for the allocation of radio wave bands,

coordination of technical standards and infrastructure protection by the state, and private companies made technical and financial investments.

In addition, PPP mechanisms are being introduced in the field of information security and digital services. For example, in 2021, within the framework of the "Electronic Government" system update, a "Cybersecurity Center" was established in cooperation with private IT companies to protect information systems in government agencies. This center provides services for the protection of the database of government bodies, network monitoring and identification of digital risks.

In the digital economy, cooperation between the public and private sectors is important not only for infrastructure development, but also for increasing human capital. Today in Uzbekistan, innovation centers such as "IT Park", "Digital City", "Technopark" were established on the basis of public-private sector cooperation. Through these centers, young programmers, start-up projects and new ideas in the field of digital technologies are put into practice. For example, within the framework of the "One Million Uzbek Coders" project, thousands of young people learned the basics of programming and had the opportunity to participate in practical projects with private IT companies.

Cooperation between the state and the private sector ensures sustainable economic development and digital sovereignty in the field of telecommunications. Because the state can offer modern, cheap and fast internet services to its citizens, and the private sector gains profit and experience. Such a mutually beneficial model serves to develop an innovative environment, expand the size of the digital services market, and attract international investments.

At the same time, it is necessary to take into account a number of important factors when implementing the PPP mechanism. First, this is the principle of transparency. All projects must be carried out on a competitive basis, with open and fair conditions. Secondly, the correct distribution of risks is important: technical and financial risks should be borne by private companies, and the state will play the role of guaranteeing social benefits. Third, long-term sustainability —

that is, PPP contracts must be structured in a way that can withstand economic changes and support technological upgrades.

Today, a solid legal framework has been formed in Uzbekistan that regulates PPP mechanisms. The Law "On Public-Private Partnership" adopted in 2019 created legal clarity in this area. After that, hundreds of PPP projects were implemented in the fields of transport, energy, healthcare and telecommunications. In the field of telecommunications, this mechanism was the main impetus in the formation of the market of digital services, as well as in the transition of public services to electronic form.

Cooperation between the state and the private sector is of strategic importance in the field of telecommunications, it accelerates the digital transformation of the country, strengthens economic stability and allows citizens to use high-quality digital services. Within the framework of Uzbekistan's "Digital Uzbekistan - 2030" strategy, such cooperation will expand further, and the role of the private sector in the projects of 5G, IoT, cloud computing, artificial intelligence and smart cities will increase in the future. In this way, mutual cooperation between the state and business is becoming the main locomotive in the country's digital economic development.

1.4. Growth of the telecommunication services market

2015–2025- significant growth was observed in the telecommunications market of Uzbekistan. The following indicators are an example of this:

1.4.1 table

Year	Volume of telecom services (trln soums)	Internet users (millions)	Mobile subscribers (millions)
2015	4,5	10,0	22
2018	6,8	15,5	26
2020	9,5	21,0	29
2023	12,5	27,0	31
2025	14,0	30,5	33

These numbers show that the country's telecommunications infrastructure is developing steadily and serving the growth of the digital economy.

New services include:

Cloud services (cloud) - secure data storage systems for government agencies and businesses;

IoT (Internet of Things) - sensor systems for smart homes, transport, agriculture;

Big Data – analysis of population needs and management optimization;

AI (Artificial Intelligence) - automated solutions in e-government and education systems.

With the help of these technologies, Uzbekistan aims to become an "exporter of digital services" by 2025.

The growth of the telecommunication services market is one of the most important indicators of the modern economy. Because the field of telecommunications is the basis of the digital economy, it determines not only communication, but also the efficiency of information exchange, business processes, public administration, education and health. Today, the telecommunications sector is considered as a strategic area that ensures the competitiveness of every country. In Uzbekistan, the pace of development of this sector has increased significantly in the last decade, especially as a result of the digitization policy, the expansion of the Internet infrastructure and the modernization of mobile networks, the market of telecommunication services has risen to a new level.

In the early years of independence, telecommunication networks in Uzbekistan operated mainly on the basis of analog technologies, but from the 2000s, they gradually switched to digital technologies. This process was carried out primarily as a result of programs aimed at modernization of the information and communication infrastructure by the state. In 2000-2010, digital ATS (automatic telephone exchanges), optical fiber communication lines and international internet channels were introduced on the national scale. This

significantly increased not only the quality of communication, but also the speed of data transfer.

The 2010s were a period of explosive growth of the telecommunications services market. During these years, mobile communication services covered almost 90% of the population. Competition between mobile operators - "Beeline Uzbekistan", "Ucell", "UMS" and "Perfectum Mobile" increased, as a result of which the quality of services increased and tariffs decreased. This has popularized the Internet and communication services for a wide range of people. The rapid development of the mobile Internet has accelerated with the introduction of 3G and 4G LTE technologies.

According to the Ministry of Digital Technologies of the Republic of Uzbekistan, the number of Internet users has increased 6 times between 2015 and 2024. In 2015, about 6 million users were registered, and in 2024 this figure will exceed 35 million. Almost 95 percent of the population has mobile coverage, and more than 80 percent actively use the mobile Internet. These numbers show that the rate of expansion of the telecommunication services market in Uzbekistan is very high.

Several factors are responsible for such a rapid growth of the market. First, the projects implemented within the framework of the state policy, that is, the "Digital Uzbekistan - 2030" strategy. In this strategy, tasks such as modernization of telecommunication infrastructure, increase of Internet speed, introduction of 5G networks, development of satellite communication systems and increase of international transit traffic are defined. Second, private sector investment has increased significantly. For example, between 2018 and 2024, the volume of direct foreign investment attracted to the telecommunications sector exceeded 1 billion US dollars. These funds were mainly directed to the modernization of the network, the construction of new base stations and the expansion of optical fiber lines.

The growth of telecommunication services is also related to the diversification of digital services. Today, telecommunication companies offer not only voice communication, but also services such as data transmission, mobile

Internet, cloud storage, IP telephony, digital payment systems, Internet television (IPTV) and smart home. Therefore, the telecommunications market is now not a traditional communication sector, but a digital ecosystem in a broad sense.

Optical fiber networks are of particular importance in the growth of the telecommunication services market. State joint-stock company "Uztelecom" is widely introducing networks based on GPON (Gigabit Passive Optical Network) technology as part of the strategic program for 2020-2025. This technology makes it possible to deliver several hundred megabits of Internet to every home and business. By the end of 2024, more than 150,000 kilometers of optical fiber lines have been laid across the country, and their coverage is increasing by 25-30% per year.

Another important area driving the growth of the market is the update of mobile Internet technologies. 4G LTE networks are currently operating in all regions of the country, and from 2023, 5G technology will be launched on a trial basis in the capital and large cities. Through these networks, users are able to transfer data at a speed of up to 1 Gbit/s. As a result of the introduction of 5G technology, the telecommunications market of Uzbekistan is moving to a new stage - the era of "intellectual services".

Digital literacy of the population has a direct impact on the growth of the telecommunication services market. The "One Million Uzbek Coders" program, "IT Park" projects, training courses in the field of information technologies and startups for young people gave a strong impetus to this process. Today, a large part of the population actively uses mobile applications, digital payment systems, electronic government services and online educational platforms. This increases the demand for telecommunication services.

One of the most important economic consequences of the growth of the telecommunications market is the expansion of the digital economy. The telecommunications sector is taking an increasingly large share of the gross domestic product (GDP). According to the data of 2024, the share of information and communication services in the GDP was 3.5 percent, and in 2025, this figure is

forecast to reach 5 percent. In addition, the telecommunications sector is creating thousands of new jobs, especially in IT, technical services and technological innovation.

Another important direction of market growth is international cooperation. Uzbekistan is introducing technologies in cooperation with global companies such as ITU, Huawei, Nokia, ZTE, Ericsson. At the same time, joint projects in the field of telecommunications are being implemented with China, South Korea, the USA and the European Union. This cooperation allows the country to bring new technologies faster, exchange experience and increase the investment flow.

Another aspect of the growth of the market of telecommunication services is the segmentation of services and increased competition. Nowadays, consumers make choices based not only on price, but also on the basis of service quality, speed, additional options (for example, "mobile TV", "cloud storage", "digital payment"). Therefore, companies are diversifying services, developing new tariffs, flexible solutions and digital products.

The market of telecommunications services of Uzbekistan has entered the stage of rapid growth in recent years. This growth is the result of public policy, private sector investment, technological modernization, increased digital literacy and international cooperation. The further development of the market will be directly related to the full implementation of 5G technologies, IoT (Internet of Things), "smart cities" and the expansion of cloud services. Thus, the telecommunications sector is forming as one of the main drivers of the digital economy of Uzbekistan.

2-chap. ECONOMIC AND SOCIAL EFFICIENCY, PROSPECTS AND STRATEGIC DIRECTIONS OF DIGITALIZATION PROCESSES IN UZBEKISTAN

2.1. The concept of digital economy and its importance

Digital economy means widespread use of information technologies in all economic processes. It increases efficiency in such areas as production, service, trade, transport, education and health.

The concept of the digital economy was gradually formed in Uzbekistan during 2015-2025. In 2019, the decision "On the development of the digital economy" was adopted, and the process of transferring the activities of state bodies to electronic form has accelerated.

Digital economy is one of the most important and rapidly developing areas of the modern world. It is a new economic system that penetrates deeply into all spheres of society, state and business, in which digital technologies, information, networks and algorithms serve as the main production factor. Simply put, the digital economy is an economic model in which information and communication technologies are widely used in the creation, distribution and consumption of goods and services. It will develop the economy through automation, efficient use of resources, lightening of human labor and digitization of production processes.

The concept of digital economy began to form at the end of the 20th century, and was initially expressed by the terms "internet economy" or "knowledge economy". But since the beginning of the 21st century, this concept has expanded to include not only Internet-based business, but also such areas as production, transportation, energy, education, health care, and public administration. Today, the digital economy accounts for about 15-20 percent of the world's gross domestic product (GDP). According to forecasts of international experts, by 2030, this figure may exceed 30 percent.

