GALAXY INTERNATIONAL INTERDISCIPLINARY RESEARCH JOURNAL (GIIRJ)
ISSN (E): 2347-6915
Vol. 10, Issue 9, Sep. (2022)

INTEGRATION OF SMART GRID SYSTEMS AND GEOINFORMATION TECHNOLOGIES: CHALLENGES AND OPPORTUNITIES

Azizbek Temirov
Namangan state university

Ernazar Reypnazarov
Tashkent University of Information
Technologies named after Muhammad al-Khwarizmi

Shakhlo Khujamatova
Academic Lyceum of Tashkent University of Information
Technologies named after Muhammad al-Khwarizmi

Abror Isakov
Academy of the Ministry of Internal
Affairs of the Republic of Uzbekistan
aaotemirov@gmail.com

ABSTRACT

In this article, in the application of geo-information technologies for Smart Grid, in the design and determination of route schedules for energy companies located in geographical and population-friendly places, choosing the most optimal option for construction, the rational use and status of centralized energy sources in the design of new energy supply systems by companies, it is very useful to gather enough information about them. The development of web portals, navigation systems and mobile phone applications on the Internet has paved the way for ordinary citizens. This article describes the application of geo-information technologies to problems aimed at improving their functions for the Smart grid implemented in the geographic information system.

Keywords: GIS geographic information system, Smart grid, Engineering network, database, information technologies.

INTRODUCTION

The integration of existing systems into general national, international and global information structures is one of the distinguishing features of the process of introducing geoinformation technologies today. Satellite imagery data is used in countries for government decision-making, civil defense operations, law enforcement, energy supply, and geographic information systems (GIS) in general. Nowadays, with the growth of the world's population, the increasing demand for energy and the need to increase agricultural production, the proper management of the world's energy and agricultural resources is becoming increasingly important. For this, first of all, it is necessary to obtain reliable information about the types of these resources, as well as their quality, quantity and location. Satellite imagery and GIS will always be an important factor in improving existing systems for agricultural and resource data collection and mapping [1].

It is being conducted by many researchers to collect data and perform statistical analysis on energy supply sources and energy consumers around the world. As a result, geoinformation technologies are rapidly developing and spreading. Satellite images are a source of information for solving problems in various fields, such as cartography, urban planning, forestry and agriculture, water management, oil and gas production and monitoring the condition of transport infrastructures, energy supply. is actively used as Environmental assessment, prospecting and forecasting of mineral deposits, areas for renewable resources, etc. in the application of geospatial technologies in the Smart grid. GIS and geoportals are used to make management decisions in data analysis. Fig. 1. shows the structure of the gis.

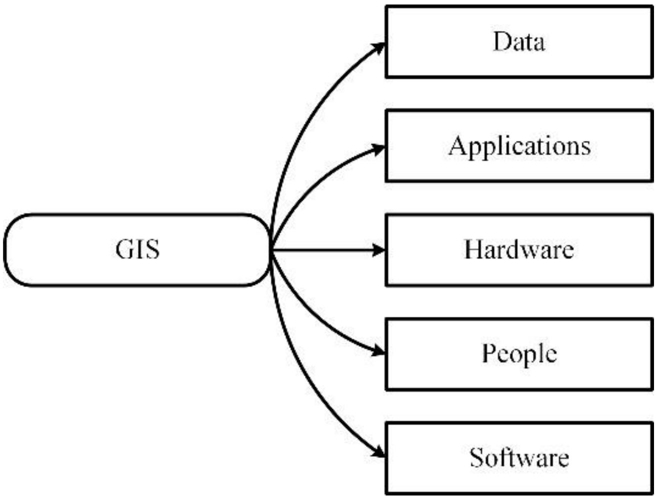

Fig.1. GIS structure

A smart grid is defined as a two-way flow of electricity and information between many interconnected elements to create a decentralized and intelligent network (Generation Transmission-Distribution) [2]. Due to the complex, distributed and unpredictable nature of the smart grid, the control system is moving from a centralized to a decentralized, autonomous, flexible and robust structure. Fig. 2. shows the structure of the smart grid.

