Smart people: the role of big data analytics in digital transformation*

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Abstract

This article explores the role of big data analytics in the digital transformation of smart cities, with a particular focus on the concept of "smart people" as a key component of urban development. Utilising authentic data concerning enrolment in IT specialties in 2024, the study undertakes an analysis of applicants' applications and the distribution thereof by IT specialties, whilst concurrently proposing the implementation of information technology tools for the dynamic tracking of changes in the enrolment process. The study demonstrates how data-driven insights can influence management decision-making in the field of educational planning and urban policy.

Keywords

smart city, smart people, big data, databases, diagrams, digital transformation, cross-platform solution

1. Introduction

At present, educational services are experiencing a surge in popularity among young people. Ukrainian universities are implementing measures to enhance the quality of their educational programs. The number of applicants in 2024 decreased significantly compared to previous years [1]. This phenomenon can be attributed to two main factors: firstly, the imposition of martial law in the region, and secondly, the increased interest among applicants in pursuing higher education abroad.

The higher education system in Ukraine is currently experiencing substantial transformation, characterised by a shift towards a more practical orientation in educational curricula, enhanced engagement with industry in the teaching process, and the introduction of selective academic disciplines.

The admission process represents a pivotal stage in the lives of applicants, as it determines their future academic and professional trajectory. The most popular majors are typically IT and law.

The admission process is the most important stage in the life of applicants, as they choose their future specialty. Usually, the most popular specialties are IT and law.

It is imperative that all admission data is consolidated and cleaned. In addition, each stage of data validation must be carried out. Furthermore, big data metrics and analytics must be created to assist university management – the rector, vice-rector, and heads of graduate departments – in making management decisions.

In recent years, Ukrainian cities have been actively implementing elements of "smartness", and the concept of a "smart city" is gaining popularity. One of the six characteristics of a smart city is "smart people" [2], because it is the presence of educated people that will ensure the sustainable development of both a single city and the entire country.

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The initial phase in the implementation of digital transformation in education is the processing of substantial data sets and collections on the admission campaign. Each university can be regarded as an autonomous business unit, and the level of its digitalisation can be determined by the quality of the digital services and facilities provided.

The objective of this article is to analyse big data on the admission campaign for IT specialties in 2024 at Ternopil Ivan Puluj National Technical University and to propose information technology tools to increase the quantitative indicators of future students.

The scientific novelty of this research lies in the development of an integrated approach to analyzing applicant behavior using big data and functional requirement models, specifically applied to university admission campaigns. Unlike previous works, this study links educational data analytics with the concept of “smart people” as a key component of smart cities, and proposes cross-platform solutions and BI dashboards for real-time monitoring. Such integration provides universities with measurable KPIs to evaluate digital transformation progress and forecast demand for IT specialties more accurately.

2. Related works

In the context of unprecedented global urbanisation, the concept of the "smart city" has emerged as a transformative force that is effecting change in the urban landscape. Urban areas are no longer merely collections of buildings and infrastructure; they are now complex systems. These systems have evolved into complex ecosystems, integrating big data and information and communication technologies to create a more efficient, sustainable, and livable environment [3]. The integration of digital innovations into urban planning and management is at the core of digital transformation, with prominent technologies such as big data analytics, deep learning, and neural networks playing a pivotal role in this evolution. The necessity for innovative urban solutions will increase in the future. According to the United Nations, 68% of the world's population will be urban dwellers by 2050 [4]. Current estimates suggest that approximately 50% of the global population now resides in urban areas, with the European Union registering an even higher proportion of urban residents, at 73.6%. Projections indicate a global increase to 58.2% and a European increase to 75.8% by 2025 [5]. In this regard, urbanisation is becoming sustainable and is being elevated to a priority area in public policy in most countries worldwide.

This extraordinary growth of cities gives rise to numerous challenges, including traffic congestion, energy consumption, public safety, environmental sustainability, and an increase in the number of applicants to higher education institutions.

Research paper [6] identifies six key features of a smart city: namely, a smart economy, smart people, smart governance, smart mobility, environmental awareness, and quality of life. These characteristics delineate the areas of urban development in which the smart city concept can be effectively implemented. This implementation involves the improvement of existing infrastructure with the aid of data and information and communication technologies. The objective is to provide quality digital services and services to residents.

In the context of the dynamic digital transformation of cities, education is playing an increasingly important role. In the context of smart cities, the educational sphere assumes a new significance. The concept is associated with the notions of sustainable development, active citizenship, and digital literacy [7]. A number of cities have undergone a rethink in terms of their economic models, with a shift towards a focus on innovation, talent attraction, and the nurturing of creative potential.

Education evolves beyond its conventional role, becoming the foundation for comprehending the challenges of contemporary society. Furthermore, it is recognised as a critical factor for empowering citizens and engaging them in active participation in the implementation of smart city initiatives [8]. The population's high level of education, the presence of a creative class, and the ability to learn throughout life are increasingly recognised as drivers of urban intelligence growth.

Consequently, it is evident that without innovative thinking, knowledge and educational processes, a city cannot become truly "smart" [7].