The main feature of the digital economy is the role of information as an economic resource. Earlier, the main resources of the economy were land, labor and capital, but now data has also been added to them. Through the flow of

information, countries conduct their economic policies more accurately, companies analyze the market, and consumers have the opportunity to use better services. That is why the phrase "information is the new oil" is widespread in the modern world.

Information and communication technologies (ICT) form the basis of the digital economy. Computer systems, networks, cloud technologies, artificial intelligence, Internet of Things (IoT), blockchain, big data and digital platforms are the main elements of the digital economy. With the help of these technologies, production processes are automated, services are rendered faster and cheaper, and new jobs are created.

The digital economy is of particular importance for Uzbekistan, as it brings the country to the stage of innovative development. After independence, the economy relied mainly on the export of raw materials, but now the possibility of producing products and services with high added value is emerging through the digital economy. The government of Uzbekistan has adopted the strategy "Digital Uzbekistan - 2030", in which digitization of all sectors of the economy, transfer of public services to electronic form, development of digital infrastructure, expansion of the Internet network and ensuring information security are defined as the main priorities.

One of the most important aspects of the digital economy for Uzbekistan is increasing labor efficiency. For example, electronic document circulation systems reduce bureaucratic processes in government agencies, save time and resources. Enterprises reduce the cost of production and increase their competitiveness by automating their production processes. These processes have a direct impact on the overall efficiency of the economy.

The digital economy also creates new jobs and professions. Unlike traditional industries, this field requires modern professions such as programmers, data analysts, cyber engineers, artificial intelligence specialists, and digital marketing experts. For this reason, the network of IT Parks is being expanded in Uzbekistan, training programs in the field of information technologies have been

launched. Projects such as "One Million Uzbek Coders", "Future Skills", "Digital Generation" serve to increase the digital literacy of young people.

Another important aspect of the digital economy is economic inclusion, that is, increasing the opportunity for every citizen to participate in economic activities. Anyone can start their own business, sell their products on e-commerce platforms or provide remote services through the Internet. In this way, the digital economy frees people from the constraints of space, time and resources. New opportunities will be opened especially for women, young people and persons with disabilities.

In the case of Uzbekistan, the role of the digital economy in regional development is also significant. The expansion of the digital infrastructure is helping to improve the internet and mobile communication services in the provinces and remote areas and to develop local entrepreneurship. E-commerce platforms, electronic payment systems and distance learning services are accelerating this process.

Another important aspect of the digital economy is improving the efficiency of public administration. State services are provided quickly, transparently and without corruption through the "Electronic Government" system. For example, tax payments, customs operations, registration processes, social payments, pension and benefit systems are being fully digitized. This strengthens trust between the state and citizens and reduces administrative costs.

However, along with the development of the digital economy, the issues of information security, cybercrime and information privacy are also becoming relevant. Therefore, Uzbekistan has adopted the laws "Concept of cyber security" and "On the protection of personal data". These documents aim to secure the digital environment, protect users' rights, and protect national information systems from cyber threats.

The social importance of the digital economy is also great. It creates new opportunities in the fields of education, healthcare, transport, ecology and culture. For example, through distance education platforms, young people are gaining

international knowledge without going to expensive foreign educational centers. Telemedicine services are providing quality medical advice to people in remote areas.

The digital economy is a new stage of development of strategic importance for Uzbekistan. It provides not only economic growth, but also social justice, transparency and innovative approach. Widespread implementation of the digital economy will deeply integrate the country into the world economic system, increase national competitiveness and serve as an important tool for achieving the goals of sustainable development. Today, digital technologies play an important role in the growth of Uzbekistan's economy. They reduce production costs, save time and provide transparency.

Along with digitalization, the issue of information security is of strategic importance for any country. Because digital systems store a large amount of data - personal data of citizens, financial transactions, information on state secrets.

2.1.1- Picture. Measures to ensure information security in digital systems.

Information security is a system of protecting information from unauthorized access, alteration, loss or distribution. It includes cyber security, data backup, user authentication, encryption and monitoring.

This issue is especially important for Uzbekistan, because after 2020, the number of digital services and the volume of users have increased dramatically. Therefore, there is a need to manage cyber security at the national level.

As a result of digitalization, the following economic achievements were achieved:

Economy of public services.

Many services are provided online through the e-government system. This reduced paper costs and eliminated bureaucratic obstacles.

For example, as of 2025, 85 percent of government services will be provided digitally.

Increase in production efficiency.

As a result of the introduction of automated control systems (SCADA, ERP) in industrial enterprises, the production volume increased by 1.8 times from 2015 to 2025.

Digitization of the banking and financial system.

Online payment systems - Click, Payme, Orange, Paynet, etc. - have become widely popular.

In 2025, there will be more than 45 million digital payment accounts in the country.

Expansion of the e-commerce market.

In 2015, the share of e-commerce was 0.2%, and by 2025 this indicator will reach 7.5%.

Online platforms such as "OLX.uz", "ZoodMall", "Asahiy.uz" and "Technomart" have become a new driver of the economy.

During 2015-2025, important documents and structures for ensuring information security were formed in the country:

Law "On Ensuring Information Security" (2017) - this document created the legal basis for protection of information resources, regulation of access to state databases.

"Concept of cyber security" (2018) - determined the mechanisms of ensuring digital sovereignty of Uzbekistan and combating cyber threats.

"CERT.uz" - computer incident response center was established (2019). It has become the republic's central body for monitoring and preventing cyberattacks.

"Digital Trust Center" (2022) - performs security audit and certification for state information systems.

Digitization has improved not only the economy, but also the quality of society's life.

1. Changes in the education system

Since 2020, the platforms "ZiyoNET", "EduMarket", "Kundalik.uz", "my.edu.uz" have been introduced.

In 2021-2025, more than 3 million students used the distance education system.

"Google Classroom" and "Moodle" systems are widely used in universities.

2.1.2 - Picture. Digitization of the educational system of the Republic of Uzbekistan.

2. Digitization in the healthcare sector

"EMR" (electronic medical record) system was introduced;

It is possible to sign up for a medical examination and view pharmacy prices online through "my.gov.uz";

2.1.3- Picture. Digitization in the healthcare sector of the Republic of Uzbekistan.

As a result of digital medicine, patients in rural areas began to use telemedicine services.

3. Social services and public welfare

More than 650 services are provided remotely through the "Single Interactive State Services Portal";

Electronic queue, online registration, electronic payment systems save people's time by 40-50%;

Through the "Digital neighborhood" project, mechanisms for quick identification and solution of social problems were introduced.

The main types of cyber threats observed in Uzbekistan:

Phishing (stealing information through fake pages) is the most common type of cybercrime;

Malicious programs (viruses, trojans) — damage user devices, delete or steal data;

DDoS attacks are attacks aimed at knocking out Internet networks and government portals;

Data leak (data leak) - unauthorized dissemination of confidential information in state or corporate databases.

2.1.4- Picture. Phishing is the most common cybercrime.

According to CERT.uz, the number of detected cyber attacks in 2019 was 3 thousand, and by 2024 this number will exceed 9 thousand.

However, in 2025, as a result of increased detection systems, real damage is reduced by 35%.

The digital economy has created new professions and jobs.

In 2015, the number of IT workers was 15,000, and in 2025, this number will exceed 120,000.

The most in-demand professions:

programmer (programmer);

cyber security specialist;

data analyst (data analyst);

digital marketing specialist;

artificial intelligence engineer.

The number of IT Park residents increased from 50 in 2019 to 1,500 in 2025.

Export of IT services equaled 500 million US dollars in 2025.

2.1.5- Picture. Indicators of IT Park residents.

The information security system in Uzbekistan consists of the following main elements:

State Information Resource Protection Network (DARS) — centrally protects state servers;

Cyber security centers are available at all major state agencies (Central Bank, Ministry of Internal Affairs, Ministry of Finance, Ministry of Finance);

Personnel training system - "Cybersecurity" courses have been opened at Tashkent University of Information Technologies and Inha University.

By 2025, there are more than 1,500 certified cyber security professionals operating in the country.

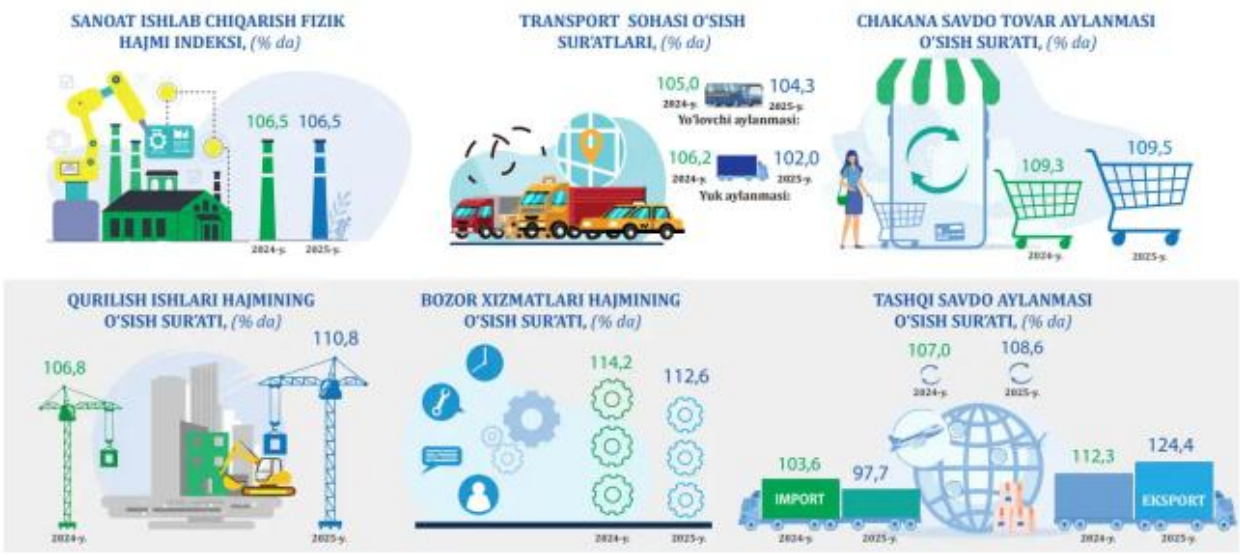
Digitization has had a significant impact on the country's gross domestic product (GDP) growth.

