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Article

Priority Directions for Digital Transformation of Public Utilities and Development of Digital Economy

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Abstract: Digital transformation has become a key factor in improving the efficiency of public utilities, yet in Uzbekistan data on electricity, water, gas and heat supply are still generated by separate departments and stored in fragmented information systems. This fragmentation hinders real-time control of resources, transparent billing and prompt management decisions. The purpose of this article is to substantiate the priority directions for the digital transformation of public utilities management and the organizational-economic mechanisms for developing the digital economy in the country. The study applies a systems approach, structural-functional analysis, comparative analysis of international practice, analysis of national policy documents and conceptual modelling. As a result, a conceptual framework of the Unified Smart Digital Platform for Public Utilities Management (USDP) is proposed. The model consists of five interrelated layers – users, sensors and infrastructure, data and technologies, processes and management, and results – and integrates scattered data into a single ecosystem based on the Internet of Things, Big Data analytics, artificial intelligence, cloud computing and blockchain. The organizational-economic mechanism of its implementation is described through institutional, organizational, financial, technological and human-capital components, a set of key performance indicators is proposed, and seven priority directions for developing the digital economy and increasing services exports are defined. The findings indicate that the USDP model can improve transparency, reduce resource losses and support the efficiency of service enterprises, provided that cybersecurity, data governance, interoperability and workforce skills are ensured. Empirical validation through regional pilot projects is recommended.

Keywords: digital economy, USDP model, IoT (Internet of Things), Big Data, blockchain, artificial intelligence, public utilities infrastructure, e-government, utilities management.

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1. Introduction

Today, in global practice, improving the quality of public utilities management and the rational use of resources depend directly on the adoption of digital technologies. Innovations such as artificial intelligence (AI), the Internet of Things (IoT), Big Data analytics, cloud computing and blockchain are elevating public utilities management to a new level [1], [2]. In the electricity sector, smart meters and data analytics enable real-time monitoring, demand forecasting and loss detection [3], [4], while IoT architectures make it possible to connect millions of physical devices into a single information

environment [5]. International organizations regard the digitalization of public services as a precondition for more efficient, inclusive and accountable governance [6], [7].

In the context of the diversification and modernization of Uzbekistan's economy, the sustainable development of service enterprises requires the improvement of their economic mechanisms. The Strategy "Digital Uzbekistan – 2030" and the measures for developing the digital economy define the digitalization of public services and infrastructure as a national priority [8], [9]. At the same time, data related to the public utilities sector are formed in various departments and scattered systems, which hinders real-time control of resources and prompt decision-making [10], [11]. Developing a platform that brings all participants into a single digital environment and implementing a coherent digital economy strategy are therefore highly urgent tasks.

1.1 Literature review and theoretical background

The effective management of public utilities and the use of digital technologies within them constitute one of the most pressing areas of modern management theory. Representatives of the classical management school, notably P. Drucker, the founder of the concept of management by objectives [12], and modern strategic management scholars such as M. Porter [13] emphasize that the efficiency of any infrastructural system depends on the speed of resource and information flows and on the interdependence of the links in the value chain. Porter and Heppelmann further show that smart, connected products transform not only operations but also the boundaries of industries and the sources of competitive advantage [14]. In the information-systems literature, digital transformation is defined as a process in which digital technologies trigger strategic responses and changes in value creation, organizational structures and culture [15].

The technological basis of utility digitalization has been studied extensively. Gubbi et al. described the architectural elements of IoT systems – sensing, communication, data processing and applications [5]; Mell and Grance defined the service and deployment models of cloud computing [16]; and reviews of Big Data analytics in smart grids have identified applications in load forecasting, asset management, fault detection and customer analytics [3]. Blockchain has been proposed for peer-to-peer energy trading, metering and billing, although its scalability, energy consumption and regulatory issues remain open [17], [18]. Integrated IoT and Big Data solutions have also been demonstrated for household energy management [4].