The amalgamation of big data analytics, artificial intelligence, and the Internet of Things is effecting a transformation of business intelligence, thereby engendering a potent milieu for the enhancement of management decision-making, predicated on the availability of data sets. Big Data offers large amounts of different types of data that are necessary for thorough analysis. These data sources are consolidated from various sources, including IoT sensors, city databases, social platforms, and open data sets and collections. These extensive data streams are imperative in the identification of patterns, trends and insights that may be overlooked by conventional data processing methodologies. The Internet of Things (IoT) technologies play an important role in facilitating this integration by providing continuous, real-time data from a system of interconnected devices. These gadgets, equipped with sensors and software, collect and send information about various parameters such as temperature, location, efficiency, and user actions [9]. It is asserted that university administrators can rely on the real-time data stream in order to monitor processes, anticipate problems, and make the necessary adjustments promptly during the admission campaign and the educational process. The advent of artificial intelligence and machine learning algorithms has rendered the exploration of big data a possibility. Recent studies also highlight the integration of fuzzy logic with neural network models as a promising approach for big data analysis. Fuzzy logic is particularly effective in handling uncertainty and imprecision, which are inherent in large and heterogeneous datasets. When combined with neural networks, these hybrid methods enable more flexible classification of information objects and provide adaptive mechanisms for pattern recognition. Such approaches have demonstrated the potential to enhance decision-making accuracy in complex urban environments and can be further applied to smart city services and educational data analytics, where data variability and incomplete information are frequent challenges [10].

The integration of digital technologies into educational practices gives rise to a substantial volume of data, predominantly attributable to the participation of students and educators within the framework of distance learning systems. Following the processes of consolidation, cleaning, and validation, this data can then be utilised to address critical issues encountered by higher education institutions [11]. For instance, the enhancement of educational programmes to appeal to prospective applicants. The success of big data analytics in various sectors has demonstrated the potential for higher education to harness this technology to inform decision-making. The authors of [12] observe that higher education has not yet been penetrated by big data and analytics, and big data itself has been termed an "untapped opportunity" in higher education.

The authors of [13] contemplated the potential of utilising big data analytics in higher education to automate and digitalise educational services. The researchers proposed three scenarios that demonstrate the application of big data analytics in the domains of learning, teaching and management. Within the conceptual framework of "smart people" focused on personalised learning and digital adaptation, the authors' study [14] demonstrates the potential of Big Data analytics in education. In particular, the authors demonstrated that the implementation of a neural network that analyses data from a virtual learning environment facilitates the identification of students who are at high risk of academic failure. This approach facilitates timely intervention and support, which is a key element of the digital transformation of the educational environment in smart cities.

Digital transformation has had a profound impact on urban governance, business development and education. The expenditure on digital transformation technologies and services across the globe surpassed $2.16 trillion in 2023 and is anticipated to attain $3.5 trillion in the imminent future [15], signifying that investment in this domain could serve as a catalyst for organisational growth [16]. A pivotal component of digital transformation pertains to the realm of big data analytics, especially in urban areas undertaking smart city initiatives.

Figure 1 illustrates the publication activity on smart cities, including smart people, by year, according to Scopus [17].

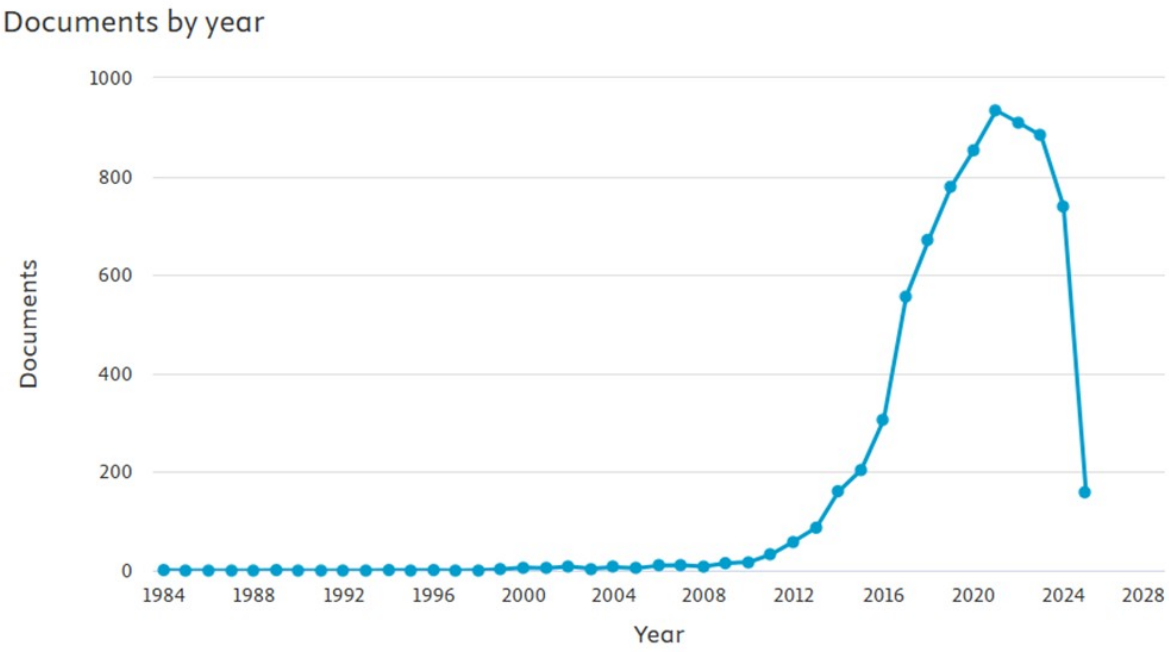


Figure 1: Level of publication activity on smart cities and smart people by year.