2.1.1 table

The table below shows these changes:

Year	GDP growth rate (%)	Share of the digital economy (%)	Internet users (millions)
2015	6,0	1,2	10,0
2018	5,1	2,8	15,5
2020	1,6	3,5	21,0
2023	5,6	5,9	27,0
2025	6,8	8,2	30,5

2025- by 2018, the digital economy accounted for about 8 percent of the country's GDP.



2.1.6 - Picture. Digital economy across sectors.

This indicator made Uzbekistan one of the most active digital economies in Central Asia.

Digital sovereignty is the ability of a state to independently manage its own information infrastructure, data centers, software and digital policy.

2.2. Problems in the digitization process. Interactive methods used in teaching the subject

The digitalization process is a set of deep systemic reforms that will change all spheres of economic, social and political life in any country. It increases economic efficiency, makes public administration transparent, improves the quality of services and makes life easier for citizens. But the process of digitalization is not only about technological innovations - it is a complex socio-economic process with a number of challenges and obstacles. In the case of Uzbekistan, these problems relate to economic, technological, organizational, legal and social aspects, and their elimination is one of the most important tasks of state policy.

First of all, one of the main problems in the process of digitization is insufficient development of infrastructure. Although optical fiber networks, mobile communication bases and Internet channels have been rapidly expanded in the country in recent years, the quality of the Internet in remote areas is still low, mobile communication is not stable, and in some places there is no coverage. Especially in some districts of the Republic of Karakalpakstan, Surkhandarya and Jizzakh regions, low internet speed limits the use of digital services. This creates a digital divide, i.e. a widening gap in digital capabilities between central cities and rural areas.

The second problem is information security and cyber security. In the process of digitization, personal data of state bodies, enterprises and citizens are stored in electronic form. This leaves them vulnerable to cyber-attacks, data theft or illegal use. Although the laws "Concept of Cyber Security" and "On Protection of Personal Information" have been adopted in this regard in Uzbekistan, their practical implementation has not yet been sufficiently established. Many organizations lack the necessary technical tools, certified professionals, and security policies to protect information systems. Therefore, the formation of a culture of cyber security remains an urgent issue today.

The third problem is insufficient human resources. Digitization does not require technical tools, but skilled human resources that manage, develop and

analyze them. But at the moment, there is a shortage of IT specialists, programmers, data analysts, artificial intelligence and cyber security personnel in Uzbekistan. Although the higher education system is introducing new educational programs in this field, their practical part is still not fully in line with international standards. Although there are projects such as "One Million Uzbek Coders" and "IT Park Academy", a large part of the population, especially the middle-aged and elderly, does not have digital skills. This slows down the overall pace of digitization.

The next important problem is the slowness of the information exchange and integration system between state bodies. Although the e-government system has been implemented, some ministries and agencies maintain their databases without connecting to each other. As a result, citizens are forced to submit the same information to different agencies several times. This is an obstacle to the main goal of digitization - reducing bureaucracy and saving time. Also, the lack of uniform technical standards among the information systems of state bodies complicates the problem even more.

There are also financial challenges in the digitization process. Many projects require high-tech hardware, software, licenses, and maintenance costs. Local budgets cannot fully finance such projects. Although foreign investments and grants are being attracted, their effective use is not always guaranteed. In some cases, projects are chosen for political reasons, lack feasibility studies or are not linked to a long-term strategy.

Another urgent issue is that the legal and regulatory framework is not perfect enough. Many aspects of the digital economy (blockchain, electronic money, artificial intelligence, data analysis, cybercrime, digital documents) are not yet fully regulated. In some cases, the existing laws do not correspond to the development of modern technologies, which makes it difficult to introduce new business models. For example, the lack of a clear regulatory framework for e-commerce, online payments and cryptocurrency-related activities is a barrier for many investors and startups.

Technical standards and integration problems are also barriers to digitization. Some government agencies or companies use different software platforms that are not compatible with each other. As a result, information exchange becomes complicated, malfunctions occur between systems. Therefore, the need to create a single "national digital platform" in the conditions of Uzbekistan is increasing.

One of the most important problems in the social aspect of digitization is the digital inequality of the population. There is a big difference between urban and rural population in terms of internet access, digital literacy and availability of technical equipment. At the same time, low-income families, representatives of the elderly generation and disabled people cannot fully use digital services. This requires solving the issue of digital inclusion at the level of state policy.

Mentality and psychological resistance is one of the important obstacles of the digitization process. Many citizens and even some civil servants distrust electronic systems. They consider "paper documents" more reliable, resulting in slow acceptance of e-signatures, online payments or digital documents. This shows how important the human factor is in the implementation of digital reforms.

In addition, high dependence on imports is also a problem in the digitization process. Software, server equipment, information security systems and mobile technologies are mainly imported from abroad. This weakens national technological independence and increases costs. Therefore, it is necessary to create a "national software product ecosystem" in Uzbekistan and support local manufacturers.

Also, the problem of data quality and their updating is relevant. Many government agencies do not regularly update their databases, resulting in inaccurate or outdated information being entered into digital systems. This can lead to errors in automated decision-making processes.

Although Uzbekistan is one of the countries that is actively implementing the digitization process, this process is not without various obstacles and problems. Uneven development of infrastructure, shortage of personnel, deficiencies of the

legal framework, cyber security problems, low digital literacy and low quality of data remain the main problems of this process. Therefore, it is necessary to see digitization not only as a technical modernization, but as a comprehensive socio-economic reform. Only by developing cooperation, education and innovation between the state, business and society, these problems can be gradually eliminated. Along with the positive aspects of digitalization, there are also some problems:

internet quality is low in some rural areas;

cyber security threats are on the rise;

the level of digital literacy is not the same in all strata;

data integration between some government agencies is insufficient.

To eliminate these problems, special measures are planned in the second stage of the "Digital Uzbekistan - 2030" program.

Uzbekistan has established cooperation with international organizations in the field of cyber security:

ITU (International Telecommunication Union) – exchange of technical standards;

OSCE (Organization for Security and Co-operation in Europe) – improving legislation against cybercrimes;

Technical cooperation with companies such as CISCO, Huawei, Kaspersky Lab;

Central Asia Cyber Security Forum (Tashkent, 2024) - gained importance as a regional experience exchange platform.

One of the important aspects of digital development is digital inclusion, that is, ensuring that every citizen can use equal digital opportunities.

2.2.1- Picture. Use of artificial intelligence (AI) in medicine.

After 2025, Uzbekistan will enter a new stage in the field of digital economy. The second stage of the "Digital Uzbekistan - 2030" program aims to transfer all economic and social processes in the country to a fully digital environment.

The main strategic directions are:

transfer of the public administration system to 100% electronic format;

Widespread introduction of 5G and 6G networks;

increase the share of the digital economy in GDP from 15% to 30%;

Development of national innovation centers in the fields of "artificial intelligence", "cyber security" and "digital sovereignty".

Problems in the digitization process are interactive methods used in teaching the subject

✓ **“ SWOT-analysis" method**

The purpose of the method: to find ways to solve problems by analyzing and comparing existing theoretical knowledge and practical experience, strengthening

knowledge, repeating, evaluating, forming independent, critical thinking, non-standard thinkingi.

2.2.2 - Picture. SWOT analysis method.

Example: Digitization and modern telecommunication standards

analyze the SWOT analysis of the methods used in teaching in this table.

S	Digitization and modern telecommunication standards a reliable method of defense in teaching on the topic of analysis	Ensures integrity, confidentiality, and authentication of information
W	Weak keys have a negative impact	When choosing keys, you need to choose a durable key
O	The method can be implemented in hardware and software form	Very convenient to use
T	The development of computing systems weakens the tolerance of cryptographic algorithms.	The length of the keys should be increased.

✓ **"INSERT" METHOD**

The purpose of the method: This method is used to facilitate students' acceptance of a new information system and assimilation of knowledge, and this method also serves as a memory exercise for students.

Method implementation procedure:

➢ the teacher will distribute the text explaining the essence of the new topic

Digitization and analysis of modern telecommunication standards before the training or show it in the form of a presentation;

- Learners get to know the text individually and express their personal views through special symbols. When working with the text, students or participants are advised to use the following special characters:

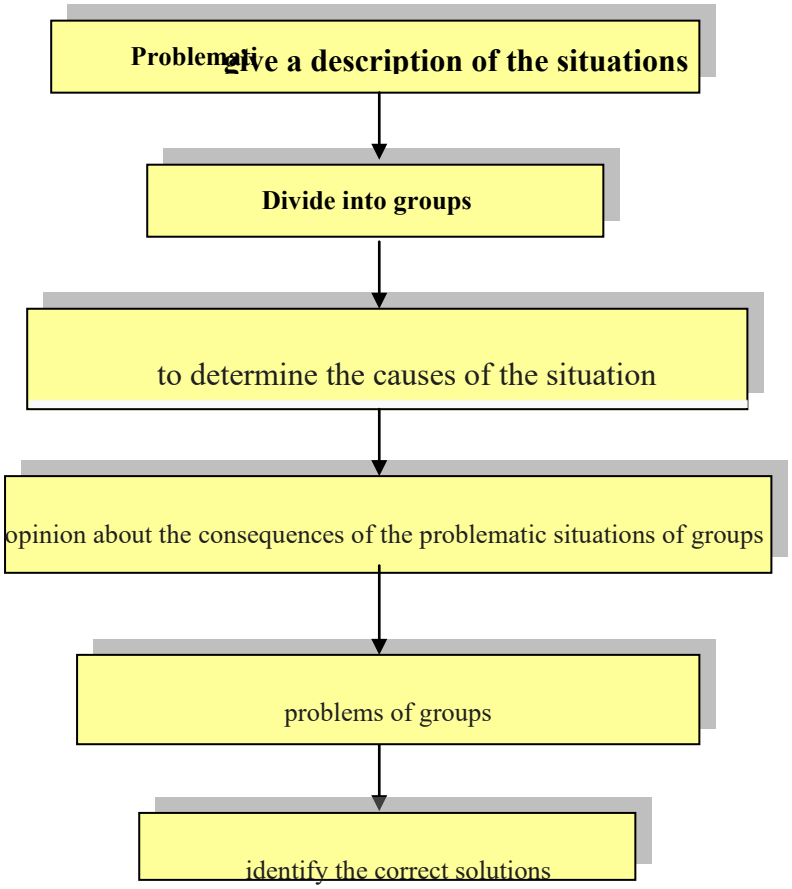
2.2.1 table

Signs	1- text	2- text	3- text
"V" – familiar information.			
"?" – I did not understand this information, I need an explanation.			
"+" this information is new to me.			
"– " I am against this opinion or this information?			