The management of public utilities based on organizational-economic mechanisms has also been examined by scholars from the CIS and Uzbekistan. V. Kh. Fedorovich developed public-private partnership and corporate governance models for utility enterprises [19]; B. A. Khodiev highlighted the mechanisms of innovative management of economic sectors [20]; and Sh. J. Ergashev analysed the management of the service sector and its impact on sustainable economic growth, substantiating the importance of service intensity and transparent management decisions [21]. National studies have also addressed blockchain technologies in the digital economy [22] and the role of digital platforms in service enterprises [11].

Despite this body of research, most studies address individual technologies or individual utility sectors. An integrated model that unites electricity, water, gas and heat supply data in a single platform and links it with the organizational-economic mechanisms of the digital economy has not been sufficiently developed for Uzbekistan. The aim of this article is therefore to propose such a model and to define the priority directions for its implementation. The objectives are: (1) to identify the main problems of utilities management caused by data fragmentation; (2) to develop the conceptual structure of the USDP model; (3) to describe the organizational-economic mechanism and the performance indicators for its implementation; and (4) to define the priority directions for developing the digital economy and increasing services exports.

2. Materials and Methods

The study is conceptual and analytical. Its information base comprises the legal and policy documents of the Republic of Uzbekistan on digital transformation [8], [9], official statistical sources [23], international reports on the digitalization of utilities and public services [2], [6], [7] and the scientific literature reviewed above.

The following methods were used: (1) a *systems approach*, which treats the utilities sector as a set of interrelated subsystems – consumers, infrastructure, information systems, management processes and results; (2) *structural-functional analysis*, used to identify the elements of each layer of the proposed platform and their functions; (3) *comparative analysis* of international practice in smart utilities, smart grids and e-government [2], [3], [7]; (4) *analysis of normative documents*, used to align the proposals with national strategic priorities; and (5) *conceptual modelling*, used to design the layered architecture of the platform on the basis of established IoT and cloud reference architectures [5], [16].

The analysis was carried out in three stages: identification of the problems caused by data fragmentation; design of the USDP model and of the organizational-economic mechanism of its implementation; and formulation of performance indicators and priority directions for the development of the digital economy. Because the study is conceptual, the expected effects are described qualitatively; their quantitative assessment requires pilot implementation.

3. Results

3.1 Problems caused by data fragmentation

The analysis showed that the main obstacle to efficient utilities management is the fragmentation of information. Data on the consumption of electricity, water, gas and heat, on payments and on the technical condition of networks are collected by different organizations in separate systems that are not interoperable [10], [11]. As a result, real-time monitoring of resource flows is limited, losses and unauthorized consumption are detected late, billing depends to a large extent on manual meter reading, and consumers must interact with several organizations through different channels. Management decisions are therefore taken on the basis of incomplete and delayed information, which reduces the efficiency of service enterprises and the transparency of the sector.

3.2 Unified Smart Digital Platform (USDP) model

To overcome these problems, the Unified Smart Digital Platform (USDP) model for public utilities management is proposed. The aggregation of data on electricity, water, gas and heat supply in a single platform enables prompt management decisions and efficient use of resources. The model consists of five interrelated layers (Table 1).

Table 1. Structure of the Unified Smart Digital Platform (USDP) model

Layer	Structural elements	Functional task
1. User layer	Population, entrepreneurs, mobile application, personal cabinet, call centre, Telegram bot	Receiving consumers' appeals and payments in a unified system
2. Sensors and infrastructure	IoT-based smart meters, sensors, 5G communication networks	Continuous real-time collection of data on electricity, water, gas and heat
3. Data and technologies	Artificial intelligence, Big Data, cloud servers, blockchain	Data processing, analysis and generation of decision proposals ("digital brain")

Layer	Structural elements	Functional task
4. Processes and management	Predictive maintenance, automatic billing, resource allocation	Prompt management of emergency situations, reduction of service costs
5. Results	Transparency, resource savings, consumer satisfaction	Increasing the efficiency of state management and the quality of life of the population

Source: developed by the author.