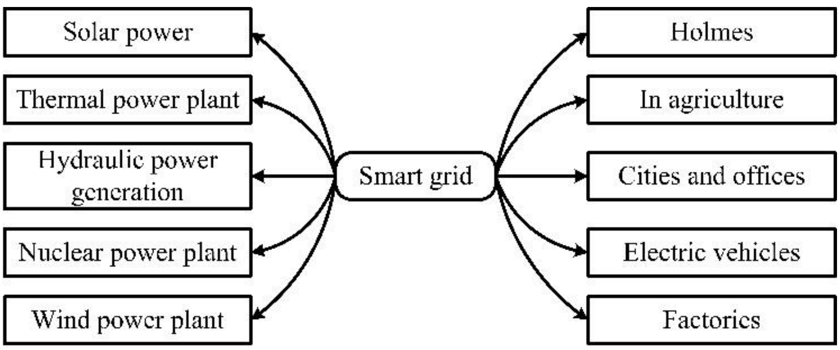

Fig.2. Smart grid structure

Today's advanced technologies, innovative products and services enable environmentally friendly, reliable and efficient energy transmission, cheap, real-time resource management and monitoring, and network security. Efficient communication requires energy storage facilities and self-healing technologies. To support the Smart Grid, the entire electricity grid and stakeholders, including distributed energy resources, distribution system operators, transmission system operators, consumers and the market structure are continuously connected and supported. In addition to conventional power plants, distributed energy resources in the next generation of smart grids will lead to an environmentally friendly and sustainable power generation solution. Synchrophase based WAMS (Wide Area Monitoring System) is emerging as a game changer at the transmission level, making the network smarter. Complex power grids can be monitored in real time over larger areas. Grid self-repair, smart energy management, smart monitors and smart automation devices or smart node control, integration with EVs, simplifying energy storage technology and other functions are part of the smart distribution system. The role of consumers in the smart grid has changed dramatically [3-4].

I. Smart Grid Features

The prospects of sustainable development of modern civilization depend on how effectively society uses energy as an alternative source of energy. In this regard, the development of energy efficiency and energy-saving technologies is important. It has an untapped energy saving potential and as an integral part of the energy sector, it should be at the forefront of reversing this trend, which can be an important factor in limiting the country's economic growth. Energy has always been a part of history to some extent, but in recent years it is clear that its role has become increasingly important. It is known that the world's population is constantly increasing, at the same time energy consumption per capita is also increasing, all of this is related to the continuous reduction of fuel reserves, which are the main source of energy [5]. Among energy experts, there is an intelligent active-adaptive network concept for Smart Grid, which can be characterized by the following characteristics:

1. Saturation of the network with active elements that allow changing topological parameters;
2. A large number of sensors that measure the current operating parameters to assess the state of the network in different power system operating modes;
3. Data collection and processing system (software and hardware systems), as well as active network elements and means of managing electrical facilities of consumers;
4. Existence of the necessary executive bodies and mechanisms for changing the topological parameters of the network in real time and interacting with neighboring energy facilities;
5. Means of automatic assessment of the current situation and network activity forecasting;
6. Management system and high speed of information exchange.

In fact, a certain narrowing of the term reduces it to the automation and optimization of the operation of secondary energy transport, apparently reflecting the problems of the current energy complex or perhaps corporate interests, but in any case solving them. Problems give clear results. Automation and optimization of transport infrastructure is a very important and urgent task considering the current state of affairs: from 10% to 14% of network losses during transportation to the final consumer (according to various estimates). At the same time, we are approaching the end of capital funds (by 2020, everything created during the economic boom of the 1960s and 1980s will be destroyed en masse), and we will solve this problem not by recovery, but by regeneration. is chosen as a modern solution [6-7].

As mentioned above, the general understanding of how to implement this concept is related to the development of the technological foundation and the information systems that are part of it. Automation and informatization in industry did not begin with the introduction of the topic of Smart Grid. The new concept simply strengthened its position, because its implementation involves hundreds of times the flow of data, which implies more effective data management technologies.

When the smart grid is turned on, the electrical system adapts to new conditions without human intervention. If the circuit limit is approached, the smart grid can automatically restore itself to overcome the overload condition. The solution to the problem can be “self-healing” by replacing the problem areas to reduce network interruptions. As electricity demand increases during the hottest days of the year, power companies must maintain large energy reserves. A smart grid makes maximum use of available resources[8].

A smart grid equipped with thousands of sensors and operators that better understand system performance predicts rather than responds to prevent emergencies. A smart grid gives operators the ability to predict failures before they happen. The corresponding action can be automated. Even in today's sophisticated SCADA and distribution control systems, switching is often done by operators based on their own interpretation of the situation. Table 1 provides a list of available communication technologies for the smart grid [9].