At the end of the specified time, the information that is unfamiliar and incomprehensible to the students will be analyzed and explained by the teacher, and their essence will be fully explained. The questions will be answered and the session will end.

"PROBLEM SITUATION"- method is a method aimed at forming students' skills in analyzing the causes and consequences of problem situations and finding their solutions.

"A problematic situation" The complexity of the problem chosen for the method should correspond to the level of knowledge of the learners. They must be able to find a solution to the given problem, otherwise, when they cannot find a solution, it leads to the loss of interest and self-confidence of the learners. When using the "problematic situation" method, students learn to think independently, analyze the causes and consequences of a problem, and find a solution. Below is the structure of the "Problem Situation" method.



2.2.3- Picture. The structure of the "Problem situation" method.

The steps of the "Problem situation" method are as follows:

1. The teacher chooses a problem situation on the topic of Digitization and analysis of modern telecommunication standards, determines goals and objectives.
2. The teacher explains the problem to the students.
3. The teacher introduces students to the purpose, tasks and conditions of the assignment.
4. The teacher divides the students into small groups.
5. Small groups study the given problem situation. They determine the causes of the problem and each group makes a presentation. After each presentation, the same points are collected.
6. At this stage, they present their opinions about the consequences of the problem during the given time. After the presentation, the same thoughts will be collected.

7. They discuss and analyze various possibilities of solving the problem. They develop ways to solve the problem situation.

8. Small groups make a presentation on the solution to the problem situation and offer their options.

9. Barcha taqdimotdan so‘ng bir xil yechimlar jamlanadi. Guruh ta’lim beruvchi bilan birgalikda muammoli vaziyatni yechish yo‘llarining eng maqbul variantlarini tanlab oladi.

“Advantages of the problem situation method:

- forms independent thinking skills in learners;
- learners learn to find the cause, effect and solutions of a problem;
- a good opportunity is created to assess the knowledge and abilities of learners;
- learners learn to analyze ideas and results.

“Muammoli vaziyat” metodining kamchiliklari:

- ta’lim oluvchilarda yuqori motivatsiya talab etiladi;
- the given problem should correspond to the level of knowledge of the learners;
- takes a lot of time.

2.3 Future development of telecommunication infrastructure

Today, the future development of telecommunications infrastructure is considered as the main factor of the global economy, information technologies, artificial intelligence, "smart" cities and digital government systems. Telecommunication networks are now not only a means of communication, but also a strategic basis for national security, economic competitiveness and innovative development. In the case of Uzbekistan, the issues of modernization of telecommunication infrastructure, expansion of optical networks, renewal of mobile communication generations and introduction of management systems based on artificial intelligence are defined as one of the most priority areas of state policy.

The telecommunications system of the future will be fundamentally different from today's traditional networks. First of all, it is based on high-speed, low-latency and comprehensive 5G and 6G technologies. 5G technology is already being introduced as an experiment in the major cities of Uzbekistan - Tashkent, Samarkand, Fergana and Bukhara. This technology not only increases the speed of mobile internet, but also lays the groundwork for the development of areas such as "Internet of Things" (IoT), remote manufacturing, autonomous vehicles and medical robotics. At the same time, 6G technology, integrated with artificial intelligence from the 2030s, will introduce not only the speed of data transfer, but also the principle of "intelligent network" — that is, the network will determine the needs of users in advance and allocate resources automatically.

Another important direction of the future telecommunications infrastructure is the expansion of optical fiber networks. Although the length of main optical lines in Uzbekistan has exceeded 150,000 kilometers in recent years, high-speed Internet is still not available in many remote areas. Therefore, based on the "single optical network" concept, it is aimed to create a high-throughput, safe and reliable network connecting the whole country. In the future, every home, school, hospital and industrial enterprise will be directly connected to optical fiber, which will dramatically improve the quality of the Internet.

Satellite technologies also play an important role in the development of telecommunications infrastructure. Uzbekistan plans to develop national satellite services through its UzSat project. Such technologies are especially important in mountainous and desert areas, that is, in places where it is difficult to install surface infrastructure. Internet transmission systems via satellite (for example, Starlink, OneWeb, Project Kuiper) will increase competition in the global network and reduce digital isolation for Uzbekistan as well.

Also, in the future, the telecommunication infrastructure will be closely connected with "cloud technologies". Every state, enterprise and organization stores its information systems on centralized cloud platforms. This not only increases efficiency, but also simplifies the processes of data management, analysis

and protection. In Uzbekistan, the concept of "Single State Cloud" is being developed, which envisages the integration of data centers of all state agencies in a single technological environment.

Smart networks will be an integral part of the infrastructure of the future. Such systems will have the ability to self-manage, self-heal, and automatically allocate resources. For example, "intelligent transport systems" monitor traffic in real time, reduce accidents; "smart energy networks" dynamically distribute electricity depending on consumption. Telecommunications networks act as the "digital nervous system" that connects all of these.

Cyber security will be one of the most important areas of future telecommunications. With every new technology comes new risks. Therefore, the network infrastructure must be not only fast, but also secure. Quantum encryption, biometric authentication, and artificial intelligence-based risk detection systems play an important role in this area. For Uzbekistan, it will be necessary to create national cyber security centers and introduce certification systems that meet international standards.

Another aspect of future telecommunications infrastructure is energy efficiency and environmental sustainability. New generation networks will be built in a way that consumes less energy, connects to renewable sources and works on the basis of "green technologies". In this, the concept of "green IT", that is, environmentally friendly information technologies, plays an important role. For example, data centers reduce their carbon footprint by upgrading their cooling systems and using solar energy.

Local manufacturers and startups will also be actively involved in the future development of telecommunications infrastructure. Uzbekistan's centers such as "IT Park", "Digital City" and "Yashnobad Technopark" provide opportunities for the development of national software products, mobile applications, cloud services and IoT solutions. This will not only reduce import dependency but also build a national innovation ecosystem.

Also, the issue of international integration and cooperation is of great importance in the future development of the telecommunications industry. By unifying regional networks, expanding cross-border optical lines, creating traffic exchange centers with neighboring countries, Uzbekistan can become not only a consumer, but also a digital transit center in Central Asia.

At the same time, the future of telecommunication infrastructure is closely related to the information economy. Information flowing through each network is an economic resource equivalent to new oil. Therefore, it will be necessary to formulate a national policy on data collection, analysis and commercial use. Artificial intelligence, machine learning and "big data" technologies will be the basis of this process.

In short, the future of the telecommunications infrastructure plays a crucial role in the digital economic development of Uzbekistan. For its effective development, there is a need for organic relations between the state policy, private sector, research institutions and international cooperation. The networks of the future must be fast, secure, intelligent, environmentally sustainable and user-centric. Only then can the telecommunications sector ensure the country's digital sovereignty and turn Uzbekistan into an advanced digital center in Central Asia.