The hierarchical structure of the model and the integration of data flows are shown in Fig. 1. Data generated by consumers and by IoT devices (Layers 1 and 2) are transmitted to the data and technology layer, where they are stored in the cloud [16], analysed with Big Data and AI tools [3] and, where transaction integrity is required, recorded in a blockchain ledger [17]. The results of the analysis are used in management processes – predictive maintenance, automatic billing and optimal allocation of resources – and finally produce socio-economic results. Control decisions and information are returned to consumers through the same digital channels, closing the feedback loop.

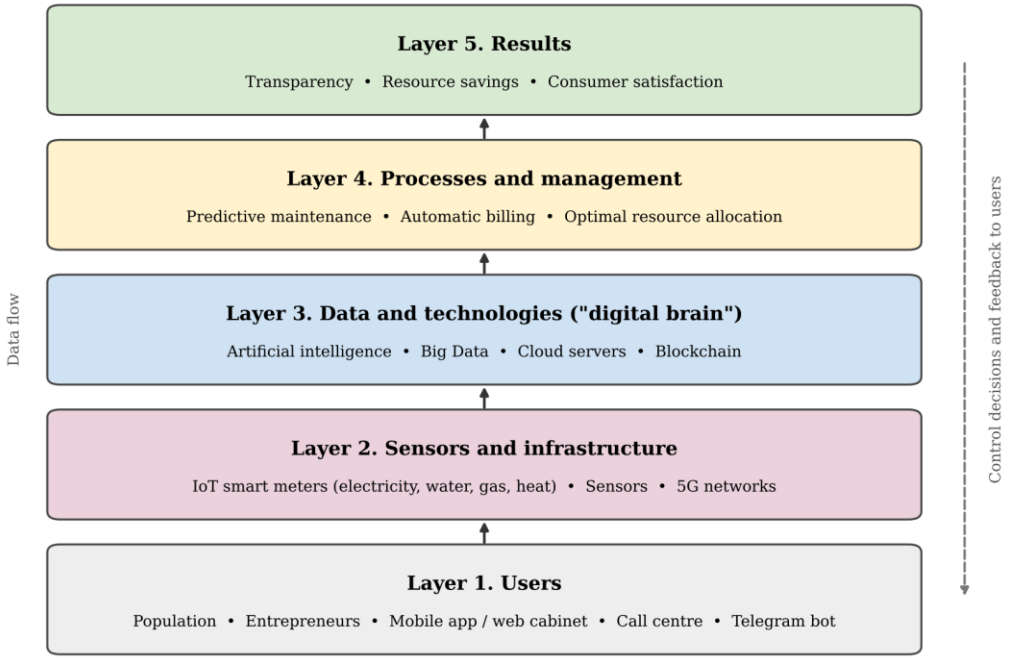


Figure 1. Conceptual structure of the Unified Smart Digital Platform (USDP) model for public utilities management

Source: developed by the author.

3.3 Organizational-economic mechanism of implementation

The implementation of the USDP model requires an organizational-economic mechanism that combines institutional, organizational, financial, technological and human-capital components (Table 2). The mechanism is based on the principle that the platform is a shared infrastructure of the state and the service enterprises, while the services provided on it can be developed jointly with private partners [14], [19].

Table 2. Components of the organizational-economic mechanism for implementing the USDP model

Component	Content	Expected result
Institutional	Legal framework for data exchange, digital identification of consumers, blockchain and e-documents; data protection rules	Legal certainty for all participants
Organizational	Designation of a platform operator; unified registry of consumers and objects; coordination of utility enterprises and local authorities	Elimination of duplicated functions and data
Financial	Public-private partnership, investment programmes of utility enterprises, phased financing linked to savings	Sustainable financing of digitalization
Technological	Common data standards and interfaces, IoT metering, cloud infrastructure, cybersecurity	Interoperability and reliability of the system
Human capital	Training of specialists in data analytics, AI and blockchain; digital literacy of consumers	Effective use of the platform

Source: developed by the author.

To monitor the effectiveness of the platform, the following key performance indicators are proposed: the share of consumers served by smart meters; technical and commercial losses of electricity, water and heat; the share of payments made through digital channels; the average time required to respond to accidents and consumer appeals; the share of utility services provided electronically; and the level of consumer satisfaction. These indicators make it possible to evaluate the platform's contribution to the efficiency of service enterprises and to compare regions.