Table.1. Analysis of smart grid network technologies.

Medium	Technology	Standart	Application
Wired	DSL	ADSL, VDSL	NAN
	PLC	PON,WDN,SONE T/SDH	WAN
	Optical Fiber	IEE P1901.2, IEE1901	HAN, NAN, WAN
	Ethernet	IEE 802.3,IEC61850	HAN, SAS
Wireless	WiMAX	IEEE 802.16	NAN, WAN
	WLAN	IEEE 802.11z	HAN, NAN, V2G
	WPAN	Bluetooth, ZigBee	V2G.HAN
	Cellular	2G,2.5G,3G,4G	V2G,NAN,WAN,Smart meter

In addition, consumers began to participate in energy demand management through the smart metering system and intelligent grid ICT market mechanism. Various communication technologies are used through two main means: wired and wireless. Ethernet, power grid connection-PLC, fiber optic and wireless communication satellite, WiMAX, mobile communication and z-wave are examples of communication methods. In the evolution of smart grid architecture, several standards have been proposed, including IEC 61970/61968CIM, IEC 61850, IEC 62351, IEC 62325, and others [10-11].

Before the Smart Grid era, everyone recognized the importance of using GIS in the energy sector, including the energy sector, to automate business processes in the smart grid. GIS in the energy industry has long been recognized as an infrastructure technology, and all IT consultants consider it an essential technology for building enterprise IT architecture for energy companies. Due to the geographical distribution, the electricity industry enterprises are mainly spatially connected, which accounts for about 90% of the data used by the electricity grid companies due to the nature of the main assets: transmission and distribution networks, as well as all related infrastructures [12-15].

Continuous service level for context-specific modular services (measurement data download, relational transformation and data sequence normalization), as well as for forecasts and intensity maps designed with interoperability and robustness in mind Manages the computation of GIS-compatible data.

II. Application of geoinformation system in smart grid

GIS for the smart grid is not a super system with a big red button, it is not seen as a solution for all possible problems. It just replaces and automates everything. Rather, it is a comprehensive integrated IT solution based on web services and standardized intersystem interfaces (CIM model). If the task of creating a super system is based on any of them, the practice of technological convergence of systems is rarely justified. For example, technology systems often include geographic images and associated functionality, but this approach does not always best reflect the overall functionality. Back to the role of geographic information systems (GIS) technology with the above considerations in mind. It is assumed that an enterprise GIS asset management system (focused on technical certification) and network topology modeling should be used to determine the current state of the engineering network. Enterprises need to retrieve spatial location and network topology information from GIS and return it using transactional mechanisms and clear rules. The changes were determined by their logic of operation and the nature of the business processes being served: operational switching, equipment shutdown, replacement, etc. When a single database (MB) is used as a source of engineering information at all stages of the life cycle (LC) - design, construction and operation, this is called a single version of the truth (SVOT) in Western practice. Fig. 3. illustrates a GIS-based database model.

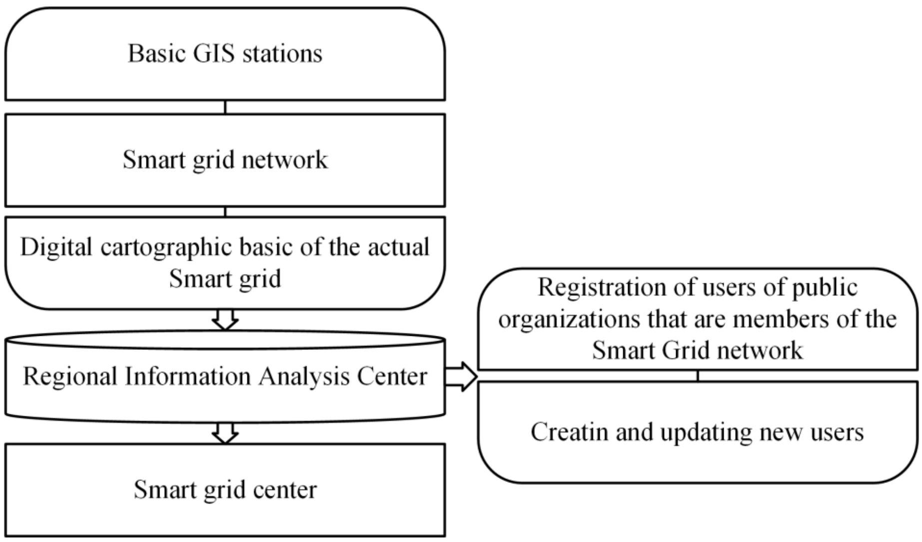

Fig.3. GIS management system for smart grid.