The year 2021 saw the highest number of publications. As illustrated in Figure 2, the publication activity on smart cities, including smart people, by country, is demonstrated according to Scopus data.

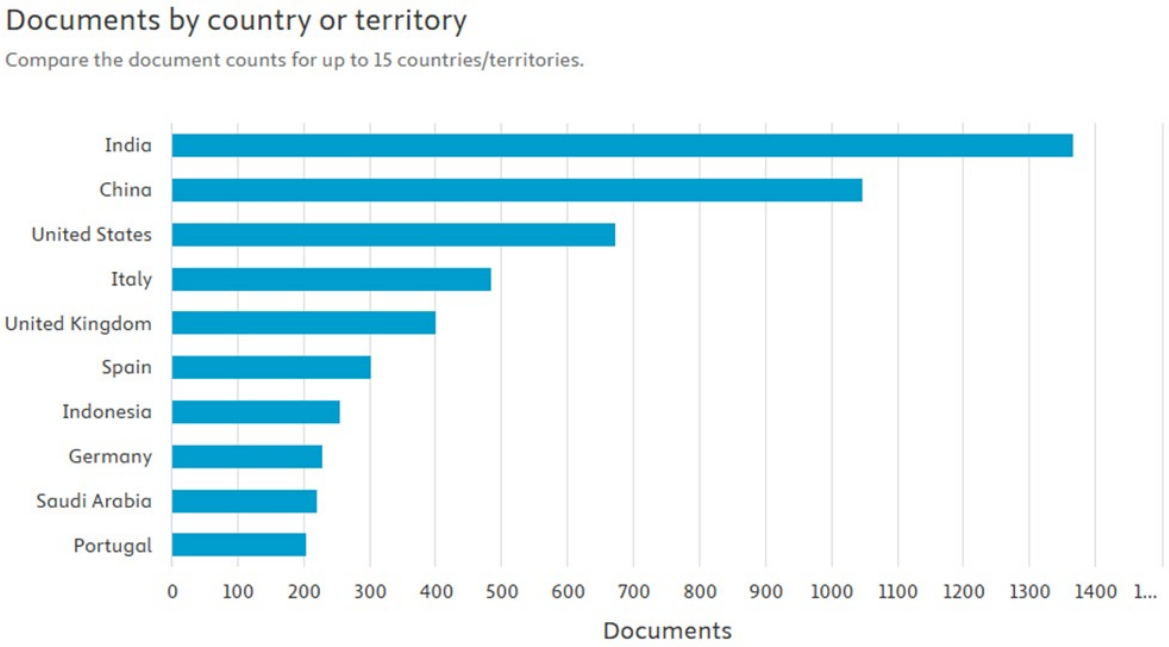


Figure 2: Level of publication activity on smart cities and smart people by country.

Consequently, authors from India, China, and the United States are responsible for the majority of research conducted on intelligent individuals. The level of interest in smart cities and big data analytics is also most pronounced among authors from these countries.

In a similar vein, an analysis of the demand for the keywords "smart city" and "digital transformation" is warranted (see Figure 3).