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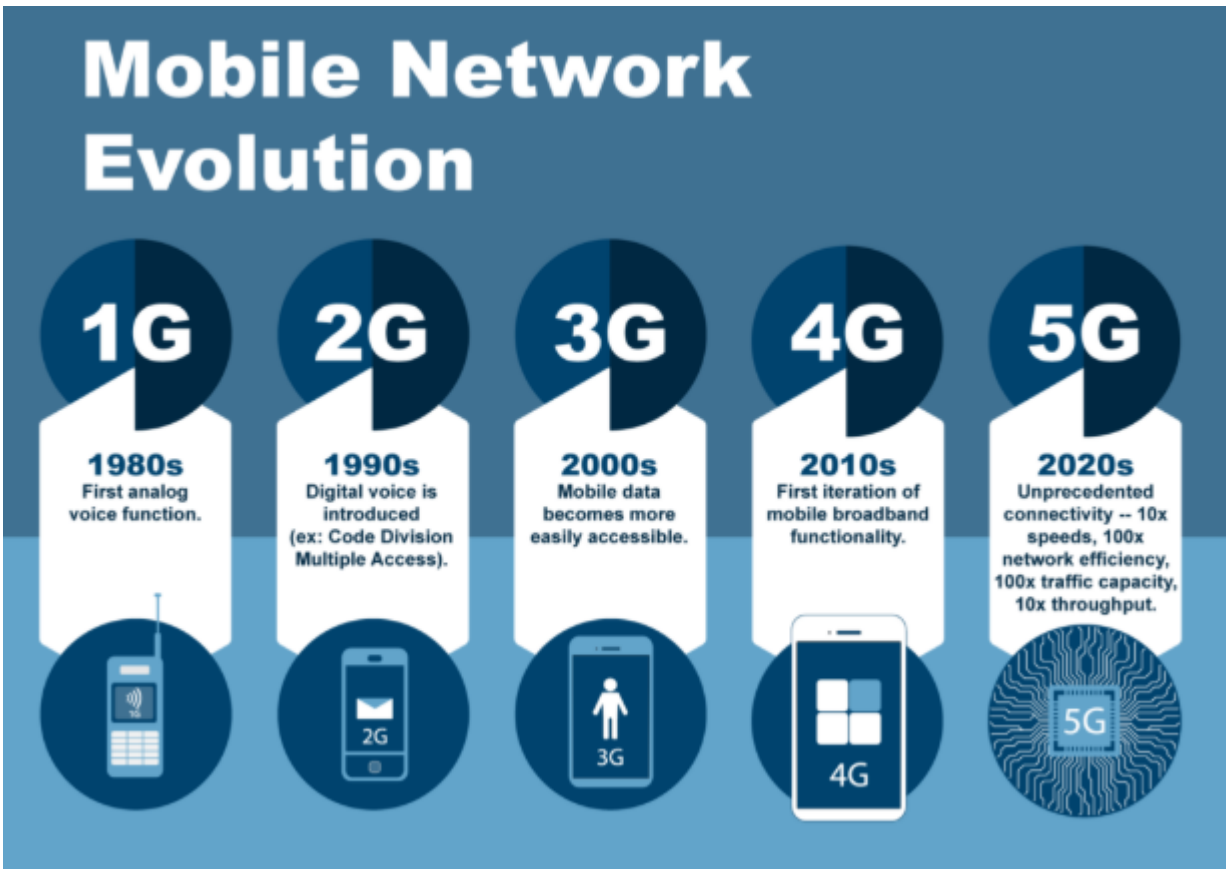
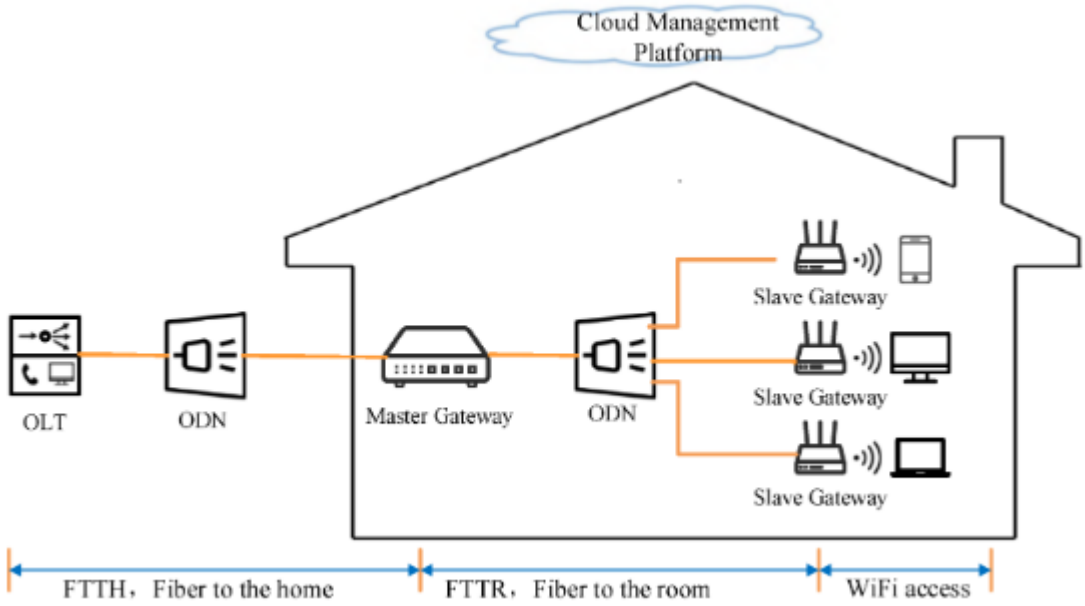


2.3.1- Picture. the evolution of mobile networks from 1G to 5G.

“"5G to every region" project - ensuring 5G coverage in all regional centers (until 2026).



2.3.2- Picture. FTTH network diagram.

“Fiber-to-Home” (bringing fiber optic internet to every home) – 90% coverage by 2030.

"Satellite Uzbekistan" - the launch of the national communication satellite (2027), which will allow independent access to the international Internet.

"UzCloud 2.0" is a new generation cloud technology platform, a unified data storage system for all government agencies.

These projects will dramatically increase not only internet speed, but also network stability and security.

Starting from 2025, Uzbekistan will start implementing the national strategy "AI Uzbekistan".

Artificial intelligence technologies are widely implemented in the following areas:

Healthcare - automatic diagnosis of patients and analysis of medical data;

Education - creation of individual educational programs on digital platforms;

Agriculture - yield forecasting through drones and IoT technologies;

Public administration - data analysis and decision-making systems based on AI.

Also, the "Big Data Center Uzbekistan" project will be launched by 2028. This center serves to analyze and integrate all digital data flows in the country.

By 2030, Uzbekistan aims to fully implement the concept of "Digital Citizenship".

Through this concept:

all citizens' documents are created in digital format;

"One ID" single electronic identification system works throughout the country;

Through "Smart neighborhood" projects, every neighborhood will be connected to the electronic management system.

By 2029, 95% of all public services are planned to be transferred to electronic form.

The number of IT Parks of Uzbekistan was 10 in 2025, and it is planned to increase their number to 30 by 2030.

Also:

The volume of IT exports was 500 million dollars in 2024, and this number is forecast to reach 2 billion dollars by 2030;

A start-up support fund will be established (2026), which will financially stimulate youth initiatives;

More than 10,000 IT specialists are employed in technoparks.

At the same time, cooperation with major brands such as Google, Amazon, Huawei, ZTE, Ericsson has been expanded.

One of the most important priorities for Uzbekistan in the next five years will be the training of personnel with digital competencies.

For this reason: "Digital management", "Cyber security", "Artificial intelligence systems" directions have been opened at the master's level at TATU and Inha universities;

Every year, 50,000 young people are trained in "Digital Skills" training centers;

Launching the "IT-scholarship" program for studying abroad;

Development of digital learning platforms for teachers through the "Digital Pedagogue" project.

Until 2030, the concept of "green technologies" will be introduced in the field of telecommunications and information technologies:

energy efficient data centers;

network equipment based on renewable energy sources;

old technological waste processing system;

"Green IT Uzbekistan" project for environmentally sustainable digital infrastructure.

Through this, it is planned to reduce the carbon footprint of IT networks up to 40%.

By 2030:

internet coverage reaches 100%;

6G technology will be launched based on experience;

95% of public services will be digital;

More than 1 million citizens will be employed in the IT sector;

Uzbekistan will become a digital center in Central Asia.

These results strengthen the country's position in the global digital economy.

3- CHAPTER. ANALYSIS OF MODERN TELECOMMUNICATION STANDARDS

3.1. The essence and tasks of telecommunication systems

Telecommunication is a system of transmitting information from one place to another by electrical, radio, optical or other electromagnetic means. This system is a complex complex consisting of information transmission means, channels, equipment, software and technical control elements.

The main tasks of telecommunication systems are as follows:

• fast and reliable transfer of information;

• data flow management;

• establishing real-time communication between users;

• ensuring information security.

The effectiveness of these systems directly depends on technological standards, transmission speed, latency and network reliability.

Telecommunication standards are a set of international regulatory rules that ensure the interoperability of communication systems. They define parameters such as signal formats, frequency bands, protocols and quality of service (QoS).

The following generations are distinguished in the history of communication technologies:

• 1G — analog voice communication (1980s);

• 2G — digital GSM standard (1990s);

• 3G — mobile Internet (2000s);

• 4G (LTE) — broadband mobile Internet (2010s);

• 5G — high speed, low latency, IoT support (2020s).

Each new generation has increased the quality, speed and scope of services in the field of telecommunications.

Today, the main international standardization organizations are:

• **ITU (International Telecommunication Union)** - the organization that sets communication standards under the UN;

• **ETSI (European Telecommunications Standards Institute)** - develops European regional standards;

• **3GPP (3rd Generation Partnership Project)** – consortium standardizing GSM, LTE and 5G technologies;

• **IEEE (Institute of Electrical and Electronics Engineers)** – develops standards for technologies such as Wi-Fi and Ethernet.

The standards developed by these organizations ensure global compatibility, technical stability and cross-industry integration.

The essence and tasks of telecommunication systems have an incomparable place in the life of modern society, because they are the main infrastructure that ensures continuous information exchange, management and coordination between people, organizations and states. The word telecommunication is derived from the words "tele" (far) and "communicatio" (communication, communication), and it means a system of information transmission in the form of information, sound, video, text or digital signal, eliminating the boundaries of distance and time. In essence, telecommunication systems arise from humanity's natural need for information. Information exchange is necessary for people to communicate with each other, conduct economic activities, make management decisions, ensure security, and receive education.

Telecommunication systems constitute a complex engineering and social system according to its structural structure and functional tasks. The main components of this system are the transmission medium, terminal devices, network nodes, signal processing devices and control software. They ensure the transfer, processing and distribution of information from one point to another in a mutually integrated way. For example, in a mobile network, a user's phone transmits a signal

to a base station, which in turn connects to the backbone network and forwards it to another user. In this way, hundreds of technical operations take place behind a simple call or message.

In order to understand the essence of telecommunication systems in depth, it is necessary to consider their functions in society. First of all, they work as a means of information exchange, that is, they provide fast, reliable and safe communication between people and organizations. It is important not only for personal or business communication, but also in government, emergency, health and defense systems.

Secondly, telecommunication systems serve to coordinate economic activity and create the basis of the digital economy. Modern markets, banking system, e-commerce, digital payments, online services - all these cannot exist without telecommunication networks. Every financial transaction, every online deal, or digital rendering of a government service is a flow of information across a network.

Thirdly, telecommunication systems serve to manage information resources and develop education and scientific research. Distance learning, online courses, video conferencing, academic databases, and digital libraries all depend on an efficient telecommunications infrastructure. Through this, scientific cooperation, innovation and exchange of knowledge will be accelerated.

Fourthly, telecommunication systems are also of great importance for social integration and cultural communication. Communication and cooperation between representatives of different nationalities, languages and cultures is increasing through the Internet, social networks, and digital media. This will serve to strengthen openness, tolerance and global solidarity on a global scale.

Fifth, telecommunication systems are also of strategic importance in the fields of national security and defense. State borders, energy systems, transport networks and other important infrastructures are controlled through information transmission networks. For this reason, each country pays particular attention to

the stability, independence and information security of telecommunication systems.