GIS-based solutions for the energy industry are sold by several major retailers and many independent companies. Energy systems around the world are being forced to "go digital", which means fundamental changes in internal architecture and management. Although some countries still do not have a single energy system that requires global changes, the growing inefficiency of electricity is becoming a factor that hinders economic development. Digitization is the current trend to improve efficiency in industry, including energy. Industry 4.0 is a key component of the digital architecture of the Fourth Industrial Revolution. Digital energy is becoming a component of the digital economy as part of the program to digitize all fuel and energy sectors, including electricity, oil and gas, and coal [15-18].

Geoinformation technologies. A computer system that collects, manages, and displays geospatial data and can be used to display information about events, occurrences, activities, or details, as well as their location. GIS is a bridge between geography, computer science and information technology theory, cartography and new computing approaches. Short-term forecasts and flattened maps create PostGIS-compatible spatial data. PostGIS is a spatial database extension for PostgreSQL that supports geographic objects and allows location queries. In addition, the properties of these spatial types allow for improved operators and indices. Fig. 4. shows the general structure of Gis [19].

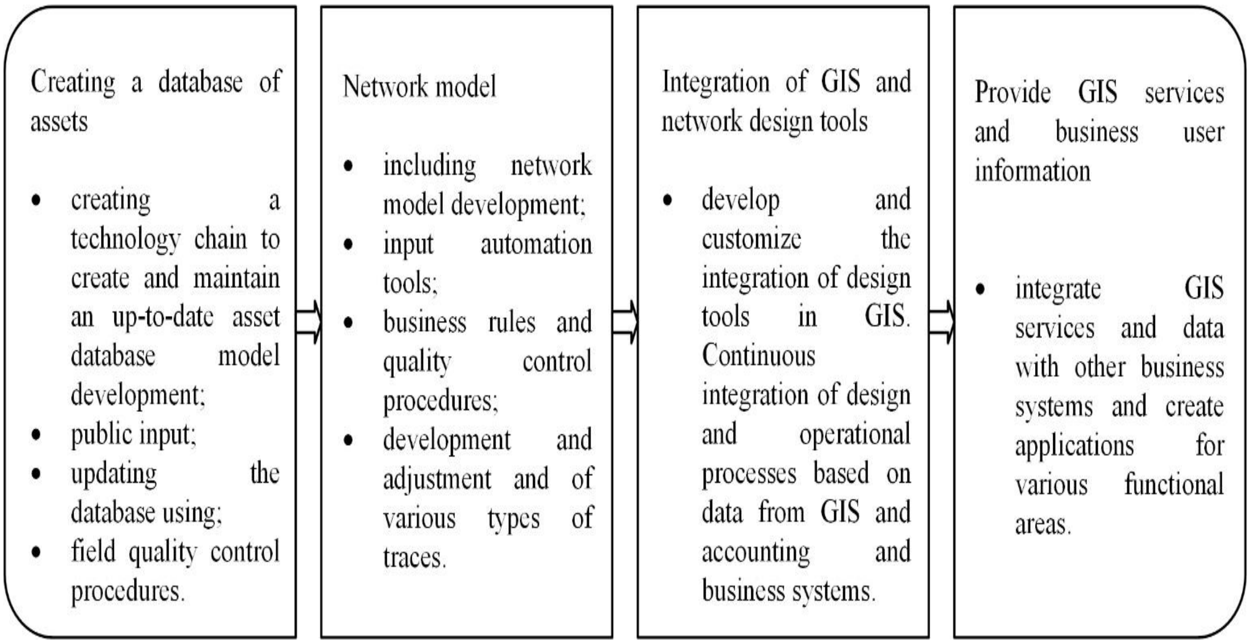

Fig.4.The life cycle of corporate GIS implementation.

Providing access to geospatial information via the Internet (organizing data storage, creating services with GIS analysis functions for users of internal and external web networks). It allows the user to organize access to information on a specific topic (spatial images, vector maps, attribute data) for a specific area from the internal network and the Internet. Table 2 summarizes the currently available GIS software [20-28].