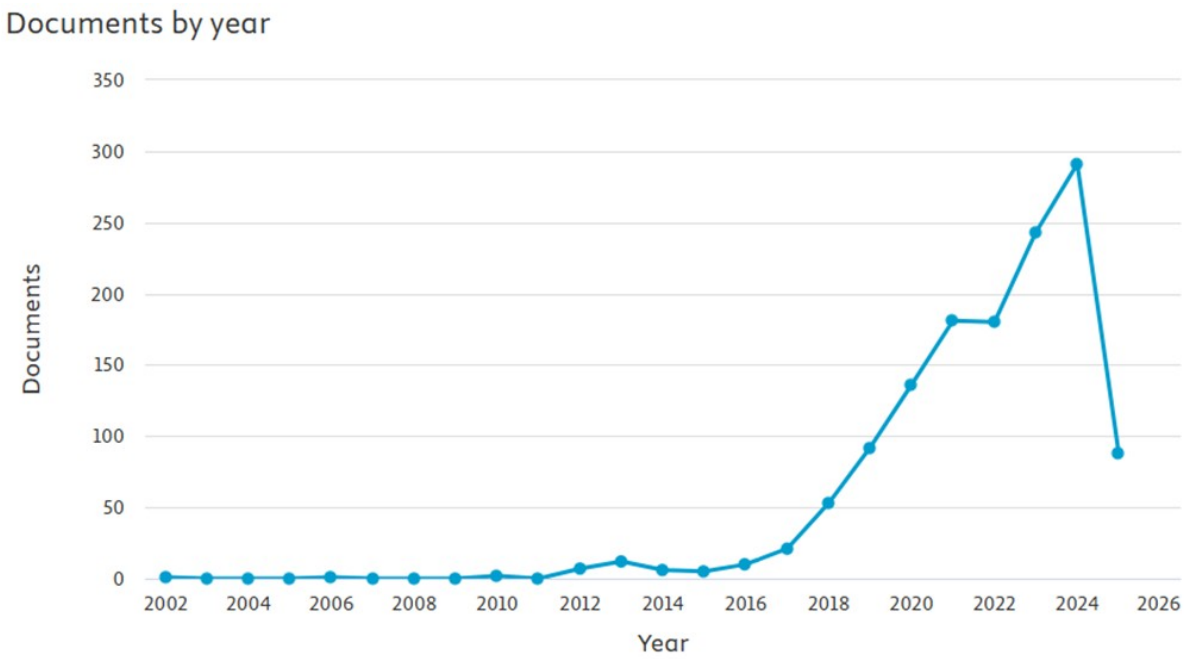


Figure 3: Publication activity by keywords “smart city” and digital transformation.

Consequently, the most prolific period of publication was in 2024, with a further increase observed in 2025. The provision of high-quality educational services for applicants is contingent upon a combination of big data analytics and digital transformation. Real-time analytics will empower the management of a higher education institution to identify key patterns, for example, during the admission campaign.

3. Analysis of the admission campaign in 2024

The analysis is grounded in data pertaining to applicants' admission to Ternopil Ivan Puluj National Technical University. The analysis considers applications to the Faculty of Computer and Information Systems and Software Engineering, in particular, to the specialties of the field of knowledge 12 (F) Information Technology:

- 121 (F2) Software engineering.
- 122 (F3) Computer science.
- 123 (F7) Computer engineering.
- 124 (F4) Systems analysis.
- 125 (F5) Cybersecurity and information protection.
- 126 (F6) Information systems and technologies.

The acceptance of applications was conducted electronically, and their registration was undertaken by information system operators within the admission committee. Applicants for bachelor's or master's degrees have the option to study either full-time or part-time, and may assign a priority rating from 1 to 5 to their applications for state-funded education, with rating K reserved for contract education.

As demonstrated in Figure 4, the hourly distribution of applications from applicants who applied for a bachelor's degree after high school (1st year) and college (2nd year) is presented.

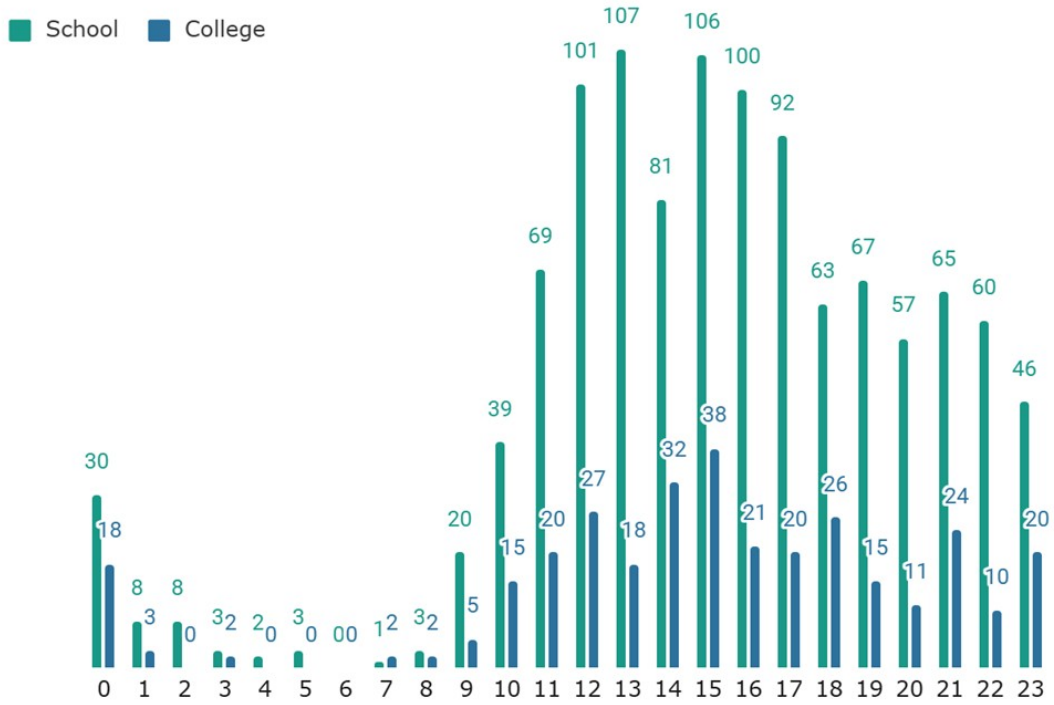


Figure 4: Hourly distribution of applications from applicants (bachelor's degree).