In essence, telecommunication systems are considered as a social and economic system, in addition to the technical infrastructure. Because it covers almost all areas of human activity. For example, new fields such as "smart cities", "digital health", "intelligent transport systems" and "artificial intelligence-based manufacturing" are emerging through 4G and 5G networks. This means that telecommunication systems now work not only as communication, but as a complex control mechanism.

Another important task of telecommunication systems is to increase the quality, speed and reliability of information. Today, the volume of data transmission around the world is growing exponentially every year. Therefore, it is necessary to ensure that the networks are not only broadband, but also stable, safe and uninterrupted. In this direction, within the framework of the "Digital Uzbekistan - 2030" strategy, work is being carried out in Uzbekistan, such as the expansion of main optical fiber communication lines, the construction of new data centers, and the testing of 5G technologies.

When analyzing the essence of telecommunication systems, it becomes clear that their biggest task is to form the infrastructure of the information age. Because today digital economy, e-government, distance education, e-health, e-commerce all work through telecommunication networks. In this sense, telecommunication systems are the "nervous system" of the modern state. If this system is stable, fast and safe, the entire economy and management system will work efficiently.

The essence of telecommunication systems is that they satisfy the most important need of mankind - communication and information. Their tasks are not only to provide technical services, but also to ensure national development, digital transformation and social stability. Therefore, every country, including Uzbekistan, considers telecommunication systems as a strategic resource and has set

investment in their development, introduction of new generation technologies and capacity building of local specialists as one of its priorities.

3.2. Expansion and modernization of telecom infrastructure

Expansion and modernization of telecommunication infrastructure is one of the most important factors for economic growth, competitiveness and social stability of countries in the current digital era. Telecom infrastructure is a complex of technical and organizational systems that provide data transmission, processing and storage. Its main elements include optical fiber communication networks, mobile networks (2G, 3G, 4G, 5G and in the future 6G), satellite communication systems, data centers, servers, transmission stations and network control centers. Modernization of the telecommunications infrastructure means updating the existing networks based on modern technologies, increasing their throughput, expanding the coverage area, and improving the quality of service. This process simultaneously includes technical, economic, organizational and political reforms.

In the case of Uzbekistan, the expansion of the telecommunications infrastructure began in the years of independence, and initially digital technologies were introduced instead of analog communication systems. Since the beginning of the 2000s, the construction of optical fiber communication lines across the country has accelerated. Through this, the quality of telephone and Internet services has improved. In the 2010s, mobile communication networks developed rapidly and 3G and 4G technologies were introduced. At the same time, operators such as "Uzbektelecom", "UMS", "Beeline", "Ucell" and "UzMobile" implemented large-scale projects to expand infrastructure networks, install new stations and increase coverage across the country.

The main goal of modernization of telecommunication infrastructure is to provide high-speed, reliable, secure and stable communication services. For this, first of all, it is necessary to expand optical fiber communication lines. Significant changes in this regard have been observed in Uzbekistan in recent years: in the period from 2015 to 2025, the length of main optical fiber networks was more than 50 thousand kilometers, and this figure is increasing every year. Optical networks

not only increase Internet speed, but also ensure transmission stability and security. Therefore, in the "Digital Uzbekistan - 2030" strategy, the government of Uzbekistan has set the main priority to connect all settlements of the country, including the most remote villages, to the optical network.

The modernization of mobile networks is also of particular importance in the expansion of the telecommunication infrastructure. As a result of the widespread introduction of 4G technology, the mobile Internet speed has increased several times. At the moment, Uzbekistan is in the testing phase of introducing the 5G network. 5G technology allows not only high speed, but also low latency and connecting a large number of devices to the same network. This technology provides the necessary infrastructure to create innovative solutions in areas such as smart cities, smart transportation, the Internet of Things (IoT), and telemedicine.

In the process of modernization of telecom infrastructure, the role of data centers and cloud technologies is increasing. Data centers are centralized server complexes where information is stored, processed and transmitted, and they provide the necessary infrastructure for public administration, the banking system, e-commerce and other digital services. Several large data centers have been launched in Uzbekistan in recent years, including the centers in Tashkent and Samarkand, which operate in accordance with international ISO standards. In the future, it is planned to integrate the information systems of all government agencies into a single infrastructure based on the concept of "single state cloud".

In the process of expansion and modernization of the telecommunication infrastructure, satellite communication systems also play an important role. Geographical features of the territory of Uzbekistan, mountainous and desert regions complicate the laying of optical networks in some places. Therefore, satellite Internet transmission technologies (for example, VSAT systems, cooperation with the global Starlink and OneWeb networks) expand communication opportunities in remote areas of the country. This makes it possible to reduce digital inequality and provide equal access to information services.

In the process of modernization, the issue of ensuring the security and stability of the network is also central. Since the volume of Internet traffic is increasing exponentially every year, measures such as data protection, protecting the network from cyber attacks, and strengthening encryption systems are urgent. For this purpose, Information Security Centers, CERT (Computer Emergency Response Team) systems, and special platforms for monitoring and protecting state information resources have been established in Uzbekistan.

International cooperation also plays a big role in the expansion of the telecom infrastructure. Uzbekistan has the opportunity to connect with neighboring countries through regional information highways and act as a digital transit center in Central Asia. This will increase the economic potential of the state, reduce the cost of international Internet traffic and ensure the stability of the network. At the same time, technological cooperation in the field of telecommunications with China, South Korea, Russia and Turkey plays an important role in the modernization of Uzbekistan's infrastructure.

Another strategic direction of telecommunications infrastructure expansion is the development of local production and technological independence. Instead of completely dependent on imports of communication equipment, Uzbekistan has begun to develop local telecommunications solutions through IT Park residents and technology parks. This not only reduces costs, but also strengthens national security.

The expansion and modernization of the telecommunications infrastructure is not only a technical process, but a set of strategic reforms that increase the economic, social and scientific potential of Uzbekistan. Every step of infrastructure modernization is an important step towards a digital society. Therefore, in the coming years, updating network technologies, expanding coverage, strengthening security, and forming an infrastructure that meets international standards will be the main guarantee of ensuring the country's digital sovereignty. Between 2015 and 2025, fundamental reforms were implemented in the field of communication and information technologies of the Republic of Uzbekistan. During this period,

modernization of communication infrastructure, expansion of optical fiber networks, renewal of mobile communication base stations and technologies conforming to international standards were introduced.

In 2015, there was only 14,000 km of optical fiber communication lines across the country, but by 2025, this number will exceed 120,000 km. At the same time, broadband Internet was delivered to more than 4,000 settlements in rural areas.

In the framework of the **"Digital Uzbekistan - 2030"** strategy, the state has allocated more than 3 trillion soums of investments for the development of communication infrastructure during 2019-2025. At the expense of these funds, new trunk networks, data transfer centers (Data Center), satellite communication systems and mobile communication base stations were built.

"Uztelecom" JSC, "UMS", "Beeline Uzbekistan", "Ucell", "Perfectum Mobile" existing networks were updated by major operators, and the throughput of international channels was increased 10 times.

For example, Uztelecom aims to connect more than 10 million users to GPON technology by 2025.

In the field of mobile communication, by 2015, 70 percent of the country's territory was covered by 3G networks. By 2025, this is the indicator:

- **4G LTE** by branches - 98 percent,
- **5G NR** by branches - reached 42%.

With the decision of the President of the Republic of Uzbekistan No. PQ-3832 (December 13, 2018), a separate program for the development of digital economy and telecommunication systems was developed. Based on this, frequencies were allocated to mobile communication operators for trial implementation of 5G networks.

In 2021, 5G technology was tested for the first time in the cities of Tashkent, Samarkand and Bukhara. From 2023, it entered the stage of commercial use.

As of 2025:

• The number of mobile Internet users in the country has exceeded 30 million;

• 85% of users use 4G LTE services;

• Average Internet speed reached 120 Mbit/s (instead of 3 Mbit/s in 2015).

Also, the throughput of international communication channels has been increased from 150 Gbit/s to 2.4 Tbit/s. This significantly improved the quality of Internet services in government agencies, educational institutions and industrial enterprises.

One of the most important technological changes in the field of telecommunications is the introduction of the GPON (Gigabit Passive Optical Network) system. This technology replaced the old networks based on copper cables and ensured the transition to a high-speed optical communication network.

Advantages of GPON technology:

• high throughput (up to 1-2 Gbit/s);

• energy saving;

• reliability in service;

• requires little maintenance.

Starting from 2020, the company "Uztelecom" began to introduce GPON technology in all regions. As of 2025, more than 2.5 million subscribers were able to connect through this system.

In addition, based on the NGN (Next Generation Network) concept, a single network combining telephone, Internet and multimedia services was created. This system allows providing "triple-play" services - that is, telephone, Internet and IP-TV services through one cable**.**

The introduction of 5G technology has brought Uzbekistan to a new technological stage. This system not only increased the speed of mobile internet, but also laid the foundation for the development of IoT (Internet of Things), AI (artificial intelligence), autonomous vehicles and Smart City projects.

The Republic of Uzbekistan established active cooperation with international telecommunication organizations during 2015-2025.

- Main partners:
- **ITU (International Telecommunication Union)** – technical and regulatory advice;
- **Huawei, ZTE, Nokia, Ericsson** – technological partners;
- **Korea, China and Russia** are partners in infrastructure investments.

Also, **"Digital Silk Road"** As part of the (Digital Silk Road) project, optical trunk lines were built together with China. This was an important step towards turning the country into a regional data transfer center.

The expansion of the telecommunications infrastructure has not only resulted in technical, but also economic and social results:

• The share of digital services in GDP increased to 8% by 2025;

• More than 100,000 new jobs were created in the IT sector;

• More than 95% of public services have gone online;

• The number of educational and medical institutions connected to the Internet in rural areas has increased by 5 times.

Thus, the telecommunication system of Uzbekistan has become one of the fastest developing infrastructures in the region in the last ten years..