ISSN (E): 2347-6915
Vol. 10, Issue 9, Sep. (2022)

Table.2.Using GIS Software on a Smart Grid

Type of work	Software products	Key features
Photogrammetric processing of remote data	INPHO line from Trimble INPHO	- Automated air triangulation for all types of frames taken from digital and analog cameras - Aerial or satellite imagery, quality control. - Build high-resolution digital height models based on editing - Create color-synthesized mosaic overlays using images from different satellites - Vectorization of terrestrial objects through stereo pairs of aerial photographs and space images - Geometric and radiometric correction
Thematic processing of remote data	ENVI line from ITT VIS	- Interactive decoding and classification - Interactive spectral and spatial image enhancement - Calibration and atmospheric correction - Obtain vector data for export to GIS
GIS analysis and mapping	ArcGIS Desktop Line (ESRI Inc.)	- Create and edit spatial data based on an object-oriented approach - Creation and design of maps - Spatial and statistical analysis of geodata - Map analysis, visual reporting
Provide access to geographic information via the Internet	ArcGIS Server Line (ESRI Inc.)	- Centralized management of all spatial data and mapping services - Create web applications with desktop GIS function

GIS is typically used as the basis for a critical document that contains a detailed description of an enterprise's IT infrastructure and IT architecture. Their formation, with their unique methods and scientific approaches, has become an important area of IT management and is an important component of the strategic enterprise management process.

There are no standards or clear rules governing how to use the GIS component in an enterprise's IT architecture. If the best practices in the field of utilities (energy companies and utilities) are generalized, GIS should play the role of infrastructure technology that provides basic support for business processes, spatially distributed asset management, and technical certification system. Supporting network topology and providing useful tools for creating and editing it is an important task when describing distribution networks whose configuration changes frequently due to, for example, operational switching. DMS class systems support the network model and generally provide a very convenient and conventionally understandable interface for working with data based on schematic views; however, they have some drawbacks. A schematic representation (basic, single line, full line, cable routing diagrams, etc.) is usually done out of scale and does not have full coordinate information. When used for network modeling in dispatching and maintenance tasks, they rarely cause problems. However, when it comes to the corporate approach and the added benefits of synergy through the sharing of different data and systems, geographic coordinate systems and precise spatial association of data with the region may be the only natural way to achieve this. In fact, in cooperation with property data (land cadastre), engineering network data, and even external data, for example, information about transitions to other engineering networks, meteorological data, etc. how to analyze and display, uses a single coordinate system and spatial analysis. GIS can effectively solve such tasks, which is why they were created in the first place.

CONCLUSIONS

Due to complex natural phenomena and energy technology, the concept of Smart Grid is developing rapidly. The proliferation of smart grids requires developers to work with large amounts of data on many aspects to ensure the reliable, resilient, and secure operation of the power grid. In this context, the general energy sector and the prospects for the use of GIS technologies in enterprises will benefit from an introduction to the materials, key concepts and technological trends in this study. It is a field manager, engineer, site supervisor, IT service representative, etc., and GIS technology will be useful for various specialized industrial applications. By sharing spatial data with everyone in your workplace, you can improve company performance and efficiency, and improve customer service for a critical resource like electricity. Due to their decentralized nature and operational robustness, the applications presented in this study are among the leading technologies. On the other hand, ICT transforms the traditional “power grid” into a “smarter” grid by enabling device integration, information exchange, data interaction, and two-way communication. A platform based on standard communication protocols and applications is an important criterion for connecting to a smart grid in this context.