3.4 Priority directions for developing the digital economy and increasing services exports

To ensure the intensity of service provision, increase the labour productivity of employees and strengthen the competitiveness of local enterprises in the international market, the following seven priority directions for the further development of the digital economy are proposed:

- **Crypto-assets and blockchain ecosystem:** developing smart contracts, consulting, token issuance and crowdfunding within a regulated framework to diversify the economy [9], [18].
- **Development of human capital:** training highly qualified specialists with practical skills in blockchain, data analytics and transactional technologies.
- **Partnership between the state and service providers:** jointly implementing innovative ideas, start-ups and digital solutions in practice.
- **International integration:** strengthening cooperation with foreign organizations in the digital and blockchain fields and using the experience of leading foreign experts.
- **Improving the legal framework:** creating solid legislative foundations for blockchain, data exchange and modern digital technologies.
- **Economic and legal support for digital education:** making productive use of artificial intelligence, virtual reality (VR) and augmented reality (AR) technologies in educational services.
- **Expanding the e-government system:** gradually transferring public and utility services provided to the population to a unified digital platform [7].

4. Discussion

The proposed USDP model is consistent with international experience, in which the value of utility digitalization arises primarily from the integration of data rather than from individual technologies [2]. Studies of smart grids show that combining smart metering with Big Data analytics improves load forecasting, fault detection and asset management [3], [4]; the USDP model extends this logic from electricity to all utility services and links it with consumer services and billing. In terms of management theory, the model shortens information flows between the links of the value chain, which, as emphasized by Drucker and Porter, is a key condition for the efficiency of infrastructural systems [12], [13].

At the same time, the implementation of such a platform is not merely a technological project. Digital transformation changes organizational structures, responsibilities and business models [15], and its success depends on the coordination of many organizations. The main risks are cybersecurity threats to critical infrastructure, the protection of personal data, the lack of common data standards, the high initial cost of smart metering and the shortage of qualified personnel. The use of blockchain should be justified by specific needs – for example, transparent settlements between suppliers or the traceability of transactions – because the technology still faces limitations in scalability, energy consumption and regulation [17]. Likewise, the development of crypto-asset activities must be accompanied by appropriate regulation and risk management. The digital divide between urban and rural consumers also requires that traditional service channels be maintained during the transition period [6].

For Uzbekistan, these considerations suggest a phased approach: pilot implementation of the platform in one region and one or two utility sectors, evaluation of the results with the indicators proposed above, and subsequent scaling within the framework of the "Digital Uzbekistan – 2030" Strategy [8]. The integration of utility services into the e-government system can also reduce transaction costs for consumers and increase trust in public institutions [7].

The study has limitations. The USDP model is conceptual, and its economic effects have not yet been quantified. Future research should estimate the costs and benefits of the platform on the basis of pilot data, assess its impact on losses, collection rates and service quality, and develop technical standards for data exchange between utility enterprises.

5. Conclusion

The study shows that the fragmentation of data among different departments is the main obstacle to efficient management of public utilities in Uzbekistan. The proposed Unified Smart Digital Platform (USDP) model, consisting of user, sensor and infrastructure, data and technology, process and management, and results layers, provides a conceptual solution for centralizing fragmented data and ensuring financial transparency in the sector. Controlling resource consumption through IoT sensors helps to reduce losses, while artificial intelligence makes it possible to predict emergency breakdowns in advance.

The implementation of the model requires an organizational-economic mechanism that combines institutional, organizational, financial, technological and human-capital components and is monitored through a set of key performance indicators. Integrating digital economy elements, particularly blockchain and e-government systems, into service enterprises can increase the efficiency and transparency of the sector, support the growth of services exports and strengthen the economic security of the country.

It is recommended to: (1) adopt common data standards and a unified registry of consumers and utility objects; (2) implement the USDP model as a pilot project in one

region; (3) develop public-private partnership mechanisms for financing smart metering; (4) strengthen cybersecurity and personal data protection; and (5) expand training programmes in data analytics, AI and blockchain.

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