3.3. The concept of telecommunication standards and their classification

The concept of telecommunication standards is one of the main foundations of the modern information society and digital economy. They are a single set of technical, organizational and regulatory rules designed to ensure compatibility, reliability and continuity between various communication systems, devices, software tools and networks. Since the telecommunications industry is a complex and multi-level system, standardization is important to maintain order in this industry, ensure global integration and coordinate technological progress. Telecommunication standards are not only technical documents, but a strategic framework that determines the direction of development of the entire network infrastructure. Through them, devices created by different manufacturers work

with each other, networks operate on the basis of uniform protocols, and a stable, secure communication environment is created for users.

Telecommunication standards are developed at the international and national level. Internationally, this process is managed by organizations such as ITU (International Telecommunication Union), ISO (International Organization for Standardization), IEC (International Electrotechnical Commission), IEEE (Institute of Electrical and Electronics Engineers). In particular, the ITU-T sector (Telecommunication Standardization Sector) plays a leading role in the development of standards for global networks, protocols, digital signaling, network interfaces and quality of service. ITU standards are adopted in the form of "Recommendations", such as documents such as ITU-T G.709 (optical transport network), ITU-T H.264 (video coding), or ITU-T G.992.1 (ADSL technology), which ensure that networks worldwide operate on a uniform technical basis.

Telecommunication standards are classified according to various criteria. First of all, they can be divided according to technological direction: network level, transmission systems, protocols, user interfaces, security standards, service standards, etc. For example, transmission standards include PDH, SDH, DWDM, Ethernet, and MPLS technologies. These standards ensure high-speed and continuous data transfer. Mobile communication standards include GSM (2G), UMTS (3G), LTE (4G), and NR (5G) technologies. Each generation of standards significantly improves data transfer speeds, network stability, energy efficiency, and service quality.

Network layer standards are also classified based on the OSI model: there are physical layer, channel layer, network, transport, session, presentation, and application layer standards. For example, Ethernet and Wi-Fi operate at the physical and channel levels, IP and MPLS operate at the network level, and TCP and UDP operate at the transport level. Through this approach, global networks are organized as a layered system that is interconnected but independent of each other.

According to the level of standardization, telecommunication standards are divided into international, regional and national types. International standards are

approved by organizations such as ITU, ISO, IEC and are used globally. Regional standards apply in certain geographical areas, for example, European standards developed by ETSI (European Telecommunications Standards Institute) or mobile network standards developed by 3GPP (3rd Generation Partnership Project). National standards are adopted in accordance with the regulatory framework of each country. In Uzbekistan, special technical committees under the agency "Uzstandart" and the Ministry of Information Technologies and Communications Development operate in this field.

Telecommunication standards can also be classified by functional direction. They are divided into standards that define transmission systems, signaling and control protocols, quality of service (QoS) and security, coding and encryption, network interfaces and equipment interoperability. For example, SIP (Session Initiation Protocol) is used to establish voice communication sessions, H.323 is a video communication standard, and Internet protocols IPv4 and IPv6 define the address system in the global network.

Another important aspect of standards are quality of service (QoS) and service level (SLA) standards. These documents define the parameters of telecommunication services provided to users, such as delay, interruption, loss ratio and network stability. For example, the ITU-T Y.1541 standard specifies QoS requirements in IP networks. Such standards are the minimum technical criteria for service companies and serve to protect the rights of users.

The formation of standards in the field of mobile networks reflects an evolutionary process. The stages of development from the era of 1G (analog communication) to 5G (digital, high-frequency and low-latency networks) represent a technological revolution. The IMT-2020 standard has been developed by the ITU for 5G technology, which allows networks to operate at a speed of 10 Gbit/s and transmit data with a delay of up to 1 millisecond. 6G networks are currently in the research phase and will integrate artificial intelligence, quantum communication and "metaverse" technologies.

Another important classification of telecommunication standards is security standards. Issues of information security and data protection have become an integral part of the telecommunications industry today. In this regard, documents such as ISO/IEC 27001 (information security management), ITU-T X.800 (network security architecture), and ETSI Cyber Security standard are important. They define protection, authentication, encryption, user identification and network security during data transmission.

Along with technical progress, political, economic and social factors also play an important role in the development of telecommunication standards. For example, competition between international companies, technological patents, national regulatory policies, and global market needs directly affect the pace and content of standards development. Therefore, every country, including Uzbekistan, strives to adapt national networks to global standards, but to form a strategically independent infrastructure.

Telecommunication standards are the language of the global communication system. They combine different technologies on the basis of a single compatibility, ensure the continuous operation of the digital economy and create the basis for future technological innovations. Therefore, a consistent policy in the field of standardization, international cooperation and development of scientific and technical potential will be of strategic importance for the digital transformation of Uzbekistan. Telecommunication standards are a set of technical standards that ensure interoperability, stability and high quality of communication systems. They define many parameters such as data transfer, coding, security, frequency bands and quality of service (QoS).

- The most important standardization organizations worldwide:
- ITU (International Telecommunication Union) - develops common international standards;
- 3GPP (3rd Generation Partnership Project) – a global consortium for the development of 3G, 4G, 5G standards;

• IEEE (Institute of Electrical and Electronics Engineers) – develops standards for networks such as Wi-Fi, Ethernet;

• ETSI (European Telecommunications Standards Institute) - develops telecommunication standards of European countries.

-Telecommunication standards are mainly divided into the following categories:

1. Mobile communication standards - GSM, UMTS, LTE, 5G NR;

2. Optical network standards - GPON, EPON, XG-PON, DWDM;

3. Network protocols and security - TCP/IP, IPv6, VPN, IPSec;

4. Multimedia and IP services - VoIP, IPTV, NGN;

5. IoT and industrial networks - NB-IoT, LoRaWAN, 6LoWPAN**.**

Development of 4G LTE network in Uzbekistan

• 4G LTE technology has been introduced in Uzbekistan's mobile communication system since 2014. At the initial stage, this technology worked as a test in the cities of Tashkent, Samarkand and Fergana.

• After 2018, LTE networks were introduced in all regions of the country.

• This technology provided the following advantages:

• Data transfer speed - up to 150 Mbit/s;

• Low latency (latency) - around 50 ms;

• Improved voice quality (via VoLTE service);

• Extensive coverage and stability.

By 2025, all major operators in Uzbekistan **(Beeline, Ucell, Uzmobile, Humans)** have spread 4G LTE networks to 98% of the entire territory of the republic.

Statistical information (2025):

• Number of LTE users – more than 25 million;

• Average speed - 100-150 Mbit/s;

• Coverage level – 98%;

• Number of 4G base stations – more than 22,000.

Based on the decision of the President of the Republic of Uzbekistan No. **PQ-5044 (April 5, 2021)**, a program for the gradual introduction of 5G technology was developed. Between 2021 and 2023, 5G test networks were launched in the cities of Tashkent, Samarkand, Bukhara, Navoi and Fergana..

- By 2025:
- 5G services have been put into commercial use in 8 major cities;
- Network speed – up to 1 Gbit/s;
- Latency – less than 10 ms;
- Support of IoT devices - up to 1 million devices/km².

Technical advantages:

- Ultra-fast mobile internet;
- Advanced IoT capabilities;
- High stability for cloud computing (Cloud computing);
- Basis for artificial intelligence and "smart city" projects.

Practical projects:

- "Smart Tashkent" - digitalization of transport, security and energy systems in the 5G network;
- "Digital Fergana" - optimization of water consumption in agriculture through IoT sensors;
- "5G Education" - introduction of AR/VR educational technologies in higher education institutions.

GPON technology (Gigabit Passive Optical Network) is a passive network system that allows high-speed data transmission based on optical fiber. This technology has been widely introduced by Uztelecom since 2018.

Advantages:

- Data transfer speed - up to 2.5 Gbit/s;
- 70% less energy consumption compared to copper cables;
- Network reliability 99.99%;
- Repair and service costs are reduced by up to 40%.

"Smart Home" and "IPTV" services were introduced based on GPON technology. By 2025, 2.5 million subscribers are using this system in more than 180 urban and district centers of Uzbekistan.

Economic efficiency:

• Optical fiber installed instead of 1 km of copper cable - provided 3 times cheaper service price;

• Internet speed increased 10 times;

• Reduced maintenance costs;

• The number of users is increasing by 12-15% per year as a result of the increase in the quality of the Internet.

NGN is a network that combines various services (telephone, Internet, video, data transmission) on the basis of a single IP platform.

Since 2016, it has been gradually introduced in the networks of Uzbekistan.

Advantages of NGN system:

• all services through a single IP-platform;

• reducing the price of service;

• possibility of remote network management;

• fast integration of new services.

The following services are actively working on the basis of NGN technology:

•**VoIP (Voice over IP)** – telephone connection over the Internet;

•**IPTV** – digital television service;

•**Video konferensiyalar** – in education and business;

•**Virtual ofis xizmatlari (Cloud PBX)** – simplification of the internal communication of the enterprise.

The introduction of modern standards gave the following positive results:

• **The total volume** of the digital economy will reach 40 trillion soums by 2025**;**

• **The volume** of IT exports increased from 46 million dollars in 2020 to 500 million dollars in 2025;

• **The share** of telecommunication services in GDP reached 8%;

• **95% of public** services have gone digital;

• **National standards** were developed in the field of cyber security (Uz DSt ISO/IEC 27001:2023)**.**

3.4. Priority areas of development of telecommunication standards

Although great progress has been made in the field of telecommunications during the period 2015-2025, a number of problems still remain in the system. They are as follows:

1.Uneven development of infrastructure.

There is a significant difference in internet speed and quality between urban and rural areas. In rural areas, 4G networks are not yet fully covered.

2. Lack of personnel.

The number of engineers and programmers with deep knowledge of telecommunication technologies is limited, and the education system is not at the international level.

3. Import dependence of equipment and technologies.

The main technical means (base stations, optical systems, modules) are imported from Chinese, South Korean or European companies.

4.Inadequate development of national standards.

In the field of telecommunications, the adaptation process according to international ISO, ITU, 3GPP standards is slow.

5. Cyber Security Threats.

The problem of data protection is becoming increasingly important in the digitalization process, but protection systems are not implemented to the same extent in all industries.