REFERENCES

1. Сиддиков, И., Хужаматов, Х., Хасанов, Д., & Рейпназаров, Е. (2018). Тарқалган параметр ва катталикли токни кучланишга электромагнит ўзгарткичларининг ўзгартириш занжирларини ҳисоблаш дастурий таъминоти. Дастурий маҳсулот учун гувоҳнома, DGU 05479, DGU 2018 0319.
2. Хужаматов, Х.Э., Рейпназаров, Е.Н., & Хасанов, Д.Т. (2019). Телекоммуникация тизимларининг шамол энергия таъминоти манбалари. In “Фан, таълим ва ишлаб чиқариш интеграциясида ахборот-коммуникация технологияларини қўллашнинг ҳозирги замон масалалари” республика илмий-техник анжуманининг маърузалар тўплами, 29-30 октябрь (pp.315-318).
3. Хужаматов, Х.Э., Рейпназаров, Е.Н., & Хасанов, Д.Т. (2020). Симсиз сенсор тармоқ орқали телекоммуникация объектларининг шамол энергия таъминоти манбаларини масофавий мониторинги. In “Иқтисодиётнинг тармоқларини инновацион ривожланишида ахборот-коммуникация технология-ларини аҳамияти” Республика илмий-техник анжуманининг маърузалар тўплами, 5-6 март (pp.246-249).
4. Хужаматов, Х.Э., Хасанов, Д.Т., & Рейпназаров, Е.Н. (2020). Телекоммуникация объектлари электр таъминоти манбаларини масофавий мониторинг тизимини қурилиш тамойиллари. In “Иқтисодиётнинг тармоқларини инновацион ривожланишида ахборот-коммуникация технология-ларини аҳамияти” Республика илмий-техник анжуманининг маърузалар тўплами, 5-6 март (pp.249-251).
5. Сиддиков, И.Х., Хужаматов, Х.Э., Хасанов, Д.Т., & Рейпназаров, Е.Н. (2020). Қуёш панелларининг энергия самарадорлигини ошириш усулларини моделлаштириш. In “Инновацион техника ва технологияларнинг қишлоқ хўжалиги – озиқ-овқат

тармоғидаги муаммо ва истиқболлари" мавзусидаги халқаро илмий ва илмий-техник анжумани илмий ишлар тўплами, 24-25 апрель (pp.786-788).

6. Siddikov, I.X., Hujamatov, X.E., Hasanov, D.T., Reypnazarov, E.N., & Toshtemirov, T.Q. (2020). Telekommunikatsiya tizimlarining avtomatik boshqariluvchi quyosh energiya ta'minotini IOT modellari asosida tadqiq etish. Muhammad al-Xorazmiy avlodlari. Tashkent, 12(2), 52-58.
7. Siddikov, I.K., Khujamatov, K.E., Khasanov, D.T., & Reypnazarov, E.N. (2020). Modelling of monitoring systems of solar power stations for telecommunication facilities on wireless nets. Chemical technology, Control and Management. Tashkent, 93(3), 20-28.
8. Khujamatov, K.E., Reypnazarov, E.N., Khasanov, D.T., Nurullaev, E.E., & Sobirov, S.O. (2020). Evaluation of characteristics of wireless sensor networks with analytical modeling. Bulletin of TUIT: Management and Communication Technologies. Tashkent, 3(2), p.8.
9. Сиддиков, И., Хужаматов, Х., Хасанов, Д., Рейпназаров, Е., & Ахмедов, Н. (2020). Телекоммуникация тизимларининг қуёш энергия таъминоти манбаларини масофадан мониторинг қилиш дастурий таъминоти. Дастурий маҳсулот учун гувоҳнома, DGU 09989, DGU 2020 2465.
10. Khujamatov, K.E., Reypnazarov, E.N., & Lazarev, A.P. (2020). Modern methods of testing and information security problems in IoT. Bulletin of TUIT: Management and Communication Technologies. Tashkent, 4(4), p.11.
11. Xujamatov, X., Reypnazarov, E., Musaboyeva, N., & Aripov, J. (2022). Simsiz sensor tarmoqlarining ishonchliligini tadqiq qilish dasturi. Dasturiy mahsulot uchun guvohnoma, DGU 14860, DGU 2022 0479.
12. Khujamatov, K., Akhmedov, N., Reypnazarov, E., Khasanov, D., & Lazarev, A. (2022). Device-to-device and millimeter waves communication for 5G healthcare informatics. Blockchain Applications for Healthcare Informatics, 181-211. https://doi.org/10.1016/B978-0-323-90615-9.00019-0
13. Khujamatov, K., Akhmedov, N., Reypnazarov, E., Khasanov, D. Traditional vs. the blockchain-based architecture of 5G healthcare. Blockchain for 5G Healthcare Applications: Security and privacy solutions, 2022, pp. 131–167
14. Siddikov, K. Khujamatov, E. Reypnazarov and D. Khasanov, "CRN and 5G based IoT: Applications, Challenges and Opportunities," 2021 International Conference on Information Science and Communications Technologies (ICISCT), 2021, pp. 1-5, doi: 10.1109/ICISCT52966.2021.9670105.
15. H. Khujamatov, I. Siddikov, E. Reypnazarov and D. Khasanov, "Research of Probability-Time Characteristics of the Wireless Sensor Networks for Remote Monitoring Systems," 2021 International Conference on Information Science and Communications Technologies (ICISCT), 2021, pp. 1-6, doi: 10.1109/ICISCT52966.2021.9670122.
16. Siddikov, D. Khasanov, H. Khujamatov and E. Reypnazarov, "Communication Architecture of Solar Energy Monitoring Systems for Telecommunication Objects," 2021 International Conference on Information Science and Communications Technologies (ICISCT), 2021, pp. 01-05, doi: 10.1109/ICISCT52966.2021.9670354.
17. K. Khujamatov, A. Lazarev, N. Akhmedov, E. Reypnazarov and A. Bekturdiev, "Methods for Automatic Identification of Vehicles in the its System," 2021 International Conference on