The period between 12:00 and 13:00 was found to demonstrate the highest level of activity among school graduates. A high level of activity was observed among college graduates, with the peak period occurring between 15:00 and 16:00.

As illustrated in Figure 5, the mean hourly distribution of applications from applicants seeking a bachelor's degree after high school (1st year), college (2nd year), and in general is presented.

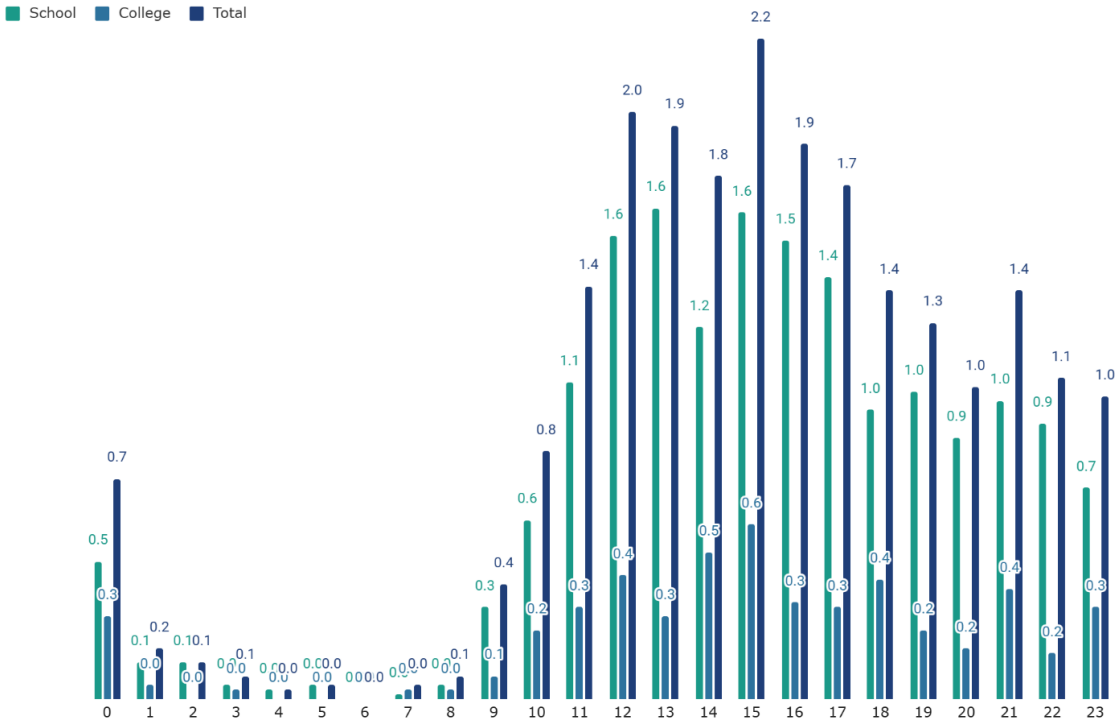


Figure 5: Average hourly distribution of applications from applicants (bachelor's degree).

The majority of applications were submitted between 15:00 and 16:00, although a surge in activity was observed between 12:00 and 16:00.

As illustrated in Figure 6, the hourly distribution of applications from applicants seeking admission to a master's degree programme on the basis of a bachelor's degree is depicted.

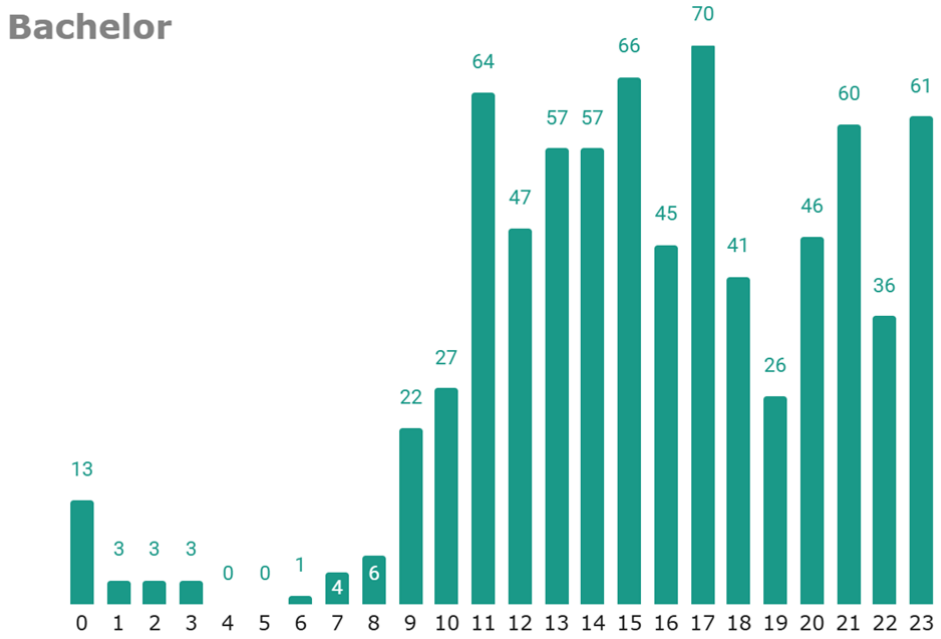


Figure 6: Hourly distribution of applications from applicants (master's degree).