In the coming years, the following areas are important for making the telecommunications system of Uzbekistan more effective:

6. Creation of a base of national standards.

Development of local regulatory documents based on UzDSt ISO/IEC and ITU-T standards;

Introducing a new certification system for 5G, IoT, Cloud and AI-based networks.

6. Expansion of digital infrastructure.

Spreading 5G networks to all regions in 2025-2030;

Bring GPON technology to every district center;

Building affordable Wi-Fi and IoT platforms for rural areas.

8. Development of local production.

Expansion of production of optical cables, modems, servers and routers in Uzbekistan;

Organization of telecommunications laboratories for local start-ups.

1. Improvement of personnel training system.

Deepening the science of "Telecommunication standards" in higher education institutions;

ITU, Establishing joint training programs with international companies such as Huawei and ZTE.

2. Cyber security and data protection.

Implementation of national cryptographic protocols in telecom networks;

Establish a security certification system for each provider;

Expanding the activities of the "Cyber Security Center"..

Telecommunication standards play a key role in the digital economy. The following technologies play an important role in the conditions of Uzbekistan:

• **5G and 6G prospects:** Industrial automation, intelligent transport systems and digital health will advance.

IoT (Internet of Things): It will be the main tool in the management of water resources, control of energy consumption and automation of logistics systems in agriculture.

• **Cloud technologies (Cloud computing):** Allows centralization of information in state services, banking system and educational institutions**.**

• **Artificial Intelligence (AI):** Used in telecom networks to manage traffic, predict outages and automate quality of service.

Based on the analysis, the following practical proposals are put forward:

1. **Establishment of a new "Telecommunications Standards Agency",** which coordinates national and international standards.
2. **“5G+ IoT Platforma – Uzbekistan”** implementation of the program in 2026-2030.
3. **Joint financing of telecom projects** by strengthening cooperation between the public and private sectors.
4. **Establishment of local analysis** centers (Data Center) in each region.
5. **Increasing digital literacy among the population** development of public programs on.

2025–2035- the development of telecommunication networks of Uzbekistan will continue in the following directions:

- **Testing of 6G and quantum communication systems**;
- **Creation of national satellite communication**;
- **Expansion of smart cities and digital regions**;
- **Building energy efficient networks based on environmentally friendly technologies**;
- **Access to the Central Asian market through regional information exchange centers**.

The priorities for the development of telecommunications standards will determine the foundation of the modern digital economy, as global information flows, economic systems, transport and energy sectors operate in an increasingly integrated and digitally controlled environment. Therefore, the standards in the field of telecommunications are not only a set of technical norms, but also gain importance as a strategic tool that ensures interstate competitiveness, innovative development, information security, and economic stability. Today, there are several priorities in the development of telecommunications standards in the world, which cover technological innovation, network architecture, security, energy efficiency and international compliance.

One of the most important directions in the development of telecommunication standards is the standardization of new generations of mobile communication systems - 5G and future 6G technologies. The IMT-2020 standard was adopted by the ITU for 5G technology, which provides high speed, low latency, the ability to connect massive devices and support for concepts such as "smart cities", "Internet of Things" (IoT). A conceptual approach to 6G technology is being developed by ITU-R under the name IMT-2030. It sets new standards for networks operating in the terahertz range, self-managing with the help of artificial intelligence, using quantum communication mechanisms. As the central backbone of the digital economy, these next-generation networks are expected to transform the entire world's communications infrastructure in the 2030s.

Another priority is the development of Internet protocols (IP) and the coordination of global transition processes. Although the IPv6 standard has been around since 1998, the transition to IPv6 has accelerated as the world ran out of IPv4 addresses. This new standard supports more than 340 trillion IP addresses, improves security and routing, and enables networks to scale. Uzbekistan is also actively working in this direction - the Ministry of ICT and the Uztelecom company have established test zones based on IPv6 from 2024, which means that the country's telecommunications infrastructure will move to a new stage.

Another important area of development of telecommunication standards is related to the standardization of "Internet of Things" (IoT) and "Machine-to-Machine" (M2M) communications. Various standards are being developed in this field by IEEE, ETSI and 3GPP organizations. For example, NB-IoT (Narrowband IoT) and LTE-M standards are designed to connect devices with energy-efficient, long-term operation and small data flows. In the conditions of Uzbekistan, these technologies are widely used in the introduction of "smart houses", "smart transport", "smart energy" and "digital agriculture" systems. For this purpose, within the framework of the "Digital Uzbekistan - 2030" strategy in 2023-2025, a project was developed to expand the IoT infrastructure and create a national IoT platform.

Telekommunikatsiya standartlarini rivojlantirishdagi yana bir ustuvor yo‘nalish bu axborot xavfsizligi va kiberxavfsizlikni standartlashtirishdir. Bugungi kunda tarmoqlarning kengayishi bilan kiberhujumlar, ma’lumotlarni noqonuniy olish, raqamli firibgarlik holatlari ortib bormoqda. Shu sababli ISO/IEC 27000 seriyasi, ITU-T X.800 va ETSI Cyber Security standartlari global xavfsizlik infratuzilmasining asosiy tayanchlaridan biri hisoblanadi. Bu standartlar ma’lumotlar uzatish paytida shifrlash, autentifikatsiya, foydalanuvchi identifikatsiyasi va tarmoq himoyasini ta’minlashni belgilaydi. O‘zbekiston ham bu borada faol islohotlarni amalga oshirmoqda – 2020-yilda “Kiberxavfsizlik to‘g‘risida”gi konsepsiya qabul qilinib, tarmoq operatorlari va internet-provayderlar uchun xalqaro xavfsizlik standartlariga muvofiqlik talablari joriy etildi.

Energy efficiency and application of green technologies in the field of telecommunications is also one of the priorities. It is intended to ensure the operation of networks in an energy-saving mode, reduce the carbon footprint, and integrate renewable energy sources into the communication infrastructure. Standards such as ITU-T L.1300 and ETSI EN 305 200 define the concept of "green communication" (Green ICT). In the conditions of Uzbekistan, work on the introduction of base stations using solar energy and the transfer of networks to an automated energy control system has been started in this direction.

The standardization of artificial intelligence (AI) and network automation technologies has also emerged as one of the most relevant trends in recent years. The ITU-T Y.3172 and IEEE P7000 series standards define common protocols for AI-based network management, automatic quality of service adjustment, and data analysis. This direction will serve as the foundation for 6G networks, as future networks will be able to manage their own load, outages and security independently.

Another important area of telecommunications standards development is the development of global standards for cloud computing and data centers. The ISO/IEC 17788 and 17789 standards define the basic principles of cloud

architecture, while the ITU-T Y.3500 series defines network security and quality of service (QoS) standards. In Uzbekistan, such infrastructures as "UZCLOUD", "Beeline Data Center", "Uztelecom Cloud" are being certified according to international standards.

Harmonization of international compliance and regulatory policies in the field of telecommunications is also an urgent issue. Because the international integration of networks and cross-border information exchange is carried out on the basis of global standards. Uzbekistan actively cooperates with ITU, APT (Asia-Pacific Telecommunication Community), and RCC (Regional Commonwealth in the Field of Communications) organizations in this regard. In this way, adaptation of national standards to international requirements, faster introduction of new technologies and integration into the global digital economy are increasing.

The priority areas of development of telecommunication standards cover technological, economic and security factors. Among them, 5G and 6G networks, IoT, cyber security, cloud technologies, artificial intelligence and the concept of "green communication" occupy the most important place. Uzbekistan is actively integrating into these global directions, modernizing the national standardization system, strengthening cooperation with international organizations, and consistently moving towards the formation of a modern digital telecommunications infrastructure. These prospects will strengthen Uzbekistan's digital sovereignty and ensure technological leadership in the region.

CONCLUSION

In this graduation thesis, the digitization process and the issues of modern telecommunication formation, as well as the practical aspects of teaching the topic "Analysis of Digitization and Modern Telecommunication Standards" were analyzed in detail. According to the results of the research, modernization of telecommunication infrastructure, improvement of service quality and introduction of digital systems that meet international standards, digitization and development of modern telecommunication education and its improvement based on international experiences will not only increase the level of knowledge of students, but also serve to prepare them for complex situations encountered in real working conditions.

Formation and development directions of digitization policy and telecommunication infrastructure in Uzbekistan, stages of formation of digitization policy, formation of telecommunication standards, public and private sector cooperation, and growth of the telecommunication services market were covered in a broad way. Digitization policy and formation of telecommunication infrastructure in the Republic of Uzbekistan has become one of the most important priorities of state policy. Within the framework of the "Digital Uzbekistan - 2030" strategy in the country, attention was paid to the issue of introducing digital technologies in all areas, expanding the information and communication infrastructure, and improving the quality of Internet services.

The concept of digital economy and its importance, the economic and social effectiveness, prospects and strategic directions of digitalization processes in the Republic of Uzbekistan, problems in the digitalization process, and the future development of telecommunication infrastructure were deeply studied. By deepening the digital transformation in the Republic of Uzbekistan, not only the development of the domestic market, but also the formation of a competitive digital economy at the international level are actively working. At the same time, within the framework of the "Digital Uzbekistan - 2030" strategy, ensuring information security, introducing 5G technologies, expanding the electronic

government system, and developing innovative infrastructure were considered as priorities.

Through the analysis of modern telecommunication standards, the essence and tasks of telecommunication systems, the expansion and modernization of telecommunication infrastructure, the concept of telecommunication standards and their classification, and the priority directions of the development of telecommunication standards were studied.

As a final conclusion, it can be said that the results of the digitization process of the formation of telecommunication standards serve to organize an effective educational process in the field of telecommunications. As a result of this approach, students acquire not only theoretical knowledge, but also practical skills and are ready for complex threats that arise in real working conditions.

Also, thanks to the introduction of telecommunication standards, inter-industry integration is increasing in the country, data exchange is accelerating, and a solid foundation is being created for being recognized as a highly qualified and competitive specialist in ensuring the stability of services. Thus, the ideas put forward in the graduation thesis include theoretically and practically significant recommendations aimed at developing the higher education system of Uzbekistan in the field of telecommunications based on modern requirements.

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