Information Science and Communications Technologies (ICISCT), 2021, pp. 1-5, doi: 10.1109/ICISCT52966.2021.9670123.

18. Tanwar, S., Khujamatov, H., Turumbetov, B., Reypnazarov, E., Allamuratova, Z. Designing and Calculating Bandwidth of the LTE Network for Rural Areas. International Journal on Advanced Science, Engineering and Information Technologythis link is disabled, 2022, 12(2), pp. 437–445
19. S. Arsheen, A. Wahid, K. Ahmad and K. Khalim, "Flying Ad hoc Network Expedited by DTN Scenario: Reliable and Cost-effective MAC Protocols Perspective," 2020 IEEE 14th International Conference on Application of Information and Communication Technologies (AICT), 2020, pp. 1-6, doi: 10.1109/AICT50176.2020.9368575.
20. N. Akhmedov, H. Khujamatov, A. Lazarev and M. Seidullayev, "Application of LPWAN technologies for the implementation of IoT projects in the Republic of Uzbekistan," 2021 International Conference on Information Science and Communications Technologies (ICISCT), 2021, pp. 01-04, doi: 10.1109/ICISCT52966.2021.9670339.
21. Nurshod, K. Khujamatov and A. Lazarev, "Remote Monitoring System Architectures in Healthcare," 2021 International Conference on Information Science and Communications Technologies (ICISCT), 2021, pp. 01-05, doi: 10.1109/ICISCT52966.2021.9670405.
22. Kamal, A., Ahmad, K., Hassan, R., Khalim, K. (2021). NTRU Algorithm: Nth Degree Truncated Polynomial Ring Units. In: Ahmad, K.A.B., Ahmad, K., Dulhare, U.N. (eds) Functional Encryption. EAI/Springer Innovations in Communication and Computing. Springer, Cham. https://doi.org/10.1007/978-3-030-60890-3_6
23. Ibraimov, R., Sultonova, M., Khujamatov, H. The Integral Distribution Function of the Kilometric Attenuation of Infrared Radiation in the Atmosphere Fergana Region of the Republic of Uzbekistan. Webology. Volume 18, Issue Special Issue, 2021, Pages 316-327. DOI: 10.14704/WEB/V18SI05/WEB18231
24. K.A. Bin Ahmad, H. Khujamatov, N. Akhmedov, M.Y. Bajuri, M.N. Ahmad, A. Ahmadian. Emerging trends and evolutions for Smart city healthcare systems. Sustain. Cities Soc. (May 2022), p. 103695, 10.1016/J.SCS.2022.103695
25. Siddikov, I. K., Khujamatov, K. E., & Temirov, A. A. (2022). Models for Determination of Maximum Power in Compatible Management of Hybrid Energy Sources. Journal of Ethics and Diversity in International Communication, 2(3), 105-121.
26. Temirov, A. A., & Olimova, S. B. (2020). Smart uylarning gibrid energiya ta'minoti manbalarining signal uzatish datchiklari va axborot tizimining funksional imkoniyatlari―Инновацион ғоялар, ишланмалар амалиѐтга: муаммолар ва ечимлар‖ Халқаро илмий-амалий онлайн анжуман.
27. Раджабов, О. С., Темиров, А. А., & Соҳобиддинов, А. А. (2019). Корхона тармоқларини―Ҳимояланган виртуал хусусий тармоқлар (VPN)‖ орқали ташкил этиш. TATU xabarlari.
28. Абидова, Ф. Ш., Хамрокулова, Г. Т., & Темиров, А. А. (2019). Алгоритм быстрого строкового сопоставления сетевых систем обнаружения вторжений. Мировая наука, (4), 170-177.