It was observed that the period between 17:00 and 18:00 was the most active time for bachelors applying for a bachelor's degree.

As illustrated in Figure 7, the mean hourly distribution of applications from applicants seeking admission to a master's degree programme is depicted.

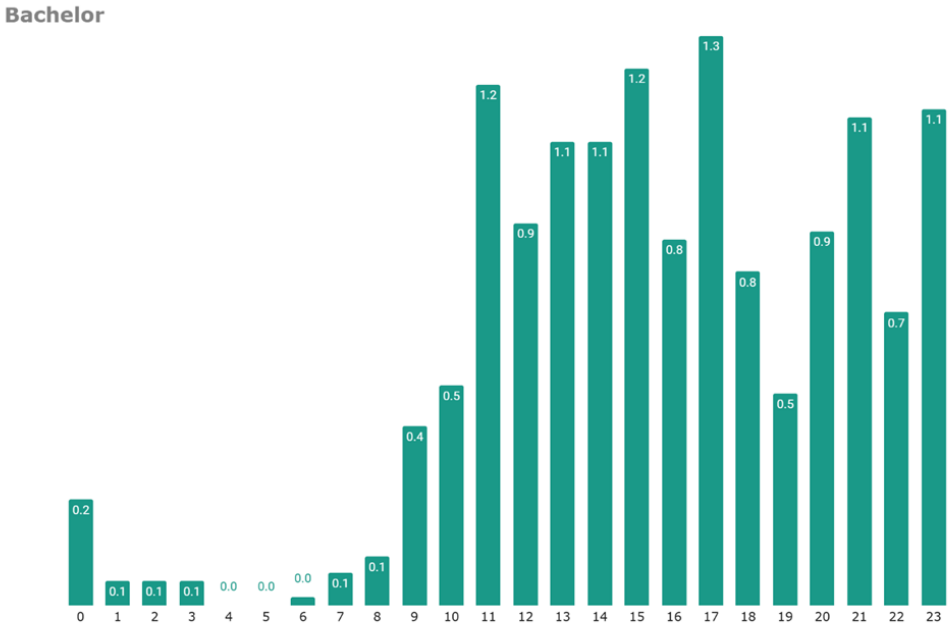


Figure 7: Average hourly distribution of applications from applicants (master's degree).

The majority of applications were received between 15:00 and 16:00, although a surge in activity was observed between 11:00 and 18:00.

The university's use of big data in admissions will facilitate the identification of key metrics, the establishment of KPIs, and the real-time monitoring of performance. When considered in conjunction with the implementation of digital transformation, this data will prove to be of significant value to the higher education institution in its capacity as an independent business unit. The subsequent sections proffer methodologies for the implementation of big data analytics, encompassing the creation of information technology tools, a specialised cross-platform application, and a dashboard utilising Business Intelligence (BI) tools.

4. Requirements for implementing a cross-platform solution

In order to digitise educational services and further analyse big data on the admission campaign, it is proposed that a cross-platform application be implemented, based on the React Native [18] or Flutter [19] framework, with access to the big data warehouse through the Apache Spark [20] or Hadoop [21] framework.

The following functional requirements are to be highlighted:

- Importing data from external sources (CSV, database, API).
- Preliminary processing (checking the format, data types, duplicates).
- Periodic data aggregation using Apache Spark or Hadoop.
- Filtering by parameters (year, specialty, type of application, time of submission).
- Visualization of graphs (hourly activity, interest in IT specialties).
- Generation of PDF reports for management.
- Cross-platform access (React Native/Flutter).
- Secure access through authorization.

The following step is to identify the set of actors in the system:

- Applicant – submits an application for admission.
- Operator – registers the applicant's application and performs other administrative operations.
- University Management – receives analytical reports to make strategic decisions.
- Big Data System – stores and processes data.
- Analytics Module – analyzes data for forecasting and visualization.
- Education Ministry – receives analytical reports to monitor educational processes.

Figure 8 shows the Use-Case diagram according to the functional requirements and the selected set of actors.

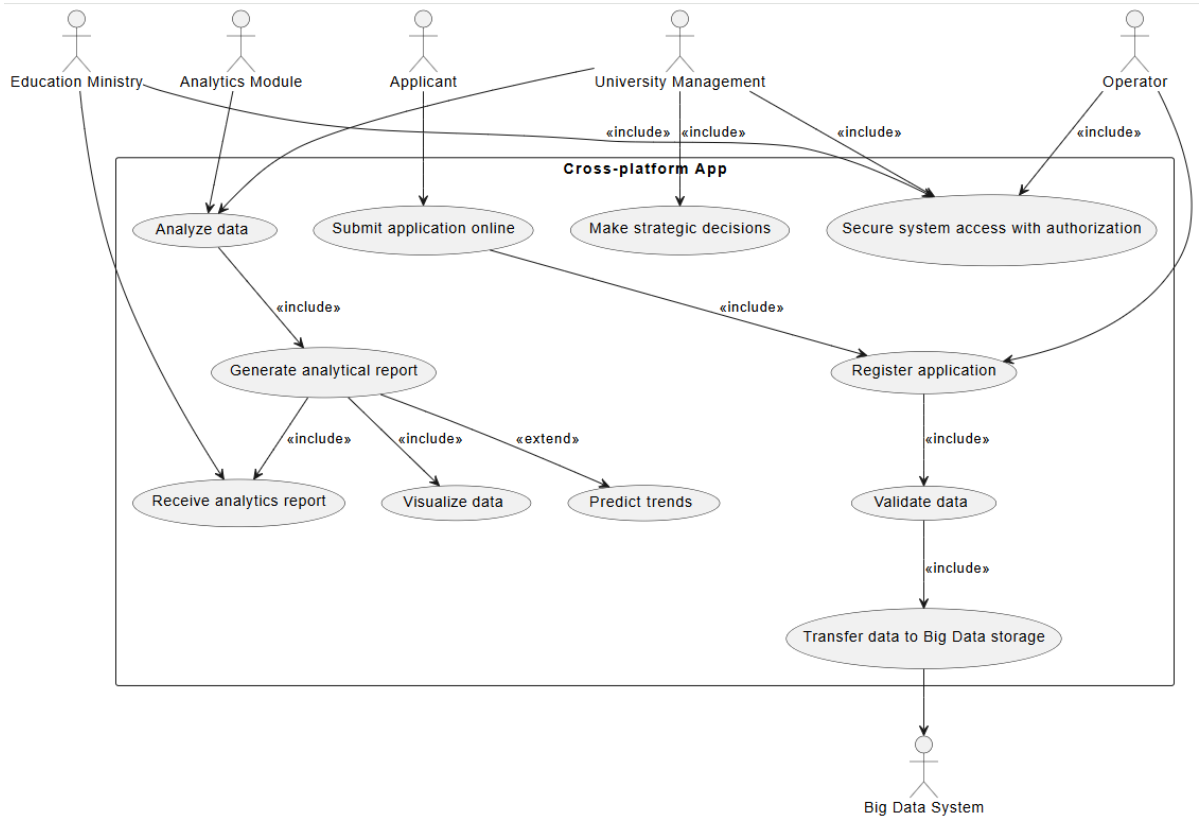


Figure 8: Use-Case diagram for the proposed cross-platform solution.

In accordance with the specified requirements, it is possible to develop an application that automates the work of the admissions office and allows the university management to generate reports in real time.

5. Information dashboard for big data analytics

As an alternative to developing a cross-platform application for big data analytics on the admission campaign, a cross-platform dashboard can be created using Microsoft Power BI [22]. The implementation of dashboards for the purpose of enhancing municipal services is presented in [23].

The consolidation of data from multiple sources, the configuration of scheduled updates to the data set, and the establishment of metrics and dynamic visualisations are of particular significance. The development of a dashboard was initiated in response to the data pertaining to the admission campaign for the IT specialties at TNTU in 2024 (see Figure 9).

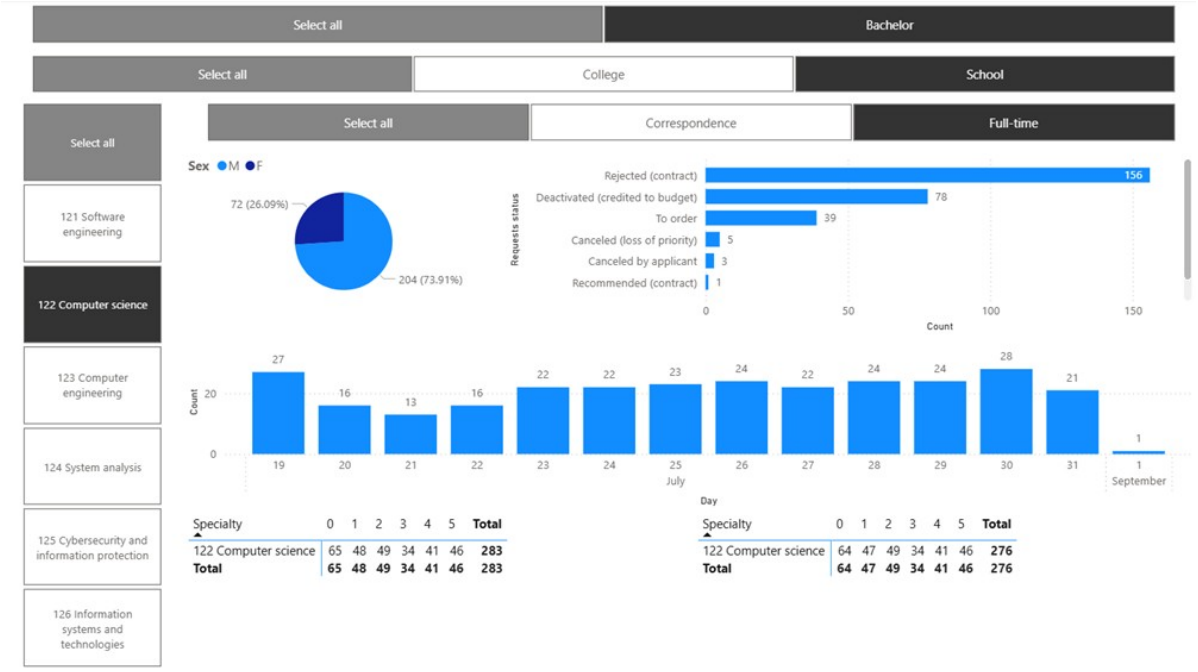
The implementation of dynamic visualisation has been undertaken, incorporating options for the selection of the educational qualification level, the level/institution of education following which admission is made, the form of study and specialty. Applications can be categorised according to various criteria, including dates, hours, days of the week, and status. Priority 0 indicates that the application was submitted solely for the purpose of contractual education. The total number of applications received was 2251, submitted by 1277 applicants.

Specialty	0	1	2	3	4	5	Total
121 Software engineering	110	108	82	68	70	46	**484**
122 Computer science	120	131	130	85	67	63	**596**
123 Computer engineering	97	118	66	74	49	42	**446**
124 System analysis	22	7	12	15	19	24	**99**
125 Cybersecurity and information protection	136	72	70	68	59	50	**455**
126 Information systems and technologies	39	13	26	36	33	24	**171**
Total	**524**	**449**	**386**	**346**	**297**	**249**	**2251**

Specialty	0	1	2	3	4	5	Total
121 Software engineering	107	106	82	66	70	46	**466**
122 Computer science	115	127	129	84	67	63	**530**
123 Computer engineering	94	117	65	74	49	42	**432**
124 System analysis	22	7	12	15	19	24	**98**
125 Cybersecurity and information protection	130	72	70	68	59	50	**441**
126 Information systems and technologies	39	13	26	36	33	24	**170**
Total	**394**	**441**	**383**	**343**	**297**	**249**	**1277**

Figure 9: Information dashboard on the admission campaign to the IT specialties at TNTU in 2024.

Figure 10 shows the level of interest of applicants in the specialty 122 Computer Science (Bachelor's degree, 1st year, full-time).



Specialty	0	1	2	3	4	5	Total
122 Computer science	65	48	49	34	41	46	**283**
Total	**65**	**48**	**49**	**34**	**41**	**46**	**283**

Specialty	0	1	2	3	4	5	Total
122 Computer science	64	47	49	34	41	46	**276**
Total	**64**	**47**	**49**	**34**	**41**	**46**	**276**

Figure 10: Admission to the specialty 122 Computer Science (1 year, full-time).

It is also possible to view the report on mobile devices (see Figure 11).

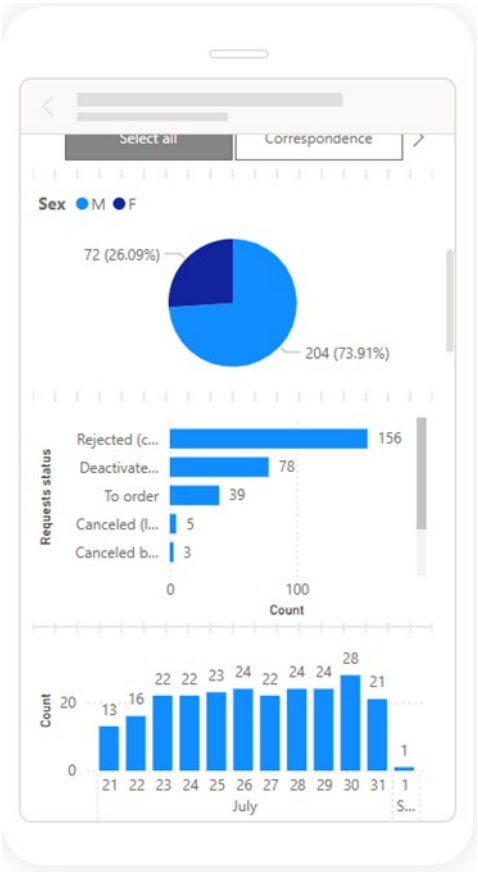


Figure 11: Mobile interface of the information dashboard.

The creation of additional metrics and other visualisations has the potential to engender further improvement.

6. Conclusion

The study concluded that big data analytics constitutes an integral component of digital transformation. The consolidation and real-time processing of large data sets will facilitate effective response and management decision-making by the university's administration.

A study was conducted to analyse the demand for educational services in IT specialties among applicants to TNTU. The following proposal is put forward: the implementation of information technology solutions for the digitalisation of the educational process. The implementation of a cross-platform application or the augmentation of dashboard functionality has the potential to enhance the admission process.

The implementation of a comprehensive solution is expected to result in an increase in the number of "smart people" in Ukrainian cities as they progress towards the adoption of the "smart city" concept.

Declaration on Generative AI

The authors have not employed any Generative AI tools.

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